To the Graduate Council:

I am submitting herewith a thesis written by Deborah Minor entitled "A Study Concerning the Training of Dichotic Right Ear Discrimination Ability of Five and Six Year Old Males." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Speech Pathology.

Harold A. Peterson, Major Professor

We have read this thesis and recommend its acceptance:

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Thesis
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A STUDY CONCERNING THE TRAINING OF DICHOTIC RIGHT EAR DISCRIMINATION ABILITY OF FIVE AND SIX YEAR OLD MALES

A Thesis

Presented for the

Master of Arts

Degree

The University of Tennessee, Knoxville

Deborah Minor

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DEDICATION

Psalm 31:1-5

In thee, O Lord, do I put my trust; let me never be ashamed; deliver me in thy righteousness.

Bow down thine ear to me; deliver me speedily: be thou my strong rock, for an house of defence to save me.

For thou art my rock and my fortress; therefore for thy name's sake lead me, and guide me.

Pull me out of the net that they have laid privily for me: for thou art my strength.

Into thine hand I commit my spirit: thou hast redeemed me, O Lord God of truth.

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Also to be thanked are the many Christian brothers and sisters and especially Mike for their constant help, encouragement, and prayer.

The author also praises and gives thanks to her Lord and Savior, whose divine wisdom, guidance, strength and love makes all things possible. She also praises the Lord for teaching her the truth of Deuteronomy 31:6, in which it says,

> Be strong and of a good courage, fear not, nor be afraid of them: for the Lord thy God, he it is that doth go with thee; he will not fail thee, nor forsake thee.

ABSTRACT

The purpose of this study was to determine the trainability of a right ear preference in a dichotic listening task performance of two groups of young children with different levels of articulatory proficiency.

Ten male Caucasian subjects between 5-0 to 6-7 years of age, who had normal hearing bilaterally, normal intelligence, normal peripheral speech mechanism and no physical disabilities, were classified into two articulation skill groups according to their responses on the Templin Darley 50-Item Screening Articulation Test. Five subjects were assigned to the good articulation group who scored above the cut-off score according to the norms for their age range; and five subjects, who scored at or below the cut-off score according to test norms, were placed in the poor articulation skill group.

The test stimuli consisted of CV syllables (computer generated) with each of the six stop consonants, /p, b, t, d, k, g/, and the vowel /a/. The pretest task presentation consisted of 90 diotic and 90 dichotic stimulus items. The diotic task consisted of 15 presentations of the six CV combinations in random order, from the left channel of the dichotic tape which represented a total of 90 diotic stimulus items. The dichotic pretest and posttest included presentation of the six CV combinations into 15 pairs (contrasting in voicing, place, or voicing and place). Each of these 15 competing pairs was randomly presented six times, for a total of 90 dichotic stimulus items. The training task

consisted of presentation of the 90 item dichotic presentations in which the examiner would alternately train (reward the right ear response) or test the child on each set of 15 items.

The data obtained for each subject consisted of a diotic discrimination score for the diotic listening task, and a right ear, left ear and error score, for the dichotic listening task.

Results of analysis of these data indicated no significant difference in diotic discrimination ability between the two articulation groups.

Significant differences were obtained in the dichotic pretest listening task performance between the two articulation groups. The good articulation group children displayed a significantly greater right ear preference on the pretest dichotic task than did the poor articulation group children. For the dichotic training task, all subjects demonstrated a significant improvement in the ability to correctly discriminate dichotically presented CV syllables from the pre- to posttraining task and there was no significant differences between the two groups on the posttest scores.

Finally, the response of the subjects tended to be for the voiceless, rather than the voiced, member of a dichotic stimulus pair differing in voicing only or in voicing and place of articulation.

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CHAPTER I

INTRODUCTION

Kimura (1961b) and Berlin and Lowe (1972) and others have reported that a significant percentage of patients with left temporal lobe damage, stutterers, children with severe speech articulation defects, and children with language disorders manifest either less of a right ear advantage than normal controls, a lack of ear preference, or left ear advantages. Shankweiler et al. (1967) suggests that right ear superiority for the perception of dichotically presented CV syllables, differing in only one phoneme, may be considered an indicator of the left hemisphere lateralization of several mechanisms for the perception of the phonological structure of auditory input. Johnson et al. (1977) cites literature which reports that the verbal dichotic listening test results of adults with aphasia have revealed a picture of reversal as reflected in left ear preference. He suggests that the "left ear preference reflects a 'shift in cerebral dominance for speech' and seems to be related in the occurrence to the onset of language recovery."

Johnson et al. (1977) investigated dichotic ear preference in adults with aphasia and the results indicated a significant relationship between left ear preference and language improvement. This suggests that the right hemisphere contains a mechanism capable of speech processing (auditory-to-phonetic recoding) but due to the early establishment of left hemisphere dominance, the mechanism in the right hemisphere lies dormant. The results of the Johnson et al. (1977) investigation

suggests that language recovery, as a function of training of language skills may be the result of "an adaptive transfer of function from the left hemisphere to the right hemisphere (Luria, 1970)."

McDuffie (1975) indicated that good and poor language group children, when presented with a diotic discrimination task, did not demonstrate a difference in diotic discrimination scores as a function of language skill. However, significant right ear advantages were obtained in a dichotic listening task performance for the good language group children.

Williams and McReynolds (1975) investigated the functional relationship between discrimination and production of speech sounds as a result of diotic (live voice) training. Results indicated that training in discrimination did result in improved discrimination performance but that discrimination training was not effective in changing articulation production.

From these and other reports it can be assumed that good and poor articulation children will differ in their choice of ear preference on a dichotic listening task, but it has not been established whether speech sound discrimination and/or ear preference will affect the trainability of a right ear advantage in dichotic listening tasks.

I. PURPOSE OF THE STUDY

The purpose of this study was to determine if it is possible to improve the right ear performance, as a function of training, in good and poor articulation children. To support the theoretical bases and

assumption for this study, literature reviewed will describe the use of dichotic ear effects as an index of cerebral dominance patterns, variables which influence dichotic identification scores, and the development of dichotic ear effects in children.

II. ASSUMPTIONS AND EXPERIMENTAL QUESTIONS

Kimura (1963) and Berlin (1972) found that laterality and right ear advantage effects in children, in response to verbal dichotic listening tasks, occur by the age of five years. McDuffie (1975) indicated that ear preference in children appears to be related to language skills. She found that the good language group children displayed a significant right ear advantage in response to the dichotic listening task, when compared to other normally intelligent five and six year old children with poor language skills.

On the assumption that good and poor articulating five and six year old males will be similar in their speech sound discrimination on a diotic listening task but differ in their relative right ear preference for dichotically presented speech signals, two specific experimental questions were investigated:

1. Is it possible to improve the dichotic right ear performance of five and six year old males as a function of training?

2. Will the good and the poor articulating children differ in their response to training?

CHAPTER II

REVIEW OF THE LITERATURE

The purpose of this study was to investigate, by means of a dichotic listening task, the trainability of a right ear preference of two groups of young children that are separated on the basis of articulatory performance. The review of literature which follows concerns the use of dichotic ear effects as an index of cerebral dominance patterns, variables which influence dichotic identification scores, and the development of dichotic ear effects in children.

I. USE OF THE EAR ADVANTAGE IN DICHOTIC LISTENING TASKS AS AN INDEX OF HEMISPHERIC SPECIALIZATION OF FUNCTION

Verbal Dichotic Listening Tasks—The Right Ear Effect

Kimura (1961b) used a dichotic listening procedure employing spoken digits which she presented to subjects with epileptic foci in various areas of the brain. Prior to surgical removal of the brain lesion, the subjects were tested with a dichotic task which included the presentation of digits in groups of six. Half the digits were presented to the left ear and half to the right. The subject was asked to report all the numbers he had heard (after presentation of each group of six numbers) in any order he liked. Surgical procedures involved the removal of either the left temporal lobe or the right temporal lobe, or one frontal lobe. The results indicated that regardless of the site of the lesion, the preoperative score was higher for the right ear than for the left. The

subjects demonstrated that unilateral temporal lobectomy on either the right or left side impaired the recognition of digits arriving at the ear contralateral to the removal. Overall efficiency was affected by left temporal lobectomy, but not by right temporal lobectomy, both pre- and postoperatively. The unilateral effect was independent of damage to Heschl's gyrus, the primary auditory receiving area, and did not occur after the frontal lobe removal. Kimura's (1961b) findings suggest that the left temporal lobe is particularly important in the perception of verbal material at the right ear (auditory modality). Kimura (1961a) stated that the impairment produced by temporal lobe operation occurred only under conditions of dichotic stimulation. Neither ear displayed an advantage, regardless of the signal to noise ratio, when the stimuli was presented monaurally. Berlin et al. (1972b) reported the results of dichotically presented CV syllables to right and left temporal lobectomy patients. The patients were unable to accurately perceive messages in the ear contralateral to the site of lesion ("weak ear") but were enhanced in reporting ipsilateral ear function in dichotic listening ("strong ear"). This suppression of the weak ear score was observed in patients with temporal lobe lesions even when the strong ear received a CV presentation 20 dB less intense than in the weak ear.

Berlin (1972b) discussed Rosenzweig's (1954) dichotic listening tasks which compared auditory encephalographic responses with an observer's sensations when his ears were stimulated by single or paired impulses via earphones. When only one ear was stimulated, the observer

reported without error which ear it was and the evoked cortical responses were larger at the contralateral hemisphere. When his ears were stimulated simultaneously (dichotic task), the observer lateralized the sound to the median plane and the cortical activity was usually equal at the two hemispheres (or slightly off to one side). Shankweiler (1971) stated that dichotic presentation was apparently a necessary condition for the occurrence of lateral differences in perception. If the stimuli were presented for recognition monaurally, neither ear had an advantage, however unfavorable the signal-to-noise ratio. He stated that each ear was represented by a somewhat larger population of cells in the opposite cerebral hemisphere. He concluded that the ear effects in dichotic listening depend jointly on differences in function of the two cerebral hemispheres and a system arranged to favor contralateral transmission during simultaneous stimulation of the two ears. The dichotic presentation may well result in a decided advantage to the input channel which has even slightly stronger representation in the hemisphere specialized for processing the type of material presented.

The left side of most human brains seems to be especially organized for speech and language functions (Penfield and Roberts, 1959) and the temporal parietal region is larger on the left side than the right side (Geschwind and Levitsky, 1968). These left hemisphere structural asymmetries which coexist with demonstrated functional asymmetries were confirmed when Geschwind and Levitsky (1968) examined 100 adult brains. Their findings indicated that the planum temporale (an area of auditory association cortex located behind Heschl's gyrus) was significantly larger on the left side.

Kimura (1961a) indicated that in a unilateral temporal-lobe excision, one set of connections (from each cochlea to the affected temporal cortex) is rendered relatively nonfunctional. The remaining pathways ipsilateral to the intact cortex are less efficient than those contralateral to it. Kimura's data (1961a) suggest that between pathways ipsilateral and contralateral to one cortex, the contralateral effect will exist when there is simultaneous presentation of stimuli to the two ear inputs. This finding suggested that verbal material dichotically presented would arrive along the right ear pathway to the left temporal lobe which conveyed an advantage in being more reliably transmitted to the hemisphere which was dominant for speech. She interpreted these facts to mean that the crossed auditory pathways in man were stronger or more numerous than the uncrossed auditory pathways and that the left hemisphere was more important than the right hemisphere in the perception of spoken material.

A subsequent study by Kimura (1961b) investigated the possibility that in subjects with speech represented in the right hemisphere, recognition of verbal material arriving at the left ear should be more efficient. Kimura (1961b) ascertained hemispheric dominance for speech by unilaterally injecting sodium amytal into the internal carotid artery. A dichotic listening task utilizing spoken digits was presented to 13 subjects with right hemisphere representation of speech and 107 subjects with left hemisphere representation of speech. She found that regardless of handedness when speech was represented in the left hemisphere, the right ear was more efficient, and when speech was represented in the

right hemisphere, the left ear was more efficient. This is consistent with results of her early study in which the crossed auditory pathway was found to be the more efficient one, and that the dominant temporal lobe was found to be more important than the nondominant lobe in the perception of speech sounds.

Milner, Taylor, and Sperry (1968) presented a dichotic digits test to patients with presumed complete midline sections of the cerebral commissures and corpus callosum. Milner, Taylor, and Sperry (1968) found that these patients gave primarily right ear responses to dichotic speech stimuli and almost completely suppressed digits dichotically presented to the left ear. In contrast to the suppression of the input from the left ear under dichotic stimulation, under monaural conditions the callosal patients correctly reported 87 percent of the numbers channeled to the left ear. Berlin et al. (1973a) stated that this suggested a one-way pathway for routing speech information from the right hemisphere to the left hemisphere through the corpus callosum. There must be some subcortical suppression of ipsilateral paths by the stronger contralateral paths since after corpus callosum section, the two temporal lobes can no longer interact directly.

Nonverbal Dichotic Listening Tasks—The Left Ear Effect

Various other research projects have employed dichotic presentation of certain nonverbal stimuli and revealed a "left ear effect" indicating right hemisphere specialization for nonverbal perceptual functions. It has also been demonstrated that certain complex auditory discrimination tasks are affected by right temporal lobectomy, but not by left. On the

Seashore Measures of Musical Talent, Milner (1962) has shown that tonal pattern perception and timbre discrimination are selectively impaired by right temporal lobectomy. Berlin et al. (1965) confirmed the results of Milner (1962) with the Seashore test. They also found that patients with right temporal lobe lesions did more poorly on tonal memory than patients with left temporal lobe lesions. A dichotic melodies test, devised by Kimura (1964), was utilized for a listening task of recognition. Pairs of different melody fragments were presented to the ears simultaneously. Each trial test consisted of a dichotically presented pair, in which a set of four melodies was presented to each subject. The subject was asked to indicate which two melodies had been presented dichotically. Kimura (1964) indicated that a significantly greater number of correct choices were made for melodies presented dichotically to the left ear. Curry (1967), cited by Shankweiler (1971), reported that dichotically presented common environmental noises are more easily recognized by the left ear. As a result of this study, Shankweiler (1966) and Kimura (1967) postulate that the verbal or nonverbal nature of the task seemed to be the deciding factor which determined the right or left ear effect in a dichotic task. It would seem to indicate that the "minor" or right hemisphere, which provides a left ear effect, plays a greater role in processing nonspeech sounds; and the "major" or left hemisphere, which provides a right ear effect, provides for the processing of speech sounds.

Effects of Ear Order of Report in Verbal Dichotic Listening Tasks

Broadbent (1958) originally suggested that the ability, successively, to reproduce a series of digits when they have been presented as two simultaneous half-spans to each ear, depended in part upon some short-term storage mechanism. Broadbent (1957) demonstrated that subjects were more accurate in identifying material from the first channel reported, and that right ear superiority listening tasks may result from this preference for reporting material from the right ear first. Due to the short term storage, the subject may first report material presented to the right ear and forget material presented to the left ear before they had a chance to report it. Inglis (1965) reported that short term storage of the material presented to the right ear to be recalled first in sequence would create an "order-effect" which might be misinterpreted as a laterality effect. He also suggested that reported ear asymmetries were the result of memory effects rather than indicators of the differential perceptual functioning of the two cerebral hemispheres.

Bryden's (1967) experiment attempted to eliminate this order effect by controlling the order of the report in dichotic listening tasks such that each ear was reported equally often. Dichotic lists of three different lengths (3, 4, and 5 pairs of numbers) were presented at three different rates. The material presented to the right ear was more accurately identified than the material presented to the left. The right ear effect remained although it was reduced in magnitude. These data revealed that right-ear superiority, when order of report was controlled,

was due to a true difference of the auditory system which favors perception of verbal material presented to the right ear. Gerber and Goldman (1970) investigated ear preference for dichotically presented verbal stimuli as a function of three different report strategies. This data revealed that there was a significant right-ear preference for dichotically presented verbal stimuli regardless of the report strategy employed: free recall, in which the subject reported stimuli in order; ordered before stimuli presentation, in which the subject was instructed which ear to report first; ordered after, in which the subject was instructed which ear to report after stimuli presentation. They concluded that subjects cannot determine in which ear they hear the stimuli. When they were told which ear to report first, the accuracy on the second ear increased; however, right-ear accuracy was greater than left ear accuracy. These studies are indicative of the right ear laterality effect in speech perception and cannot be attributed to a memory effect.

II. PHONETIC EFFECTS IN VERBAL DICHOTIC LISTENING TASKS

Ear Effects for Consonants and Vowels

Lowe et al. (1970) dichotically presented rhyming monosyllabic words starting with the six stop consonants that varied as a function of different syllabic lengths and phonetic contents. This introduced a mixture of phonetic and linguistic effects which can be obtained through dichotic listening tasks. The authors indicated that a dichotic task was more difficult than a diotic task. When the syllables that differ

in only one phoneme were employed, the resultant laterality effect, obtained through a dichotic listening task, was greater. Gerber and Goldman (1970) as well as Lowe et al. (1970) showed that, in the simultaneous dichotic mode, the voiceless consonant was more intelligible than the voiced. The effect was seen primarily in voiced-voiceless pairs and was independent of the right-ear advantage. Berlin et al. (1973a) stated that if a voiced consonant were to come later in a sequence than the voiceless consonant, it would become about as intelligible as the voiceless consonant.

The purpose of Shankweiler's et al. (1967) study was to determine whether all processes involved in language perception were lateralized in the left hemisphere (explaining right ear superiority) or if the lateralization was restricted to the perception of the meaning in language. Shankweiler (1971) stated that the motor activity of speech consisted largely of movements which overlap one another in time. Because of the temporal overlap, a complex relationship exists between perceptual units (phonemes and their features) and acoustic characteristics. As a result, speech becomes encoded or restructured in time in the process of transmission from speaker to the listener. It was also indicated that the perceptual apparatus responsible for the perception of phonemes functions as a speech decoder and is lateralized in the left hemisphere. The decoder is able to separate and determine overlapping relationships of phonemes within a given acoustic signal. In the same study, Shankweiler (1967) also investigated the characteristics of the laterality effect. Since the laterality effect

presumably depends on some optimal level of competition, dichotic listening tasks were utilized to provide the acoustic signal. Shankweiler (1967) suggested that overlapping articulatory movements occurring in speech cause distinctive features in each phoneme to be emitted in parallel fashion rather than sequential fashion. It appears that phoneme perception may be lateralized in the left hemisphere and that the hemisphere must function as a "decoder." Shankweiler's (1967) experiment employed presentation of synthetic speech because of its uniform specifiable structure. The CV stimulus pairs were made up of all combinations of the six stop consonants (/p, b, d, t, k, g/), and the vowel /a/. The syllables differed in the initial consonant only, so that the linguistic effects could be eliminated and the possible lateralization of phoneme perception could be revealed. To eliminate memory effects, experimental trials consisted of single pairs of syllables. Subjects were instructed that different syllable presentation would always be to both ears and their task was to write down both syllables, in order of the syllables they thought they perceived initially. The subjects were given a set of syllables from which they were to make their choices. The authors reported that 14 out of 15 subjects reportedly received better right ear scores (in identification of syllables presented) with a mean right ear advantage of 16 percent. Shankweiler (1971) stated that when stimuli consisted of nonsense syllables that contrasted in only one phoneme:

> the specific language processing system of the dominant hemisphere is engaged at the level of the sound structure of language, that speech perception in the narrow sense depends

> on the specialized machinery of the left hemisphere. Moreover, since the effect occurred with presentation of single pairs of syllables, that the effect has a genuinely perceptual basis, and is not due to memory (p. 192).

Studdert-Kennedy and Shankweiler (1971) tested the same subjects with a dichotic listening task containing contrasting vowels alone. The vowels were prolonged, monotone, or steady-state vowels which in speech are formed with the vocal tract in a fixed, open-tube configuration. The data indicated that a much smaller right ear advantage was displayed for vowels, in contrast to the decisive right ear advantage for stop consonants. They suggested that vowel stimuli are processed equally well by either hemisphere of the brain and that these vowels would not engage the processor specialized for speech perception. The authors indicated that the difference may have been larger if the vowels had not been monotone and presented in isolation and if they had been presented in syllabic context.

In order to clarify the identification of consonants and vowels in syllables, real speech syllabic context was utilized. It has been previously noted that the ear effect for consonants was reliable from subject to subject but vowels were unreliable. The stop consonants yielded a significant right ear effect ($p < .001$); while only one vowel demonstrated a right ear effect with $p < .01$. Although the vowels were paired in CVC combinations contrasting in only the vowel portion, they were identified equally well by either ear (and either hemisphere).

Shankweiler (1971, p. 197) stated that "the perception of stop consonants is highly dependent upon the dominant hemisphere function whereas vowels may or may not be processed in the dominant hemisphere."

He also postulated that vowels were neither processed like music nor other nonspeech auditory patterns nor like consonant speech sounds. Shankweiler (1971) also stated that the right ear advantage occurred mainly for speech cues of brief duration, such as the bursts and rapidly changing formant frequencies that characterize stop consonants but not vowels. He suggested that CV differences may be attributed to the speech processing mechanism that attunes to those phonetic properties of speech that are a consequence of encoding (the degree to which phonemes are restructured in time in the process of articulation). The dichotic right ear advantage observed for "nonsense" CV syllables may be a result of the competition between two stop consonants which involves a singly phonetic decoding mechanism in the hemisphere that is dominant for speech. A right ear advantage for vowels or nonspeech signals would be small or reduced.

Ear Effects in Response to Competition Other Than Speech

The phonetic decoding processes which may be revealed by dichotic listening tasks can be interpreted in several ways. Berlin et al. (1973a) demonstrated that dichotic presentation of a CV to the left ear and presentation of any other acoustic event to the right ear does not provide a sufficient competing task for observation of the suppression of intelligibility scores in the left ear. They indicated that when noise was dichotically presented to the right ear the left ear is not suppressed in the perception of CV syllables (Shankweiler, 1971), since noise would not compete with the processing of speech stimuli by the

left hemisphere speech processor. A study conducted by Berlin et al. (1972b) attempted to explain the relationship that existed between right and left ear effects in response to nonspeech competition. The authors presented six stop consonants paired with /a/ to the left (weak) ears of normal subjects, temporal lobectomized, and hemispherectomized patients while simultaneously presenting a different syllable (CV stimuli) or synthetically produced bleats (Berlin, 1973a) to the right ear of each subject. The acoustically isolated second and third formants of synthetic CV's were designated as the bleats. Berlin et al. (1973a) indicated that the suppression of left ear scores (CV identification) obtained through dichotic presentation (of vowels and bleats) to the right ear was almost as large as the left ear suppression caused by CV presentation to the left ear.

The above findings reveal that the suppressive effects observed for dichotically presented vowels and bleats are contradictory to the "lack of effect," as shown by Shankweiler's consonant processing mechanism, which would have been predicted for these signals. The data collected and analyzed by Berlin (1973a) suggested that vowels and bleats dichotically presented produce suppressor effects because they appear to the nervous system as if they might be speech signals rather than actually competing for the hypothetical left-hemisphere "speech processor." Right ear detection of presented acoustic patterns may sufficiently disrupt the specialized processing of CV stimuli presented to the left ear. It was noted that the disruptive effects of competitive input could occur before or during phonetic processing itself. Due to

suppression of left ear identification scores by the right ear during dichotically presented (bleats) tasks, the authors suggested that "intelligibility of dichotic signals, such as speech, is not always necessary to generate weak ear suppression."

In attempting to determine whether dichotically presented nonspeech sounds produced by the human vocal musculature would be processed as speech sounds (left hemisphere yielding a right-ear superiority) or as nonspeech sounds (yielding no difference to the left ear-right hemisphere), King and Kimura (1972) employed two listening tasks. One task dichotically presented to normal right handed subjects, employed hummed melodic patterns, while the other task employed human emotional sounds (laughing, crying, sneezing, moaning, coughing, and sighing). Results indicated that on both dichotic tasks the perception of vocal nonverbal speech sounds showed a stronger left-ear than right-ear effect which confirms the fact that recognition of hummed melodies occur and depend more on the right hemisphere than on the left. This is significant in that the same phonatory and articulatory musculature is involved in producing these sounds as in the production of actual vocal speech. The presence of voice quality in itself would not be expected to induce a right-ear superiority or engage the specialized speech processor of the left hemisphere since steady-state vowels yield no significant ear differences (Shankweiler and Studdert-Kennedy, 1967). The authors stated that the vocal nonverbal stimuli contained the same rapid acoustic changes that have been evidenced in consonant phonemes. King and Kimura (1972, p. 115) stated that "the articulatory patterns for the

production of consonants and the production of vowels have been found to be different (Perkell, 1969), and presumably this is true for consonant and nonverbal vocal sounds as well." Abbs and Smith (1970) stated that vowels are equally monitored by both the right and left ears when elongation under delay conditions occur. But that consonants, which account for most of the articulatory errors in production, are monitored primarily by the right ear. This differential functioning of the two hemispheres appears to be important in the perception and eventual feedback control of speech production. It would also appear that if this feedback system is not functional, then actual production could be impaired.

Effect of Articulatory Features in Dichotic Identification

Liberman, Shankweiler, and Studdert-Kennedy (1967) analyzed articulation and the unique properties of speech sounds. They stated (p. 189) that:

> The motor activity of speech consists largely of gestures which overlap one another in time. As a consequence of this temporal overlap, the relationship between the acoustic characteristics of speech and the perceptual unit is highly complex (phonemes and their features). Speech becomes encoded or restructured in time in the process of transmission from the speaker to the hearer.

It is apparent that special requirements are placed on the perceptual apparatus due to the encoded nature of the speaker's message. Shankweiler and Studdert-Kennedy (1967) dichotically presented single stop consonant vowel syllables to determine whether lateral differences could be obtained with single stimuli pairs. Stop consonants were

divided into features of voicing (present, absent) and place of articulation (labial, alveolar, velar). All subjects presented a right ear advantage in the consonant test. Their findings indicated that perception in verbal dichotic listening tasks involved the processes of the left hemisphere (as previously stated). Right ear performance was found to be the same for all three feature contrast conditions, but the left ear performance varied in the percent correct. The right ear advantage, in contrast to the lower percent correct for the left ear, was greatest for the double contrast of voicing and place (17 percent), next greatest for the voicing contrast (12 percent), and least for the place contrast (6 percent). The overall effect for the right ear advantage of CV syllables differing in voicing and place of articulation was significant. The authors suggested that because of the greater error rate for dichotically presented CV syllables to the left ear and the fact that an analysis of feature process may be involved, it is logical to assume that speech signals of this kind are more readily processed in the left hemisphere when the identification task is difficult. When only one feature is common to both stimuli of a pair, the task involves correct assignment of the remaining feature. With the implementation of the dichotic task, in which a pair has no features in common, the assignment of each stimulus pair was increasingly difficult. In explaining this aspect, Gerber et al. (1970) indicated that consonant pairs differing in either voicing or place were most frequently identified.

In attempting to explain feature values, Studdert-Kennedy and Shankweiler (1970) conducted an experiment to determine consonant features of voicing and place. They demonstrated that when a feature value is common to both ears, in which the dichotic pairs contrasted in one phoneme, error scores are less likely and responses are more likely to be correct. A larger proportion of error was observed when the pair has no feature values in common.

Their experiment employed CVC syllables as stimuli and each stop consonant (/b, d, g, p, t, k/) was paired with each of the six vowels. This dichotic listening task was utilized in order to determine whether or not dichotic discrimination performance depended on the sharing of consonant features (voicing and place). The authors indicated that the feature most adversely affected was place (when voicing was shared) and that this contrast in place depressed performance. It was observed that performance varied with feature contrasts and also when the features were separately processed, voicing values were more accurately identified than place. Since feature performance appeared to vary according to which feature was shared (with voicing values more accurately identified), the experimental data indicated that the voicing and feature values were individually lateralized and separately processed during perception of dichotically presented stimuli.

Previous findings by Shankweiler (1967) suggested that the right ear has about a 2 percent advantage over the left ear and neither feature (voicing nor place) is lateralized to a greater extent than the other. From analysis of these data, Shankweiler and Studdert-Kennedy

postulated that although the auditory system is able to analyze the auditory parameters of a speech signal in the right and left hemisphere, the dominant or left hemisphere is specialized for the extraction of linguistic features from those auditory parameters. Furthermore, the perceptual process would appear to be linguistic in nature rather than primarily acoustic. It would follow that these complex auditory parameters would be separated and sorted into phonological features. Vocal stimuli would appear to contain the necessary phonological information and would be processed by the dominant (left) hemisphere, while the nonverbal vocal stimuli (King and Kimura, 1972) may not contain the necessary information for processing. Studdert-Kennedy and Shankweiler (1970) concluded that the resulting laterality effect of the dominant hemisphere's ability to extract the auditory information (the parameters of speech signals) could be due to the interhemispheric transfer of the ipsilateral signal to the dominant hemisphere for linguistic processing.

Effects of Stimulus Onset Time Alignment in Dichotic Identification

Dichotic simultaneous and time-staggered speech studies were conducted by Berlin et al. (1972b). The results of these studies revealed several pertinent aspects to consider. Berlin et al. (1972b) utilized competing pairs of nonsense CV syllables, one to each ear, in which the initial consonant was one of the six stop consonants. With simultaneous onset, normal subjects showed right ear superiority; with time separation of 30 to 90 msec, the subjects showed a "lag effect"

(better scores for the trailing stimulus). The right ear scores for both lag and lead signals were consistently higher than were left ear scores for comparable conditions. When a so-called lagging advantage was given to the subjects, the lag advantage was not used by the speech processor. When normals listen to simultaneous dichotic speech, their left ears do not perform badly, only somewhat more poorly than right ears. Information from both ears is often correctly identified.

Berlin et al. (1972) indicated that left ear lag scores become equal to right ear lead scores at 10 msec of separation, and higher than right ear lead scores at 60 and 90 msec of separation. Thus, right ear asymmetry disappeared when left ear messages lagged by 30 msec. These findings agree with that of Studdert-Kennedy and Shankweiler (1970), who reported that the right ear does more poorly than the left ear when the left ear receives speech 20 msec or more later than the right ear. Berlin et al. (1972) stated that in monotic time-staggered tests the two ear functions were virtually symmetrical for leading and lagging syllables. They observed that, when onsets of the dichotic stimulus pairs were simultaneous, the unvoiced (voiceless) consonants were more intelligible than the voiced, regardless of which ear received the voiceless consonant. In the time-staggered tests, when voiced consonants were employed as the lagging stimuli, enhancement of the lag ear at 30 to 90 msec was equal for both ears. When the consonants are simultaneous monotic presentations, the unvoiced CV's occurred later in time than does the voiced onset CV (voiced CV's were more often correctly identified).

A single left-hemisphere speech processor being entered from two partially interactive channels may explain the dichotic lag effect (Berlin et al., 1973a). The authors stated this hypothetical processor would require a finite time (30-60 msec) to handle a CV accurately, "provided it was not interrupted by different information arriving from the other channel." Berlin et al. (1973a) cited Huggings (1972) which stated that intelligibility of syllables drops markedly when interruptions occur in the 50-70 msec range with no succeeding information available. Huggins' (1972) observation supported Berlin et al. (1973a) in his suggestion that the lag effect may be related to an interruption of the analysis of one syllable by the intrusion of the second syllable. They also noted that when CV's were delayed by more than 90 msec, syllable identification improved, indicating that the signals were now being analyzed sequentially due perhaps to the amount of time available.

Berlin et al's. (1973a) subject data revealed that dichotically presented voiceless consonants were more intelligible than the voiced consonants because the speech processor might view a voiceless CV as "lagging" because of its long burst duration (as opposed to the voiced CV). When voiced consonants were delayed in time and trailed the voiceless CV, the former became equally as intelligible as the voiceless in CV identification scores. They also stated that the periodicity cues may "switch" to analyze a new incoming signal, thus enhancing intelligibility from the lagging ear when presented with dichotic presentation of conditions.

Intensity Effects in Dichotic Identification

A study conducted by Thompson et al. (1972) was designed to investigate interaural intensity differences in dichotically presented CV syllables. The intensity levels of the dichotic stimuli varied from 30 to 80 dB SPL. Asymmetry was in favor of the right ear advantage at all intensity levels. Thompson et al. (1972) conducted a subsequent study to observe dichotic signal presentation when the signals were presented at unequal intensities. The signal remained a constant 50 dB SPL at the reference ear and the variable ear heard the signal from 30 to 80 dB SPL in progressive 5 dB steps. Right ear asymmetry was evidenced for most of the intensities except for the extreme presentations. Thompson et al. (1972) concluded that in order to achieve adequate intensity control, the intensity level must be within plus or minus 10 dB (at intensity levels between 50 and 80 dB SPL) to reveal an ear effect.

III. DICHOTIC LISTENING TASK PERFORMANCE IN CHILDREN

The previous review of literature indicates that performance on verbal dichotic listening tasks is related to speech lateralization to the left dominant hemisphere. It is apparent then that the application of this technique to children should provide information relative to cerebral dominance as well as possible speech lateralization.

In a study utilizing spoken digits that were dichotically presented to children, aged four to nine years, Kimura (1963) investigated initial appearance of right ear superiority. Her efforts attempted to determine

at which age speech was represented and lateralized in the left hemisphere. Both boys and girls more efficiently recognized digits presented to the right ear than digits presented to the left ear. This study demonstrated the right ear effect (left cerebral dominance) for speech is established in boys and girls by four years of age. A study by Kimura (1961a) strongly indicated that aphasic recovery, after left-sided damage, may mean that speech representation is less rigidly established in children than in adults. Although there appears to be an early preponderance of the left hemisphere dominance in children, participation of the right hemisphere in speech perception cannot be ruled out. In the right ear effect, no significant sex difference was noted in the age range tested. However, at the age of four, boys demonstrated significantly greater perception for the right than for the left ear but this effect was not significant at earlier ages, for boys or girls. There was a difference between boys and girls in overall efficiency of the task, which was evident at age four, and was statistically significant at ages five and six. Kimura (1963) suggested that boys lag behind girls in the perception of speech sound stimuli as well as in production, and that this developmental lag difference disappears in normal children at seven years of age. Kimura also stated:

> Although there is no evidence at present that normal right handed boys develop speech lateralization differently from girls, there may be such a sex difference in children who show other signs of irregular cerebral organization (1963, p. 902).

Berlin et al. (1973) also demonstrated that children exhibited a right ear advantage for verbal dichotic stimuli by the age of 5. This

right ear advantage appeared to be independent of sex and independent of the total number of dichotically presented CV syllables that children can identify correctly. The ability of the speech processor to correctly identify two simultaneous stimuli increases with age, and phonetic errors made by 9-, 11-, and 13-year olds are similar to adults. At 5- and 7-years of age, this adult pattern has not yet emerged.

It was observed that the development of speech lateralization in dichotically presented tasks to left and right handed second, fourth, and sixth grade children (Bryden, 1970) demonstrated that the frequency of right ear advantage increases with the grade level in right handed children but decreases in left handed children. Bryden (1970) observed that this difference was significant by grade six for both left and right handed boys and girls. By grade four, girls displayed an emergence of adult dominance patterns while boys' cerebral dominance emerged at the sixth grade. It is indeed noted, that a discrepancy exists between Kimura's (1963) results and Bryden's (1970) results. Kimura (1963) noted that the significant right ear advantage could be displayed as early as age four, in both boys and girls. This observation may be indicative of the differences in presentation of results. It was observed that Kimura (1963) presented left ear and right ear scores in terms of the mean number of correctly identified digits. Dependent on which ear scored better in the dichotic listening task, Bryden (1970) classified his subjects as either left ear or right ear dominant.

Bryden (1970) cited literature that related reading dysfunction to incomplete or abnormal speech lateralization. He attempted to assess

the relationship between reading ability and dichotic listening performance. Bryden (1970) stated that children who manifest reading disorders are less likely to exhibit a right ear superiority in dichotic listening than are normal readers. Therefore, Bryden (1970) attempted to assess the relationship between dichotic listening performance and reading ability in children. Poor-reading boys displayed a crossed dominant pattern (dominant hand opposite to the dominant ear) while good-reading boys exhibited an uncrossed dominant pattern. Girls did not exhibit such an effect except at grade two level, and the effect reversed at grade six. Overall, about 70 percent of the relatively good readers showed uncrossed dominance at all grade levels. In contrast, 40 percent of the poor readers displayed uncrossed dominance, but the percentage increased sharply from grade two to grade six.

At the time when speech lateralization is incomplete, the poor-reading boys (with crossed dominance) displayed noticeable difficulty with the acquisition of age-appropriate reading skills; therefore, laterality effects appear to be more closely related to reading ability in boys than in girls. This association between reading ability and lateral dominance on a dichotic listening task is significant at least in the early grades. Perhaps then, it may be that if an ear dominance could be trained and laterality established, the subsequent reading and language skills should eventually emerge.

In a study by Knox and Kimura (1970) the authors employed verbal and nonverbal dichotic listening tasks to determine the development of perceptual asymmetry skills in children. The subjects were boys and girls

between the ages of five and eight years. Verbal tasks included identification of stimuli such as digits and words, while nonverbal stimuli included recognition of environmental and animal sounds. Subjects were presented verbal tasks with a nonverbal method of report (such as pointing to a picture or placement of an object on a picture). This method of reporting was utilized to determine whether or not the nonverbal method significantly affected ear function. In addition to this nonverbal method of reporting, the conventional verbal method was employed. Since the tasks involved hand usage, and most subjects used their right hand, the effect of using the right or left hand was examined. Data results reported by Knox and Kimura (1970) indicated that nonverbal dichotically presented environmental or animal sounds were more often correctly identified from the left ear than the right ear. Also dichotic presentation of digits or words resulted in a significant right ear advantage. It was demonstrated that this right ear advantage for verbal stimuli was not altered by the nonverbal method of report. Knox and Kimura (1970) stated that on dichotically presented nonverbal tasks, boys correctly identified significantly more nonverbal sounds than did girls. Knox and Kimura (1970) proposed that perception of verbal and nonverbal sounds may be lateralized to the left and right hemispheres by age five, but the young child's brain is still capable of radical reorganization if damaged. The authors indicated that differences in right ear-left ear scores resulted from asymmetries in the reception of the stimuli (input) rather than from the expression of what was perceived (output). Thus, it appears that verbal stimuli

dichotically presented would be perceived and represented in the left hemisphere and this perception would result in a right ear advantage.

Relationship between Language and Ear Dominance in Dichotic Tasks

Previous studies (Broadbent, 1954; Kimura, 1961a; 1963; 1967; Shankweiler and Studdert-Kennedy, 1967; and Studdert-Kennedy and Shankweiler, 1970) have demonstrated that the majority of normal adults evidence a right-ear advantage when dichotically presented with auditory-verbal material. Similarly, adults with aphasia demonstrated reversed laterality (left-ear preference) when presented with verbal dichotic listening tasks. It has been suggested that a relationship may exist between the onset of language recovery and the "shift in cerebral dominance for speech" as reflected by a left-ear advantage.

In an attempt to explain the relationship between language recovery and ear performance, Johnson et al. (1977) conducted an experiment to investigate ear preference, as a result of dichotically presented CVC stimuli word pairs, in aphasic and normal adults. The authors examined the variables of initial severity of aphasia, time post-onset, and language recovery relative to the direction and magnitude of ear preference. Results indicated that the normal control group demonstrated a right ear preference for dichotic CVC stimuli. Johnson cited the work of Kimura (1961a), Berlin and Lowe (1972, p. 287) stating that:

> Patients whose language dominance is in the left hemisphere, according to intracarotid amytal testing, do better with their right ears in the dichotic listening task; conversely,

in patients known to have right hemispheric dominance for language function, a left ear superiority is observed.

Conversely, the aphasic subjects demonstrated a significant left ear preference which reflected a superiority of the right hemisphere, over the damaged left hemisphere, in auditory-verbal recognition. Johnson (1977) suggested that the right hemisphere has the ability to process speech (auditory-to-phonetic recoding) and, as evidenced in various other studies, left hemispheric dominance is established in children by the age of five (Berlin, 1973), and the mechanism in the right hemisphere is abandoned and lies dormant. Although this preference is somewhat lateralized to the right hemisphere by age five, the young child's brain seems capable of radical reorganization if damaged. Knox and Kimura (1970) indicated that children who sustain left hemisphere damage will quickly recover the use of language functions, in contrast to adults who sustain similar injury. This reorganization of language functions may occur within the undamaged parts of the left hemisphere or "speech representation may transfer to the right hemisphere." Johnson (1977) also suggested that the right hemisphere may assume the receptive processing functions and cause an "adaptive transfer of function" from the left to the right hemisphere. The results of Johnson's study (1977) indicated that moderate language improvement may accompany increases in the magnitude of left ear preference. This observed relationship may be the result of spontaneous recovery, lessening of edema, establishment of colateral circulation, or apparent shift in cerebral dominance for speech. However, no significant correlation

appeared between the time spent in therapy and the slight increase in observed magnitudes of left ear preference six months post onset.

Johnson (1977, p. 287) cited other studies and reported:

> that a significant percentage of aphasic patients with left-temporal lobe damage, stutterers, children with severe articulation defects, and children with language disorders manifest either less of a right ear advantage than normal controls, a lack of ear preference, or left-ear advantage.

Similarly, McDuffie (1975) presented a verbal dichotic CV listening task to ten male children, aged 5 to 6 years, in an effort to determine the relationship between the dichotic listening task performance and the level of language development. She found that no language differences existed in diotic discrimination ability among the good, middle, and poor language groups. However, the dichotic listening task performance of the three language groups revealed significant differences. It was observed that three of the four children in the good language group demonstrated a statistically significant right ear preference. A statistically significant right ear difference was found for two of the four subjects in the poor language group, but they demonstrated a significantly smaller right ear advantage than the good language group. The middle language group did not demonstrate consistent ear preference patterns. McDuffie (1975) stated that overall task efficiency in responding to the dichotic stimuli was greater for the good language group (mean error score being 17.8 percent), than for the poor language group (mean error score being 40 percent). Thus, it appears that the response differences between the good and poor language children, when presented with dichotic stimuli, may be attributed to differential

ability to handle competitive auditory output. It appears that as a child continues to develop cerebral dominance for language, an ear preference is developed, or there is an increase in the facility to perceive stimuli contralateral to the newly dominant hemisphere under conditions of competitive input. As this increased capacity to correctly perceive preferred ear input is developed or possibly trained, the child's language perception should improve.

Relationship between Training and Ear Dominance in Dichotic Tasks

Only one study has reported data on the effect of training on the perception of dichotically presented CV stimuli. Porter et al. (1976) employed verbal dichotic listening tasks over an eight-week period to determine the long-term effects of training on performance in a dichotic task. The subjects were eight students (four females) at the high school and college level. Porter et al. (1976) used a forced-response mode whereby the subjects generated written responses for the identification of both stimuli on each trial. The results reported by Porter et al. (1976) indicated that there was a significant increase in the number of dichotic CV syllables correctly reported during the first three sessions of their study. The investigators interpreted the improvement as an increase in the efficiency of a single lateralized speech processor in handling competitive inputs and suggested that approximately 300 dichotic trials of CV stimulus pairs were required before stable measures could be obtained. Also, the right ear outperformed the left while both ears got better with practice. Porter et al. (1976) also

suggested that the right ear advantage tended to be invariant with practice and that the organization of the neural pathways does not presumably change with practice.

The only data pertaining to the training of a dichotic discrimination ability are those reported by Porter et al. (1976). These data only deal with the performance of adults on a dichotic training task and do not reflect the performance of children. Therefore, the purpose of this study was to determine the trainability of a right ear preference in a dichotic listening task performance of two groups of children with different levels of articulatory proficiency.

IV. SUMMARY

A summary of the relevant literature concerning the use of the dichotic listening task revealed the following generalizations:

1. Cerebral dominance for speech and language functions is located in the left hemisphere for most individuals (Penfield and Roberts, 1959). Consequently, the contralateral ear (opposite the dominant hemisphere for speech) is more efficient in a dichotic listening task (Kimura, 1961b).

2. In response to dichotically presented nonsense pairs, a right ear advantage (left hemisphere dominance) is effected for the perception of the phonological structure of auditory input by the age of five (Kimura, 1963; Bryden, 1970).

3. Adult dominance patterns for language seem to emerge earlier in girls than boys (Kimura, 1963; Bryden, 1970).

4. Studdert-Kennedy and Shankweiler (1967) indicated that dichotic listening task performance varies significantly with the distinctive feature contrasts between syllable pairs. The right ear had an advantage of 12 percent over the left ear for all CV pairs. The discrimination of voicing, when the feature of place was shared, resulted in a higher percentage of correct responses for both the left and right ears than did the discrimination of place when voicing was the shared feature. The overall effect was least for the right ear advantage of CV syllables differing in voicing and place of articulation (Studdert-Kennedy and Shankweiler, 1970).

5. Laterality effects are observed when two dichotic stimuli are staggered in time, such that the onset time of the first leads that of the second by 30 to 90 msec, and the lagging stimulus becomes more intelligible. Right ear asymmetry disappeared when left ear messages lagged by 30 msec. Also, Studdert-Kennedy and Shankweiler (1970) observed that the right ear does more poorly than the left ear when the right ear receives speech 20 msec or more later than the right ear.

6. The Berlin et al. (1973a) subject data revealed that dichotically presented voiceless consonants are more intelligible than the voiced consonants, regardless of which ear receives the voiceless consonant when the onset times are simultaneous.

7. Significant right ear advantages are obtained when CV syllables are dichotically presented at equal intensities, plus or minus 10 dB, from 50 to 80 dB SPL (Thompson et al., 1972).

8. Johnson (1977) states that a significant percentage of aphasic patients with left-temporal lobe damage, children with severe articulation defects, and children with language disorders manifest either less of a right-ear advantage than normal controls, a lack of ear preference, or left-ear advantage.

9. McDuffie (1975) stated that overall task efficiency in responding to the dichotic stimuli was greater for the good language group than for the poor language group.

10. Williams and McReynolds' (1975) subject data revealed that training in diotic (live voice) discrimination did result in improved discrimination performance but that discrimination training was not effective in changing articulation production.

11. For a dichotic training task with adults, data reported by Porter et al. (1976) indicated that a significant increase in the number of correctly identified dichotic CV syllables was observed. Approximately 300 dichotic trials of CV stimulus pairs were required before stable measures were obtained.

CHAPTER III

PROCEDURES

The purpose of this study was to determine the trainability of a right ear preference in a dichotic listening task performance of two groups of young children with different levels of articulatory proficiency. This chapter contains a discussion of the experimental task, the criterion for subject inclusion, and the procedure and equipment which were used.

I. CONSTRUCTIONS OF THE EXPERIMENTAL TASK

A six-choice picture selection task, utilizing 90 diotic and 90 dichotic item presentations, was constructed for administration to the subjects in this study. The following procedure was duplicated from McDuffie (1975).

Stimuli

Stimuli employed for the experimental task consisted of six CV combinations that were composed of one of six stop consonants, /p, b, t, d, k, g/, and the vowel /a/.

The dichotic task included the grouping of the six CV combinations into 15 minimal pairs, each contrasting in voicing and/or place of articulation. The stimulus pairs, grouped according to their distinctive feature contrasts, were as follows:

Voicing		Place		Voicing and Place	
(a)	(b)	(a)	(b)	(a)	(b)
pa	ba	pa	ta	pa	da
ta	da	pa	ka	pa	ga
ka	ga	ta	ka	ba	ta
		ba	da	ba	ka
		ba	ga	ta	ga
		da	ga	da	ka

Each stimulus pair was dichotically presented three times with each pair member (a) channeled to the right ear and pair member (b) channeled to the left ear, and three times with pair member (a) channeled to the left ear and pair member (b) to the right ear. This represented a total of six presentations of each of the 15 dichotic stimulus items totaling 90 CV syllables, which were presented in random order.

The diotic task consisted of 15 presentations of the six CV combinations from the left channel of the dichotic tape. These combinations were diotically presented in random order and represented a total of 90 diotic stimulus items. Thus, the pretest task consisted of the randomized presentation of the 90 diotic items followed by the randomized presentation of the 90 dichotic items for a total of 180 stimulus items.

Experimental Tape

One stimulus tape, on which recorded computer-generated synthetic speech stimulus pairs (described above), was obtained from the Kresge

Hearing Research Laboratory, Louisiana State University Medical Center. The tape was composed of 90 dichotic stimuli with each pair having simultaneous onset. The stimuli were randomly recorded in groups of thirty pairs with an interstimulus interval of seven seconds. The duration of the tape was approximately 12 minutes. For the diotic task, stimulus items from the left channel of the dichotic tape were utilized by channeling track one of the tape simultaneously into both ears of the subject being tested. A list of both the diotic and dichotic stimuli, in the order of presentation, is contained in Appendix A.

Validation checks of stimulus onset synchronization for the dichotic tape were conducted using a Teac TC A40 Playback Recorder and a Tektronix Type 5103N Dual Trace Cathode Ray Oscilloscope, with storage capability. Initial, medial, and final checks of stimulus onsets were determined to be aligned within 20 msec.

A graphic display of intensity levels, between and within stimulus pairs for the dichotic tape and stimulus items for the diotic tape, was obtained through the use of a Teac TC A40 Tape Recorder, Bruel and Kjaer Type 2307 Level Recorder with a 50 dB potentiometer, and Bruel and Kjaer Type 2603 Microphone Amplifier. Stimulus intensity levels between and within the channels were found to be within 2 dB. The signal-to-noise ratio was determined to be in excess of 24 dB for the stimulus tape.

Response Paradigm

Six pictures from the "Alphabet of Sounds" chart were identified to represent the six CV syllables and the children were trained to 100 percent accuracy of identification (live voice presentation) prior to the gathering of the experimental data. For both test and training procedures each child was presented with a six picture selection choice and asked to select the picture that corresponded to the stimulus presentation. Both the diotic and dichotic task utilized the six pictured CV combinations. The instructions were as follows for the pre- and posttest presentations:

> I want to play a listening game with you. Let me explain what I'm going to do. First, you will hear some silly words and I want you to point to the picture that goes with the word that I say. Then, you will hear the same word or a different word in each ear, but I want you to point to the picture that goes with the sound that you hear best.

The directions were repeated in part, if necessary, and examples were used if the child failed to understand the task. During the initial pretest and the subsequent training tasks, the subjects' response consisted of pointing to the picture which represented the CV syllable they perceived. The response sheet containing the depicted CV stimulus syllables is represented in Appendix B.

Training Task

The training task was divided into several segments over a period of two days. Pretest data for diotic and dichotic presentation responses were gathered on the first day and all children received the diotic presentation first. The instructions for the training procedure were as follows:

> First, you will hear more silly words like the ones you heard before and I will point to the picture that goes with the word that you hear in your right ear (pointing to the right ear). Then, I want you to point to the picture that goes with the word that you hear in your right ear (pointing to the right ear). I want you to pretend that you don't hear the word in the other ear. I will point to the first group of pictures and then I will tell you to point to the second group.

The directions were repeated in part, if necessary, if the child failed to understand the task.

Training procedures, outlined in Table 1, consisted of the following presentations:

(a) presentation of the 90 diotic and 90 dichotic items (previously described) to establish a base line performance;

(b) 90 item dichotic presentation whereby the examiner would alternately train or test the child on each set of 15 items;

(c) repeat of (b);

(d) repeat of (a_2) to compare pre- and posttraining results and repeat of (a_1) if the child did not attain 100 percent accuracy for the diotic pretest.

The total training period lasted approximately forty minutes. A short break followed each of the 90 item tape presentations. The first day's trials consisted of presentation of tasks (a_1) and (a_2). The second day's training consisted of the dichotic training tasks (b) and (c); as well as (posttest) task (d). Pre- and posttest results were compared to establish any changes in the level of performance.

Table 1. Description, Purpose, and Result of the Training Task

Description		Result
Task (a)		
a_1 90 item diotic presentation a_2 90 item dichotic presentation	Base line performance in quiet	Go to task (b)
Task (b)		
90 dichotic items whereby the examiner alternately trains or tests the child 1 15 items train 2 15 items test 3 15 items train 4 15 items test 5 15 items train 6 15 items test	Training dichotic - competing signal (verbal reward for correct right ear responses)	Go to task (c)
Task (c)		
Repeat of (b)	Training dichotic - competing signal (verbal reward for correct right ear responses)	Go to task (d)
Task (d)		
Repeat of (a_2)	Compare pre- and posttraining results	Report results
Repeat of (a_1)	Compare pre- and posttraining results if pretest score was not 100 percent	Report results

II. SUBJECTS

The subjects for this study were obtained from the University of Tennessee Hearing and Speech Center, the Knox County Public School System and area day care centers. Subjects were selected on the basis of the following criteria:

1. male sex;
2. member of the Caucasian race;
3. chronological age between five and six years;
4. hearing sensitivity within normal limits bilaterally;
5. normal intelligence;
6. no significant oral anomalies of the structure or function of the peripheral speech mechanism;
7. no obvious physical disabilities.

Five subjects were assigned to each of the two articulation groups according to the following criteria:

1. Subjects who scored above the cutoff score according to the norms for their age range, on the Templin Darley 50-Item Articulation Screening Test were placed in the good articulation group;

2. Subjects who scored at or below the cutoff score according to the norms for their age range, on the Templin Darley 50-Item Articulation Screening Test were placed in the poor articulation group.

III. TESTS AND PROCEDURES

Measure of Hearing Ability

A pure tone audiometric screening test was administered to each child using a Belltone Model 10-D Audiometer. Threshold responses were obtained for all subjects at the following frequencies: 500, 1000, 2000, and 4000 Hz. Subjects were rejected who demonstrated pure tone threshold responses of greater than 25 dB (ANSI) at any of the tested frequencies, or demonstrated greater than a 10 dB threshold difference between ears at any frequency.

Measure of Intelligence

The Peabody Picture Vocabulary Test was employed as a measure of verbal intelligence. Subjects were accepted who demonstrated an intelligence quotient of at least 90 or above according to the norms published by Dunn (1965) for this test.

Measure of Oral Structure and Function

An oral peripheral examination was administered to assess the adequacy of the structure and function of the oral peripheral speech mechanism through subjective evaluation by the examiner.

Diotic and Dichotic Listening Task

Method of presentation. Presentation of stimuli was accomplished through the use of a Teac TC A40 Three Head Stereophonic Tape Playback Recorder and Grason-Stadler Model 1704 Audiometer, through Grason-Stadler THD 49-10Z Stereophonic Headphones. The stimuli were presented

at a level equivalent to a 1000 Hz calibration tone at 78 dB SPL. Berlin et al. (1973) employed this intensity level in his experiments. Before each testing session, the examiner calibrated the audiometer (according to ANSI 1969 standards) utilizing a Bruel and Kjaer Type 2203 Sound Level Meter with Type 1613 Octave Filter Set, and Bruel and Kjaer Type 4152 Artificial Ear with Type 4144 Condensor Microphone to validate the intensity level of stimulus presentation at both earphones. In order to simplify analysis of the experimental data, the subjects' headphones were not switched during the experimental task. Throughout the testing procedure and the training procedure, the examiner constantly monitored presentation of the test stimuli through earphones.

Testing procedures. Each subject was tested individually by the examiner in a two-room audiometric test booth. The ambient noise level was determined to be no greater than 58 dB, SPL-Linear Scale, as measured by a Bruel and Kjaer Type 2203 Precision Sound Level Meter. A short training procedure preceded testing to insure familiarity with pictorial representations of stimulus items. Only subjects correctly identifying all of the six pictured sound stimuli in response to live voice presentation by the experimenter were included in this study. Each subject was given the response sheet bearing all six pictures (Appendix B) prior to the experimental and training tasks. One to two of these pictures corresponded to the stimulus item(s) that the subject was to hear. The subject was asked to point to the one picture that best represented the syllable that he thought he heard. The

examiner recorded a number (one through six) on an answer sheet to indicate the subject's selection. A short rest period followed each of the 90 item presentations.

Treatment of the Data

Data collected were in terms of (a) correct identification of diotically presented signals; (b) identification of right ear and left ear responses and an error score for dichotically presented signals;[1] and (c) identification of right ear and error responses in dichotically presented signals during the training procedure. Data reported are in terms of group performance.

A two-factor mixed design analysis of variance with repeated measures on one factor was utilized to compare the pre- and posttest scores for the dichotic tasks in the good and poor articulating experimental groups.

The differences between pre- and posttest scores for the dichotic task were analyzed for significance by the use of t-tests for independent means (Bruning and Kintz, 1969). As the basis for significance or nonsignificance an alpha level of .05 was selected.

The differences among both the pre- and posttest means (comparing the good and poor articulation group's performance) for the dichotic

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[1]One of the six pictures would be a correct identification for the syllable presented to the left ear, one would be a correct identification for the CV presented to the left ear, and the other four pictures would be scored as error choices.

task were analyzed for significance by the use of t-tests for related means (Bruning and Kintz, 1969). As the basis for significance or nonsignificance an alpha level of .05 was selected.

CHAPTER IV

RESULTS AND DISCUSSION

The primary purpose of this study was to investigate the following experimental questions:

1. Is it possible to improve the dichotic right ear performance of five and six year old males as a function of training?

2. Will the good and the poor articulating children differ in their response to training?

The test stimuli consisted of CV syllables (computer generated) with each of the six stop consonants, /p, b, t, d, k, g/, and the vowel /a/. The pretest task presentation consisted of 90 diotic and 90 dichotic stimulus items. The diotic task consisted of 15 presentations of the six CV combinations in random order, from the left channel of the dichotic tape which represented a total of 90 diotic stimulus items. The dichotic pretest and posttest included presentation of the six CV combinations into 15 contrasting pairs (consisting of voicing, place, and voicing and place). Each of these 15 competing pairs was randomly presented six times, for a total of 90 dichotic stimulus items. The training task consisted of presentation of the 90 item dichotic presentations whereby the examiner would alternately train or test the child on each set of 15 items.

The data analyzed were the responses made by each subject for the diotic and dichotic pretest and posttest tasks, each subject's training scores, and mean scores for the two groups. The diotic discrimination

score represented the number of correct choices made by the subject in response to the 90 diotically presented stimulus items. The dichotic pretest yielded a right ear score (number of right ear responses correctly corresponding to each stimulus pair member), a left ear score (number of left ear responses correctly corresponding to each stimulus pair member), and an error score.

Raw scores were converted to percentages of correct response. Administration of the two separate sections of the 90 item dichotic training task (180 items total) yielded two scores for each subject: a right ear score (previously described) and an error score.

I. RESULTS

Subject's Performance

Subjects selected were ten male children who exhibited a right ear preference and who met the criteria for inclusion in this study. On the basis of articulation skills as measured by the Templin-Darley 50-Item Screening Test, five children were classified as good articulation and five were classified as poor articulation. Table 2 displays a description of each subject's chronological age, mental age, and intelligence quotient as measured by the Peabody Picture Vocabulary Test, and articulation skill as measured by the number of items correctly produced on the Templin-Darley 50-Item Articulation Screening Test.

From inspection of the data in Table 2 it may be seen that the good and poor articulation groups ranged in age from 5-0 to 6-7 years and were of normal intelligence as determined by the Peabody Picture

Table 2. Chronological Ages, Mental Ages, Intelligence Quotients, and Articulation Scores for Subjects in the Good and Poor Articulation Groups

Subject	C.A.	M.A.	I.Q.	Templin-Darley*
Good Articulation				
1	5-6	5-4	97	46
2	6-5	6-10	106	49
3	6-4	8-0	126	49
4	6-7	9-10	149	50
5	5-11	7-3	122	49
Mean Percentage	6-2	7-3	120**	48.6
Poor Articulation				
6	5-4	5-6	103	3
7	6-2	8-11	144	24
8	5-10	5-3	90	6
9	5-11	5-8	95	6
10	5-0	4-11	98	20
Mean Percentage	5-7	6-1	106**	11.8

*Total number of correct responses possible for each subject was 50.

**The difference between group mean IQ scores was not significant ($t = 1.06$, $p = .321$, $df = 8$).

Vocabulary Test. The mean number of phonemes and blends correctly produced by the subjects in the good articulation group was 48.6 out of 50 items, with a range from 46 to 50 correct responses. One of the five good articulation group subjects exhibited a perfect score of 50 items correct in response to the articulation screening test. The poor articulation group correctly produced 11.8 out of 50 items, with a range from 3 to 24 correct responses. A statistical analysis using the t-test for Independent Means (Bruning and Kintz, 1968) indicated the difference between IQ scores for the two groups on the Peabody Picture Vocabulary Test was not significant ($t = 1.06$, $p = .321$, $df = 8$). In other words, for purposes of this study, the children differed significantly only in their articulatory proficiency.

It is therefore to be inferred that the differences which may be obtained in the dichotic listening tasks are actually a function of the children's ability to discriminate and the subsequent trainability of a right ear response and not a function of intelligence.

Diotic Pretest Listening Task Performance

The diotic listening pretest performance for each subject is reported as the correct percentage of response and is displayed in Table 3. Diotic discrimination scores for the good articulation group ranged from 89 to 100 percent correct with a mean percentage of 97.6 correct. For the poor articulation group, diotic discrimination scores ranged from 94 to 100 percent correct with a mean of 97.2 percent correct. Observation of the data reveals that the good and poor

Table 3. Mean Percentage of Correct Responses for the Diotic Pretest Listening Task Performance and Pretest Dichotic Mean Percentage Correct Responses of Right Ear, Left Ear, and Error Responses, Standard Deviations, Range of Errors, and Significance of Differences between Good and Poor Articulation Groups

Subject	Diotic Pretest Responses Correct	Dichotic Pretest Responses Right Ear	Left Ear	Errors
Good Articulation				
1	89 %	67 %	12 %	21 %
2	100	60	19	21
3	100	57	18	25
4	99	51	27	22
5	100	59	23	18
Mean Percentage	97.6	58.8	19.8	21.4
Standard Deviation		5.76	5.63	2.50
Ranges	89-100	51-67	12-27	18-25
Poor Articulation				
6	96	51	11	38
7	94	52	22	26
8	96	50	20	30
9	100	40	26	34
10	100	55	18	27
Mean Percentage	97.2	49.6	19.4	31.0
Standard Deviation		5.68	5.54	5.0
Ranges	94-100	40-55	11-26	26-38
Significance				
Between Groups	NS	.0346[a]	NS[b]	.005[c]

[a] $t = 2.54$, $p = .03$, $df = 8$. [b] $t = 0.11$, $p = .91$, $df = 8$. [c] $t = -3.84$, $p = .005$, $df = 8$.

articulation groups did not differ in their performance on the diotic listening task. Thus, it may be stated that articulation delayed children are generally able to perform an identification task as efficiently as children with age appropriate articulation skills. Since there was no consistent difference in diotic discrimination ability between articulation groups, any subsequent differences that may be obtained across groups in the dichotic listening and training tasks may be interpreted as resulting from a differential ability to deal perceptually with the competitive input of the dichotic task.

Dichotic Pretest Listening Task Performance

Table 3 also lists the dichotic pretest listening task responses for all subjects. The data reported are the percentages of correct responses for each ear, number of error responses, group means, standard deviations, and ranges for each response category on the pre-training dichotic listening task.

The same forced choice response paradigm was utilized in the dichotic task as in the diotic listening task. For each item in the 90 item pretest dichotic task, one stimulus pair member was channeled to the left ear while the competing syllable pair was presented to the right ear. It is theoretically possible for a subject to respond correctly one out of six times by chance alone. Prior to further analysis of the data, the test for significance of a proportion (Bruning and Kintz, 1968) was applied to the mean pretest responses for the right ear and left. These test results, summarized in Table 4,

Table 4. Results of Tests for Significance of a Proportion for Pretraining Dichotic Listening Task Responses of All Subjects in Both Groups

Responses	Good Articulation Group S's 1	2	3	4	5	Poor Articulation Group S's 1	2	3	4	5
Right Ear										
Proportion Observed	.67	.60	.57	.51	.59	.51	.52	.50	.40	.55
Proportion Expected by Chance	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17
z	12.50	10.75	10.00	8.50	10.50	8.50	8.75	8.25	5.75	9.50
p	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
Left Ear										
Proportion Observed	.12	.19	.18	.27	.23	.11	.22	.20	.26	.18
Proportion Expected by Chance	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17
z	-1.25	0.50	0.25	2.50	1.50	-1.50	1.25	0.75	2.25	0.25
p	NS	NS	NS	<.05	NS	NS	NS	NS	<.05	NS
Error Responses										
Proportion Observed	.21	.21	.25	.22	.18	.38	.26	.30	.34	.27
Proportion Expected by Chance	.67	.67	.67	.67	.67	.67	.67	.67	.67	.67
z	-11.50	-11.50	-10.50	-11.25	-12.25	-7.25	-10.25	-9.25	-8.25	-10.00
p	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01

indicate that the number of right ear responses for the two groups is greater than would be expected by chance alone. The error response is less than would have been expected by chance alone while the left ear score indicated that eight out of ten subjects could have identified that number of left ear choices by chance alone. Nine of the ten subjects demonstrated a 50 percent or greater accuracy in the identification of signals presented to their right ears.

The assumption that good and poor articulating five and six year old males will differ in their relative right ear preference for dichotically presented speech signals was statistically tested. Although there was some overlap of scores (see Table 3, p. 51), the t-test for Independent Means (Bruning and Kintz, 1968) indicated the difference between the group means was significant for the pretraining right ear responses ($t = 2.54$, $p = .0346$, $df = 8$), and for the pretraining error response ($t = -3.84$, $p = .005$, $df = 8$). The difference between the two groups was not significant at the .05 alpha level for the pretraining left ear responses ($t = 0.11$, $p = .91$, $df = 8$). Thus, it may be stated that a child's performance on a dichotic listening task is related to his level of articulation skill and that as a group the good articulation children displayed significantly better right ear responses than did the poor articulation children.

Dichotic Training Task Performance

Inspection of the data displayed in Table 5 indicates the group mean percentage distribution of right ear responses by each subject on the

Table 5. Percentages of Right-Ear Response on the Six Test Sections of the Dichotic Training Task Performance. Pretest and Posttest Scores are Included for Comparison

Subject	Pretest (90)	1 (15)	2 (15)	3 (15)	4 (15)	5 (15)	6 (15)	Posttest (90)*
Good Articulation Group								
1	67%	87%	73%	47%	80%	87%	73%	85%
2	60	67	47	27	53	60	53	72
3	57	60	53	53	80	80	60	73
4	51	53	47	53	67	40	47	58
5	59	53	60	53	73	60	53	68
Mean Percentage	58.8	64	56	46.6	70.6	65.4	57.2	71.2
Poor Articulation Group								
6	51	60	53	47	53	53	53	66
7	52	47	53	33	53	33	53	74
8	50	53	60	67	60	87	67	82
9	40	53	40	40	60	40	33	61
10	55	80	80	53	80	60	80	76
Mean Percentage	49.6	58.6	57.2	48	61.2	54.6	57.2	71.8

*The numbers in parentheses indicate the number of stimuli.

dichotic listening and training tasks. Figure 1 displays a visual representation of the mean percentage scores of right ear responses for the dichotic pretest and training task for both articulation groups. The training procedure utilized an alternate train-test paradigm. As described earlier, the first 15 items in the 90 item dichotic tape were identified for the child as a training task, the next 15 were tested for his discrimination, the third segment of 15 items were utilized for training, the fourth 15 item segment was tested, the fifth segment of 15 items were utilized for training, and the sixth 15 item segment was tested. The "1, 2, 3, 4, 5, and 6" designations on the horizontal axis of Figure 1 for the training presentations indicate the test segments. The graphs on Figure 1 indicate a consistent downward trend for the three test segments of each 90 item tape presentation for the good articulation group and less consistency for the poor articulation children. Inspection of the data for individual children on Table 5, however, indicate that children in both groups were inconsistent in their percentages of correct responses across the three test segments within each tape presentation. A rest period followed each 90 item presentation (test segments 3 and 6) and group means again indicate an improvement in accuracy of test segment four over test segment three for both groups of children, but data on individual children indicate some inconsistency among each three segments for each training tape. The variations around the mean performance for individual children within each group, can therefore probably be attributed to chance. What was consistent is that all ten children improved the accuracy of their right ear responses from the pretest to the posttest condition.

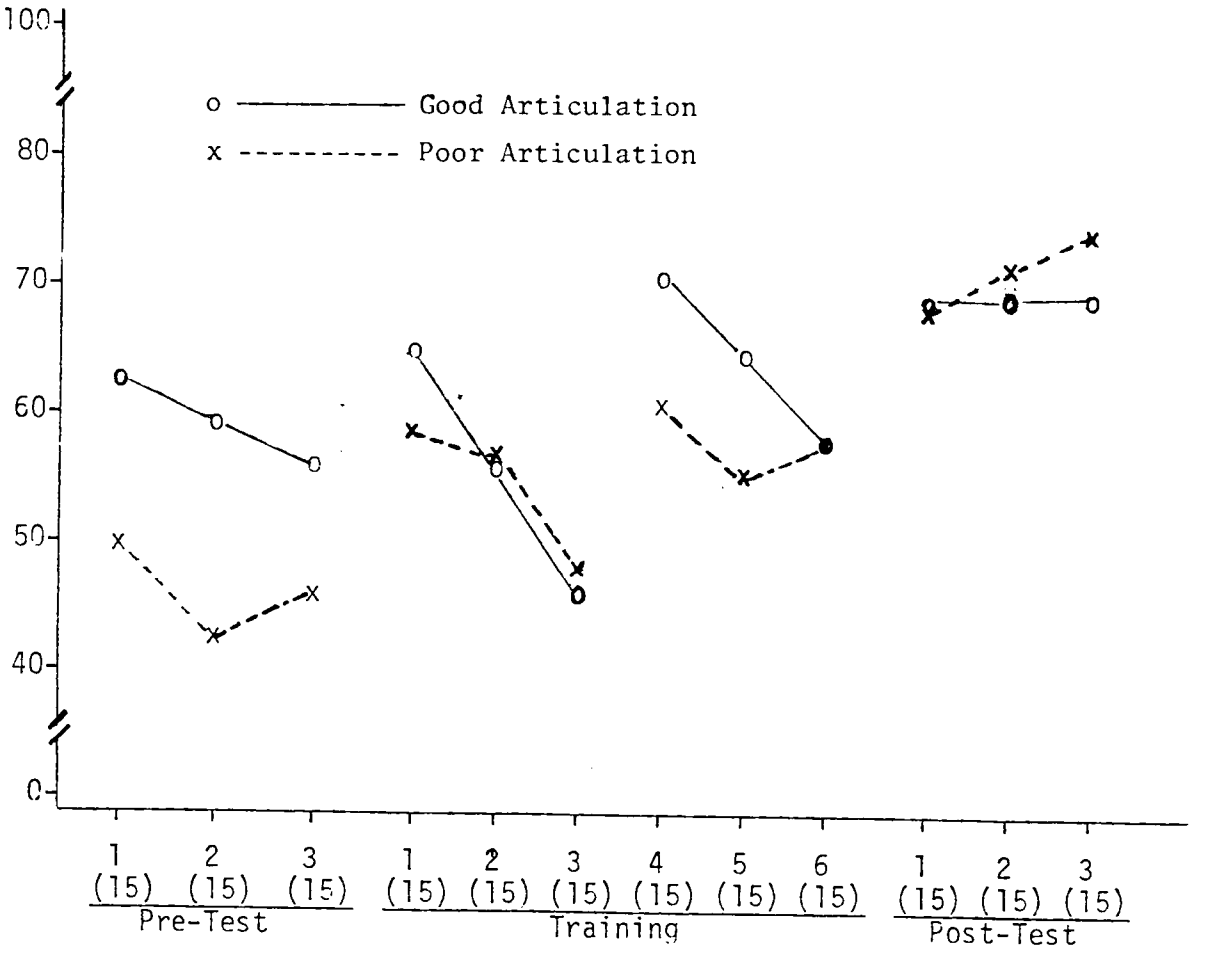


Figure 1. Mean percentages of right ear response for the dichotic training task for both articulation groups for the pretest, training, and posttest tasks.

Diotic Posttest Results

The diotic listening posttest performance for each subject and group are reported as correct percentages of response and are displayed in Table 6.

The diotic listening task was readministered as a posttest to those subjects in both groups who did not attain a 100 percent correct response score on the pretest. Table 6 demonstrates that each subject subsequently achieved a 100 percent correct score on the diotic posttest. This observation reveals that there is no difference in the diotic discrimination ability between the good and poor articulation groups for the posttest task.

Dichotic Posttraining Task Performance

The t-test for Independent Means (Bruning and Kintz, 1968) indicated that the difference between the group means (Table 6) was not significant at the .05 alpha level for the posttraining right ear responses ($t = -0.11$, $p = .92$, $df = 8$), the postraining left ear responses ($t = 0.93$, $p = .38$, $df = 8$), nor the posttraining error responses ($t = -0.57$, $p = .58$, $df = 8$). Thus, it may be stated that a child's posttraining performance on a dichotic listening task for all responses is not related to his articulatory ability.

The F-ratio for the articulation group factor (Table 7) was not significant at the .05 alpha level of significance ($F_{obs} = 1.61$; $p = .222$, $df = 1,16$). However, it is apparent from inspection of the data in Table 7 that there is a significant difference in the pre- and posttraining performance of the total group ($F_{obs} = 26.09$; $p = .0001$,

Table 6. Mean Percentages of Correct Response for the Diotic Posttest Listening Task Performance and Posttest Dichotic Mean Percentages of Correct Response, Standard Deviations, Range of Errors, and Significance of the Difference between the Good and Poor Articulation Groups

Subject	Diotic Posttest Responses	Dichotic Posttest Responses		
	Correct	Right Ear	Left Ear	Errors
Good Articulation				
1	100%	85 %	11 %	4 %
2	--	72	18	10
3	--	73	16	11
4	100	58	27	15
5	--	68	29	3
Mean Percentage	100	71.2	20.2	8.6
Standard Deviation		9.73	7.59	5.02
Ranges		68-85	11-29	3-15
Poor Articulation				
6	100	66	16	18
7	100	74	15	11
8	100	82	11	7
9	--	61	28	11
10	--	76	9	15
Mean Percentage	100	71.8	15.8	12.4
Standard Deviation		8.31	7.39	4.97
Ranges		61-82	9-28	7-18
Significance				
Between Groups		NS[a]	NS[b]	NS[c]

[a] $t = -0.11$, $p = .92$, $df = 8$. [b] $t = 0.93$, $p = .38$, $df = 8$. [c] $t = -0.57$, $p = .58$, $df = 8$.

Table 7. Summary of Two-Factor Mixed Design Analysis of Variance for Mean Scores between and within Groups for Pre- and Post-training Tasks and Articulation

Source of Variation	Sum of Squares	df	Mean Squares	F	p
Total	2626.55	19	--	--	--
Group	92.45	1	92.45	1.61	.222
Training	1496.45	1	1496.45	26.09	.0001
Group x Training	120.05	1	120.05	2.09	.1673
Error	917.60	16	57.35	--	--

df = 1,16). Table 7 also indicates that the F-ratio is not significant for the interaction of articulatory performance and pre- and posttraining skills. Thus, it may be stated that children's performance on a dichotic listening task employing contrasting pairs of CV syllables is trainable.

Further analysis of the training of dichotic right ear discrimination ability was made in terms of the improvement in the mean pre- and post-training responses of the good and poor articulation groups. The good articulation group right ear pretest scores ranged from 51-67 with a mean of 58.80 percent and right ear posttest scores ranged from 68-85 with a mean of 71.20 percent (Table 8). The poor articulation mean percentage for the pretest task performance was 49.6 percent and the posttest task performance was 71.8 percent. A t-test for dependent means (Bruning and Kintz, 1968) revealed a significant difference between the pre- and posttraining right ear response of the good articulation group children ($t = -6.01$, $p = .004$, $df = 4$) and the poor articulation group children ($t = -8.08$, $p = .001$, $df = 4$). It can therefore be stated that the good and poor articulation children's right ear performance improved as a function of training. Further inspection of the dichotic scores for the left ear response (Table 8) revealed that there was not a significant difference between the pre- and posttest left ear response of the good articulating children ($t = -0.280$, $p = 0.794$, $df = 4$) or the poor articulation group children ($t = .720$, $p = 0.50$, $df = 4$). It can be stated that both groups maintained their approximate left ear pretest response patterns. Table 8 also indicated that there was a significant reduction between the pre- and posttraining

Table 8. Percentages of Correct Response for Pre- and Posttraining Right Ear, Left Ear, and Error Discrimination Ability Including Dependent t-Test for Significance of Difference between Pre- and Posttest Scores for Both Groups

Group	Pretrain Right Ear	Posttrain Right Ear	Pretrain Left Ear	Posttrain Left Ear	Pretrain Error	Posttrain Error
Good Articulation						
Means	58.80%	71.20%	19.80%	20.20%	21.40%	8.60%
Ranges	51-67	68-85	12-27	11-29	18-25	3-15
t	-6.01		-0.280		7.34	
Significance	.004		0.794		.002	
Poor Articulation						
Means	49.60	71.80	19.40	15.80	31.00	10.40
Ranges	40-55	61-82	11-26	9-28	26.38	7-18
t	-8.08		0.720		12.26	
Significance	.001		0.50		.001	

error response scores of the good articulation children ($t = 7.34$, $p = .002$, $df = 4$) and the poor articulation children ($t = 12.26$, $p = .001$, $df = 4$).

As may be observed from inspection of Table 5 (page 55), the posttest results show a significant improvement in right ear responses as compared to the pretest results. A dichotic learning effect may have resulted from repeated exposure to the competitive dichotic input and/or from positive verbal reward.

Post Hoc Comparison: Dichotic Performance Two Months Posttraining

Because of the ease of training, and the dramatic improvement in right ear response made by the poor articulation children, a post hoc question arose as to the possible carryover effect of the training procedures. Only two of the five poor articulation subjects could be brought back for a retest. The data for these two children are presented in Table 9. For comparative purposes, the articulation scores and pretest, posttest, and post-plus-two-month scores are shown for right ear, left ear and error scores. The data indicate that although there was an immediate improvement in right ear scores and reduction in error scores as a function of the training, the post-plus-two-months data indicate that the training effect was not maintained. One subject (S 8) showed an improvement in his articulation score. Just before this subject entered the test suite for the post plus session his mother reminded him to "be sure to use his 'good' speech." Although the second subject (S 9) showed a slight improvement in right ear score and

Table 9. Correct Responses for the Templin-Darley Articulation Test and Percentages of Response for the Dichotic Pretraining, Posttraining, and Posttest-Plus-Two Months for Two Subjects in the Poor Articulation Group

	Templin-Darley		Pretraining			Posttraining			Posttest + 2 Months		
Subject	Pre	Post + 2	Right	Left	Error	Right	Left	Error	Right	Left	Error
8	6	12	50%	20%	30%	82%	11%	7%	50%	18%	32%
9	6	6	40	26	34	61	28	11	44	29	27

a reduction in the error score for the post plus two months condition, the magnitude of those responses is well within the range of scores for the pretest performances of the poor articulation subjects (see Table 3, page 51), and therefore probably due to chance.

In other words, in terms of the questions originally asked in this study, the children did significantly improve in their right ear discrimination ability as a function of the training task. But, on the basis of two children's responses collected two months after the end of the training period, this improvement in dichotic discrimination skill was apparently not maintained.

Patterns of Left and Right Ear Responses

The distribution of left ear and right ear responses of all subjects was examined in order to determine the important factors that influence a subject's response to the dichotic stimulus items. The left ear preference stimulus characteristics examined were in relation to the stimulus pair member which was presented to the right ear while the right ear stimulus characteristics were examined with regard to the stimulus pair member presented to the left ear. When stimulus items differed in voicing only, the stimulus items could be either the voiced pair member (e.g., /b/ in the pair /p,b/) or the voiceless pair member (/p/ in the pair /p,b/). For those stimulus pairs that differed in place of articulation, the stimulus items could have a place of articulation anterior (/p/ in the pair /p,t/), or posterior (/k/ in the pair /t,k/). When stimulus pairs differed in both voicing and place, the stimulus, for example, could be anterior and voice (/b/ in the

pair /b,t/), anterior and voiceless (/t/ in the pair /t,g/), posterior and voiced (/g/ in the pair /p,g/), or posterior and voiceless (/k/ in the pair /d,k/), with respect to the preferred ear stimulus pair member.

The data displayed in Table 10 indicates total numbers, percentages and mean percentage distribution of left ear response by each subject. Table 11 displays the percentages, and mean percentage distribution of right ear responses.

Articulatory feature characteristics may be an important factor in the distribution of left and right ear responses. For example, when considering stimulus pairs differing in voicing only, the data reveal that five of these ten subjects demonstrated a marked tendency for their left ear responses to be the voiceless rather than the voiced stimulus pair member (Table 10). One subject's responses were evenly divided, one had no left ear response, and three subjects preferred the voiced pair member. Also, five of these ten subjects demonstrated a marked tendency for their right ear responses to be the voiceless pair member (Table 11), one subject's responses were evenly divided, and four subjects preferred the voiced pair member. Inspection of the mean percentage (Tables 10 and 11) values for this response category demonstrate the consistency of the voiceless stimulus pair preference. The tendency for left ear responses to be voiceless rather than voiced agrees with the results of the Berlin et al. (1972) study in that dichotically presented voiceless consonants are more intelligible than voiced, regardless of which ear receives the voiceless consonant.

Table 10. Percentage Distribution in Terms of Phoneme Distribution of Pretest Left Ear Responses for All Subjects

Left Ear Stimulus	Subject (Total Number of Left Ear Responses in Parentheses) 1(12)	2(19)	3(18)	4(27)	5(21)	6(11)	7(22)	8(20)	9(26)	10(18)	Mean Percentage
Pairs Differing in Voicing											
Voiceless	8.3%	17.7%	6.2%	20.8%	4.8%	0	% 25	% 5.5%	8.7%	12.5%	11.0%
Voiced	16.7	0	0	0	14.3	0	0	11.1	8.7	0	5.0
Pairs Differing in Relative Place of Production											
Anterior	41.7	29.4	18.8	25.0	23.8	30	10	16.7	30.4	18.7	24.5
Posterior	16.7	17.6	43.8	16.7	28.5	30	25	33.4	21.7	37.4	27.1
Pairs Differing in Voicing and Relative Place of Production											
Anterior-Voiced	8.3	5.9	0	0	4.8	0	0	16.7	8.7	6.3	5.0
Anterior-Voiceless	0	11.8	6.2	20.8	4.8	20	10	11.1	17.4	12.5	11.5
Posterior-Voiced	0	0	0	0	9.5	0	0	0	4.4	6.3	2.0
Posterior-Voiceless	8.3	17.6	25	16.7	9.5	20	30	5.5	0	6.3	13.9

Table 11. Percentage Distribution in Terms of Phoneme Distribution of Pretest Right Ear Responses for All Subjects

Right Ear Stimulus	Subject (Total Number of Right Ear Responses in Parentheses) 1(60)	2(54)	3(51)	4(46)	5(53)	6(46)	7(47)	8(45)	9(36)	10(50)	Mean Percentage
Pairs Differing in Voicing											
Voiceless	6.7%	14.8%	17.6%	17.4%	5.7%	13.0%	19.2%	11.1%	11.1%	10.0%	12.7%
Voiced	8.3	9.3	11.8	8.7	11.3	15.2	8.5	15.6	11.1	8.0	10.8
Pairs Differing in Relative Place of Production											
Anterior	26.7	25.9	15.7	23.9	22.7	15.2	19.1	13.3	22.2	14.0	19.0
Posterior	16.6	20.3	23.5	13.0	24.5	28.1	21.3	28.9	27.8	26.0	23.0
Pairs Differing in Voicing and Relative Place of Production											
Anterior-Voiced	8.3	5.6	5.9	4.4	9.4	6.6	2.1	4.5	2.8	10.0	5.9
Anterior-Voiceless	6.7	11.1	9.8	13.0	9.4	6.6	17.0	13.3	5.6	10.0	10.3
Posterior-Voiced	11.7	5.6	3.9	6.6	13.2	6.6	6.4	2.2	0	12.0	6.8
Posterior-Voiceless	15.0	7.4	11.8	13.0	3.8	8.7	6.4	11.1	19.4	10.0	10.7

Inspection of pairs differing in relative place of production (Table 10) reveals that five of the ten subjects demonstrated a left ear tendency for posterior rather than for the anterior stimulus pair member. One subject's responses were evenly divided and four subjects tended to prefer the anterior place of production. Table 11 demonstrates that seven of the ten subjects demonstrated a right ear tendency for posterior rather than for the anterior stimulus pair member. Three subjects tended to prefer the anterior place of production.

The individual subjects' percentage scores for pairs differing in voicing and place of production (Tables 10 and 11) suggest that the voicing feature is more important than the place feature in determining the subsequent distribution of left ear and right ear responses while the place distinction is less important. These data are in essential agreement with previously reported findings in terms of expected feature and ear preferences.

II. SUMMARY OF RESULTS AND DISCUSSION

Based on the assumption that good and poor articulation five and six year old males will be similar in their speech sound discrimination on a diotic listening task but differ in their relative right ear preference for dichotically presented speech signals, two specific experimental questions were investigated.

1. Is it possible to improve the dichotic right ear performance of five and six year old males as a function of training?

2. Will the good and the poor articulating children differ in their response to training?

The discussion of the results is divided into four sections. The first section concerns the performance of both articulation groups on the diotic test. The second section discusses the dichotic pretest performance of both groups, and the third section discusses the trainability of a dichotic right ear discrimination ability of the two groups. The fourth section discusses the dichotic posttest performance of the good and poor articulation children as well as the post hoc comparison.

Diotic Performance of the Two Groups

The data indicate that both groups of subjects performed above the level of chance on the diotic discrimination test. Results obtained indicated that good and poor articulation children did equally well in their pretraining diotic discrimination. Three of the good articulation children and two of the poor articulation children were 100 percent accurate in their diotic discrimination prior to the training exercise. Following the training period, the other five subjects were retested on the diotic task and these five were 100 percent accurate on the posttest. This finding agrees with McDuffie (1975) who reported that children with different levels of linguistic skill did not differ in their ability to discriminate in a diotic task. Therefore, the subjects were able to adequately perform on a diotic task and the subsequent differences observed in the dichotic task may be attributed to the subjects' differential ability to deal with the dichotic competitive input. As

observed in McDuffie's (1975) data, dichotic ear preference patterns need not be considered an artifact of diotic speech sound discrimination ability.

Dichotic Pretest Performance of the Two Groups

The data indicated that while all the children demonstrated a right ear preference on the dichotic pretest[1] there was a significant difference in the relative right ear preference for dichotically presented speech signals. Nine of the ten subjects demonstrated a 50 percent or greater accuracy in the identification of signals presented in their right ears. The data revealed that four of the five children in the good articulation group demonstrated relatively higher right ear scores in response to the dichotic pretest task, than did the poor articulation group. The assumption that good and poor articulation children will differ in their relative right ear performance was supported and it may be concluded that five and six year old male children with good articulation skills do generally demonstrate a significantly greater right ear preference in response to a dichotic listening task employing CV stimulus pairs. It is interesting to note that the good articulation group subject (S 4) who displayed the poorest right ear preference also had the highest PPVT IQ and the highest articulation test score. The group data finding is in agreement with McDuffie (1975) who found that good language children demonstrated a greater preference for the right ear

[1]Because the effect of the training was not known, no children who showed a left ear preference were included as subjects for this study.

stimuli than did the children in the poor language group. Holler (1967) and others (Kimura, 1961a; Berlin and Lowe, 1972; and Johnson, 1977) suggested that speech defective children might be impaired in auditory perception and this impairment might be evidenced by using more refined tests of auditory discrimination. Lowe et al. (1970) indicated that a dichotic task is more difficult than a diotic task and the use of a dichotic listening task does provide such a refined measure.

Finally, inspection of the data obtained for each child indicated that the distribution of left and right ear responses may be influenced by the phoneme feature contrasts. The contrast in voicing between dichotic stimulus pairs was found to influence distribution of both the left and right ear responses. For the contrasts involving CV stimulus pairs that differed in voicing only and voicing and place of articulation, the left and right ear responses usually involved the voiceless pair member. These data are in agreement with Berlin (1972). Place of articulation did not appear to be significant in determining the distribution of left or right ear responses.

Dichotic Training Task Performance of the Two Groups

The data obtained on the dichotic training task performance demonstrated a significant difference between the number of pre- and posttraining test results for all children. Both groups of children improved from pretest item 1 to training items 1 and 4. Berlin et al. (1973) stated that as children increase in age from between five and 13 years, there is a significant improvement in the ability to correctly

discriminate and recall dichotic CV syllables and this ability has been related to a growth in speech processor "capacity." There was an erratic trend toward improvement in the right ear for the dichotic listening and training procedures and the individual variation in terms of the fluctuations observed in performance may be related to fatigue and/or boredom following each initial test segment of each listening task. A rest period preceded each 90 item tape presentation and both the good and poor articulatory groups displayed improved performance at the initial test segment of each listening task. These data are in agreement with Millay, Roeser, and Godfrey (1977) who found that there was a slight increase in accuracy of response during the initial sessions for their response conditions. While the good articulation group children held their performance steady in the posttest, the poor articulation group showed a slight but steady gain over this condition from the pre- to posttest scores. The poor articulation group showed greater overall improvement but more erratic performance. The training of a dichotic right ear discrimination ability was displayed as an overall increase in correct identification of stimulus items presented to the right ear with a concurrent decrease in the error choices for all of the ten subjects.

Dichotic Posttest Performance of the Two Groups and Post Hoc Comparison

Results of this study suggest that while there is a significant difference in the pretest dichotic scores of the good and poor articulatory groups, children who displayed a lower level of articulatory skill, as measured by the Templin-Darley 50-Item Screening Test,

responded to a dichotic training task with more overall efficiency and demonstrated a significantly greater pre- to posttraining test score than did children of the same age and sex with age-appropriate articulation skills. As in agreement with Millay et al (1977), these data demonstrate differences in discrimination ability or capacity that could be observed between groups but within group differences were relatively small over time.

This study has demonstrated that the initial dichotic pretest listening task performance is related to articulatory ability and that right ear dichotic listening patterns may be modified through training. It also demonstrated that while the poor articulation children had significantly lower right ear advantages on the pretest than did the good articulation subjects, they demonstrated a slightly larger right ear preference on the posttraining task. One possibility the data seem to suggest is that while the poor articulation group responded less efficiently on the pretest than did the good articulation group, the poor articulation group had farther to go. It may be that 85 percent was the ceiling and that the good articulation children started closer to the ceiling and both groups (with individual variation) reached the ceiling.

The Williams and McReynolds (1970) study involving speech sound discrimination training did not involve competition between ear inputs. The present study and others (McDuffie, 1975) have failed to demonstrate a consistent relationship between the ability to perform such diotic discrimination tasks and level of articulation and language ability in

children. However, if a child's ability to learn strategies for responding to a diotic speech sound discrimination task is not related to his articulation skill, then one may question the appropriateness of diotic discrimination task training to articulation therapy. This is in agreement with Williams and McReynolds (1970) who found that training in production aids discrimination but that training discrimination does not aid production.

Of practical interest is that these results demonstrate it is possible to train a right ear response to dichotic stimuli. The increased discrimination ability in identifying verbal dichotic input presented contralateral to the dominant hemisphere occurred in the presence of verbal feedback to the child when he responded appropriately to the training items. The post hoc data on two children revealed that the posttraining task performance was not maintained. Porter et al. (1976) suggested that some aspects of the mechanism underlying the right ear advantage do tend to be invariant with practice. Therefore, it seems that while training of a right ear response exhibits improvement, the organization of the pathways would presumably not change with practice (Porter et al., 1976).

From the results of the present study, it is possible to conclude that a dichotic right ear discrimination ability is trainable (albeit temporarily). Perhaps what was being "trained" was a selective attention rather than a dichotic ear preference per se.

CHAPTER V

SUMMARY AND CONCLUSIONS

I. SUMMARY

This study included ten male subjects, five of whom were classified as good articulation children and five of whom were classified as poor articulation children. On the assumption that good and poor articulation five and six year old males would be similar in their diotic speech sound discrimination, but differ in their relative right ear preference for dichotically presented speech signals, two specific experimental questions were investigated:

1. Is it possible to improve the dichotic right ear performance of five and six year old males as a function of training?

2. Will the good and the poor articulating children differ in their response to training?

Results of examination and analysis of the data obtained in this study indicated that:

1. The good and the poor articulation groups did not differ in their performance on a diotic discrimination task.

2. Prior to the training procedures, the good articulation group demonstrated a significantly greater right ear preference on the dichotic task than did the poor articulation group children.

3. All subjects demonstrated a significant improvement in the ability to correctly discriminate dichotically presented CV syllables from the pre- to posttraining task.

II. CONCLUSIONS

On the basis of the results of this study, the following conclusions may be tentatively drawn:

1. Articulation ability is not consistently related to a child's ability to respond to a diotic discrimination task.

2. Articulation ability is significantly related to right ear preference patterns obtained in response to a dichotic listening task.

3. Differences in dichotic ear preferences among children with different levels of articulation development cannot be attributed to differences in diotic discrimination ability.

4. Articulation-delayed children demonstrate less of a right ear preference than that demonstrated by good articulation children.

5. As a result of a training task, children can become more efficient in dichotic presentation identification.

6. On the basis of the results of two children, this training effect is not maintained.

III. SUGGESTIONS FOR FURTHER STUDY

During the course of the present study several possibilities for further research presented themselves:

1. On the basis of the two poor articulation children who were retested two months after the training task and who showed no apparent improvement over pretest scores, it would be interesting to note if dichotic discrimination changes with improvement in articulation skill or if articulation skill improves as a function of dichotic right ear discrimination training?

2. Because of the performance of the good articulation group subject who displayed the poorest right ear preference but who also displayed the highest PPVT IQ and the highest articulation test score, it would be interesting to obtain a larger sample size for each level of articulation proficiency in order to observe more diverse degrees of articulation skill and to determine the variability of the subjects' performance and the amount of right ear preference.

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APPENDIXES

APPENDIX A

DIOTIC AND DICHOTIC STIMULUS ITEMS IN ORDER OF EXPERIMENTAL PRESENTATION

I. DIOTIC STIMULUS ITEMS

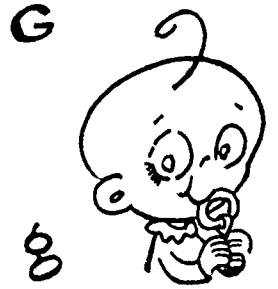
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7.	da	37.	ka	67.	ta
8.	ba	38.	da	68.	pa
9.	pa	39.	pa	69.	ka
10.	ba	40.	ka	70.	ta
11.	pa	41.	ka	71.	ga
12.	ta	42.	ga	72.	da
13.	ka	43.	ba	73.	da
14.	ka	44.	ba	74.	ba
15.	ba	45.	da	75.	da
16.	da	46.	ba	76.	ba
17.	ta	47.	pa	77.	ta
18.	pa	48.	ga	78.	ta
19.	pa	49.	pa	79.	ka
20.	ka	50.	ta	80.	da
21.	ga	51.	ka	81.	ba
22.	ta	52.	da	82.	ga
23.	ta	53.	ka	83.	pa
24.	ga	54.	pa	84.	ba
25.	da	55.	pa	85.	ka
26.	ga	56.	ga	86.	da
27.	ta	57.	da	87.	ta
28.	ka	58.	ba	88.	pa
29.	ba	59.	ta	89.	pa
30.	ga	60.	ta	90.	ba

II. DICHOTIC STIMULUS ITEMS

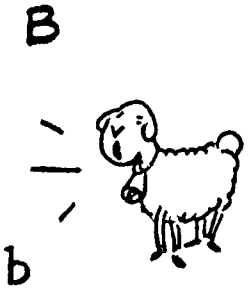
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APPENDIX B

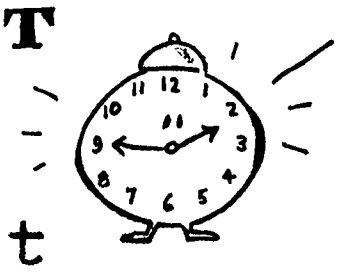
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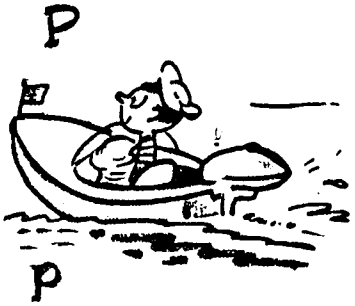
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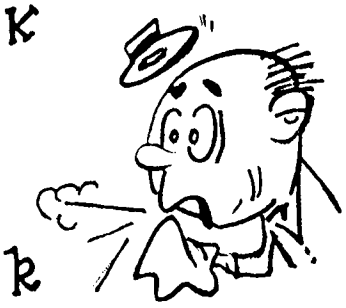
BA



TA



PA



KA



DA

VITA

Deborah Minor was born in Jefferson City, Tennessee, on April 5, 1952. She did undergraduate work at East Tennessee University, Johnson City, Tennessee. She was graduated, with honors, from East Tennessee State University in 1974 receiving a Bachelor of Science Degree, majoring in speech pathology and minoring in special education. Following graduation she worked in the Grainger County school system as a speech therapist until May, 1976.

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