To the Graduate Council:

I am submitting herewith a thesis written by Charlene M. Rowland entitled " The Performance of Language-Learning Disordered Children on a Tone Pattern Recognition Test ." I have examined the final copy of this thesis for form and content and 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 Peterson

Harold A. Peterson, Major Professor

We have read this thesis and recommend its acceptance:

Sol Adler

Allan O. Diefendorf

Harold L. Luper

Accepted for the Council:

CW Minkel

Vice Provost
and Dean of The Graduate School

PERFORMANCE SCORES OF LANGUAGE LEARNING DISORDERED CHILDREN ON A TONE PATTERN RECOGNITION TEST

A Thesis

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Degree

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Charlene Marie Rowland

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ABSTRACT

The purpose of this study was to determine if scores on a tone pattern recognition test statistically separated between a group of "normal language" children and a group of children identified as "language-learning disordered."

The subjects were asked to listen to six tone pattern recognition tasks, and respond appropriately by identifying the tone, or pattern of tones. Subjects responded in a manual form.

Statistical analysis indicated that subtests two and six of the tone pattern recognition tasks statistically separated between the two groups. Age and sex were not found to be significant factors influencing subjects scores.

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CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

Introduction

Researchers have recently began to examine central auditory dysfunctions as a possible underlying cause of language-learning disorders. Several studies such as Glass,Franks and Potter (1986), Marston and Larkin (1979), Reidlinger-Ryan and Shewan (1984), Stubblefield and Young (1975), and Willeford, (1983) examined possible learning difficulties in children using language stimuli. While in the past,language skills have been examined using tests of language stimuli, the available tests, i.e., attentional and competing message tasks which these authors used may not be appropriate tools for assessing language-learning disorders when underlying central auditory processing dysfunctions are in question.

Children with auditory processing problems are frequently described as easily distractable and poor listeners, as well as exhibiting short attention spans. These characteristics are often cited for language-learning disordered children (Willeford, 1983). Therefore, children may perform poorly on language tests and be classified or labeled as language-learning disordered, when actually the problem identified is not a language-learning based problem but may stem from a central auditory processing problem. Therefore the tests which the above authors used are potentially biased because of their use of linguistic stimuli, (Katz, 1962 and Glass, Franks and

Potter, 1986) when the disorder in question is not a language-based disorder but rather a central auditory processing problem.

An assessment of processing abilities which does not use language stimuli should be a consideration for examiners. The left hemisphere of the brain is primarily responsible for the processing of language, and tone pattern recognition tasks have been shown to be a left-hemisphere function when the subjects report employing a strategy to determine the pattern of tones (Mazziotta and Phelps, 1985; Revich, Alavi, Gur and Greenburg, 1985). Therefore the processing of tone patterns may relate to language processing by also being a left hemispheric task.

Waldrop (1985) states that in order to learn language an individual must utilize strategies to recognize and classify words, and to put them into phrases, clauses and sentences. Therfore if a breakdown in these strategies occur, a child may have difficulty with his language skills, thus, a language-learning disorder.

This study is designed to determine if scores on a tone pattern recognition task are different in children classified as having a language- learning disorder and children classified as having normal language skills. If scores are indeed different, it may be assumed that a breakdown in strategies for learning language may be the underlying cause of central auditory processing disorders in the children described as language-learning disordered.

Review of Literature

Language-learning disabled children are "those individuals whose learning disabilities are manifested as continuous problems in the acquisition and development of language systems." (ASHA Committee on Positions, 1982 p. 937) The strategies necessary for a child to process language are "recognizing individual words, classifying them according to parts of speech,. . . figuring out the grammatical role each word is playing, and linking the words into phrases, clauses and sentences" (Waldrop, 1985 p.1564). Without the use of a strategy, Miller, (1956) and Waldrop, (1985) suggest that an individual can process no more than four unrelated pieces of information at a time. Therefore, the language-learning disordered child may not be able to process four or more pieces of information (tones) due to a breakdown in strategies. Tone pattern recognition tests may determine if assumed defective auditory processing abilities in language-learning disabled children are related to a lack of strategies needed to process auditory stimuli by showing a difference in performance scores between language-learning disordered children (lack of strategies, low performance) and children with normal language skills (use of strategies, high performance).

Pinheiro (1985, p.219) stated that temporal sequencing or serial ordering in the central auditory system "involves the perception and/or processing of two or more auditory stimuli...". Hirsch (1985) concluded that the perception and production of speech and analysis of patterned temporal stimuli, (e.g. tone patterns) depends on an individual's ability to deal with different patterns of sound. Mazziotta and Phelps (1985) and Revich, Alavi, Gur and Greenburg (1985) found that on a tone pattern test, individuals who employed an analysis strategy in recognizing the tone patterns showed more left-hemispheric activity than those who did not report using a strategy, and who showed more right- hemispheric activity as shown by Positron Emission Tomography.

Molfese and Molfese (1985) reported that infants are able to discriminate between different auditory stimuli in the first 36 hours post-birth. Neurophysiological responses were obtained by presenting the infants with consonant-vowel speech syllables and computer synthesized nonspeech stimuli which were matched to the center frequency for each speech syllable stimulus. All stimuli were matched for intensity, duration and amplitude relationships. Results showed that the infants could discriminate between speech and nonspeech variables. The authors stated that some infants appear to be advantaged in their language development because of abilities to make finer discriminations between varying auditory signals, of which some are co-existing with speech perception events. In addition, the authors suggest that "the earlier an infant can detect and discriminate between patterns of sound in their language environment, the better that infant will be able to utilize such information as the extensive process of language acquisition begins."(p.208). Molfese and Molfese retested the infants in this study at three years of age and found that the infants who had greater sensitivity to the sound variations at birth had better language skills at three years.

Stark and Bernstein (1984, p.58) hypothesized that "there are cause-and-effect relationships between deficits in auditory processing... and language and language-based learning disorders in children." They reasoned that "language depends on the ability to process the speech wave form," thus suggesting that auditory processing deficits may underlie language disorders.

Interest in assessment of central auditory processing has been motivated by researchers in the area of identifying language learning disabled children (Stark and Bernstein, 1984). If a relationship exists between auditory processing skills and comprehension and use of language, then a disorder in these areas may need intervention for the child to learn language. Aten and Davis (1968), and Lowe and Campbell (1965) reported deficits of temporal sequencing skills in language impaired children. They suggest that both the language impairment and defective sequencing abilities may be the result of underlying deficits for rapidly processing auditory stimuli.

Willeford (1983) characterized children with auditory processing disorders as being easily distractible, poor listeners, underachievers and exhibiting short attention spans and other behaviors which affect communication processing. He suggested that other authors may classify children with these characteristics as "learning-disabled". He stated further that some children with central auditory processing deficiencies exhibit learning difficulties while others do not, and some learning disabled children present central auditory processing difficulties when others do not. One reason for this discrepancy may be a function of the types of test procedures used to identify processing deficiencies.

Assessment of Auditory Processing Disorders

No standardized tests for diagnosis of central auditory dysfunction have been established, however, assessment falls generally into three categories: (1) attentional tasks, (e.g. Willeford, 1981), (2) competing message tasks, (e.g. Katz, 1962), and (3) pattern recognition tasks (Pinheiro, 1985). Important considerations in the use of tests falling into these three categories are discussed below.

A child who does not appear to be attending well on attentional tasks and whose test results indicate low performance may be judged to have auditory processing difficulties when actually he is having difficulty understanding the language. On the other hand, a child who attends poorly, but whose performance is adequate on the task, may not be identified as having auditory processing difficulties. Thus not only does language facility affect performance, but attentional tasks have not proven favorable in identifying children with auditory processing difficulties (Lubert, 1981).

Competing message tasks may be characterized by speech-versus- speech stimuli as in dichotic listening tasks (Kimura, 1963) and the Staggered Spondee Word Test (Katz, 1962) or speech versus noise stimuli such as the Goldman-Fristoe-Woodcock Auditory Discrimination subtests, (Goldman-Fristoe-Woodcock, 1970) or the Flowers Auditory Test of Selective Attention (Flowers, 1975).

Reduction in performance on any of the above tests has not been shown to denote a lack of competence in auditory processing abilities (Baran and Gengel, 1984) but may be attributed to either a lack of attention to a particular stimuli or inadequate language skills.

Tone pattern recognition tests (Pinheiro, 1985) provide the listener with a set of tones and the listener is to indicate which ones are "high" or "low". According to Pinheiro, the recognition of a pattern or temporal ordering of the tones requires some degree of language-like processing when the stimulus components must be identified ("high/low") but not when duplicated (e.g. hummed) in a verbal response. Thus tone patterns may measure processing abilities without incorporating language stimuli.

Three categories of assessment of central auditory processing disorders (1) attentional tasks, (2) competing message tasks and (3) pattern recognition tasks are discussed below.

<u>Attentional tasks</u>

Auditory comprehension involves memory association along with perceptual, linguistic, and cognitive processing. Breakdowns in these areas may be observed through "a decrease in the speed of processing, misinterpretation of the message, or the forgetting of pertinent information" (Reidlinger-Ryan and Shewan, 1984 p.127). These deficiencies may affect academic performance which is usually first noticed by the classroom teacher. The behavior rating scales completed most often by the classroom teacher rate behavioral descriptions of auditory processing difficulties.

Reidlinger-Ryan and Shewan evaluated a behavioral scale of classroom listening skills in learning-disabled adolescents as a predictor of language comprehension performance. Thirty subjects ranging in age from eleven- to twelve-years-old completed the rating scale along with the classroom teachers. The authors concluded that this attentional task did not appear to identify children with learning disorders in that the rating from neither the subjects nor the classroom teachers correlated significantly with other test results.

Glass, Franks and Potter (1986) employed the Central Auditory Processing Behavior Rating Scale (Willeford, 1981) as an indicator of learning disabilities in children. The auditory profile scores determined as "weak" by the classroom teachers had no significant correlation with the Flowers Auditory Test of Selective Attention (FATSA) or the Goldman-Fristoe-Woodcock-Auditory (GFW-A) which were also used to identify learning-disabled children.

Competing Message Tasks

Competing message tasks such as the Flowers Auditory Test of Selective Attention, the Goldman-Fristoe-Woodcock, and the Staggered Spondee Word Test (SSW) are frequently cited in the literature. Norms for the SSW were not appropriate for some children, for example, Stubblefield and Young (1975) studied performance of 40 seven-year-old to eleven-year-old children on the SSW. Twenty children had been classified as normal achieving children and twenty children had been identified as having learning difficulties. Although significant differences in performance were found between the two groups, the group of normal achieving children scored at or below the suggested norms set by Katz (1962). This suggests that Katz's norms were not appropriate for the normal achieving children.

Katz (1962) developed the SSW primarily for identifying lesions in the central nervous system. No norms have been established for children under the age of eleven-years, while the norms that have been established refer basically to patients with lesions of the CNS. Katz reported that results of the SSW may be influenced by language facility.

Performance on the SSW may in some instances identify children with learning-disabilities, but the test does not differentiate between children with auditory processing difficulties and language-impaired children. This may be due to the fact that it was not designed to be used with this population.

Marston and Larkin(1979) used the Goldman-Fristoe-Woodcock (GFW) Noise Discrimination subtest to evaluate the performance of 24 third and fourth grade children. Twelve children were classified as underachievers in reading and twelve children were classified as achievers in their reading skills. The criterion measurement used was the Iowa Test of Basic Skills. The results indicated that the reading achievers scored significantly higher on the GFW-Noise subtest than did the underachievers.

Condon (1984) examined the performance of 20, seven- to ten-year-old normal children on the SSW, and on the Noise and the Memory for Sequence subtests of the GFW for identification of central auditory functions. The children were in normal classrooms and reportedly had normal hearing. Results showed a weak, but significant correlation between the Noise subtest on the GFW and the right-competing raw score on the SSW, while a greater correlation was evident between the SSW and the GFW Memory for Sequence subtest.

A low test-retest reliability of the GFW Selective Attention subtest was found by Baran and Gengel (1984). They suggest that this test may not be "a reliable indicator of a individual's true ability." (p.203). Therefore the reliance on the SSW (e.g., Condon,1984) and GFW as adequate assessment tools of auditory processing in children is in question.

The Flowers Auditory Test of Selective Attention(FATSA) and the Goldman-Fristoe-Woodcock Selective Attention test (GFW-SA) were compared using results of 30, eight-year-old to twelve-year-old children's performance on each (Glass, Franks and Potter, 1986). All subjects were identified as having reading deficiencies with the assumption that some of the children studied would present auditory processing difficulties. Although both tests used are categorized as selective attentional tasks, the low correlation (r=.44) found between the two tests suggests that the tests differ in what they measure.

The FATSA also presents questionable reliability as a test of auditory processing, in that the test is a difficult listening task, using a high signal-to-noise-ratio along with speech stimuli. As shown above, Stubblefield and Young, (1975), Marston and Larkin, (1979) Condon, (1984), and Baran and Gengel, (1984), competing message tests are more likely to test language competence of the child than central auditory processing.

Neeley (1986) explored performance on a dichotic task in eight-and nine-year-old children with different levels of articulation skill. Group one exhibited normal articulation skills, group two displayed now-normal articulation skills but previously had required therapy, while the third group had poor articulation skills and were in therapy. All subjects had average verbal intelligence as measured by the Peabody Picture Vocabulary Test. Results indicated a significant difference between the normal group and the now-normal and the poor articulation groups. In addition, the now-normal group did not differ significantly from the poor articulation group. Neeley concluded that the differences in dichotic performance of each group may be the diverse ability of individual subjects to handle competitive input which is characteristic of a dichotic listening task.

Dichotic tasks are susceptible to training as shown by Minor (1977) who studied trainability of right ear preference on a dichotic task with 20 five-year-old to six-year-old children. The subjects were divided into a group of 10 children characterized by poor articulation skills and 10 children presenting good articulation skills. She trained the poor articulation children to pay attention to the right-ear stimulus when listening to dichotic signals. Pre-trial results showed a relatively low right-ear preference. After a short training period the poor articulation children showed ear preference scores at least as good as the good articulation control group. When these experimental group children were tested one month later, their dichotic scores were comparable to their pre-test performance. What had been trained, was evidently not the ability to perform on a dichotic task but only temporarily to attend to one ear.

In summary, dichotic test results have been shown to be influenced by language skills, but can also can be trained without improving language skills. Lack of competence on dichotic tasks could be masqueraded by lack of language skills instead of poor processing abilities.

Pattern Recognition Tasks

PInheiro (1985) employed a three tone pattern recognition task to assess central auditory processing. Subjects were asked to identify three tone sequences (each tone identified as high or low). Results separated subjects into either good performers or poor performers.

Mazziota and Phelps (1985) presented tone patterns to eight individuals and examined the metabolic responses of the individuals using Positron Emission Tomography. The subjects listened to two sets of tones and were asked if the second set was different or identical to the first set of tone patterns. The authors stated that "The metabolic response to the tone-sequence paradigm correlated with the analysis strategy employed by the subjects." The subjects who reported using strategies for their comparisons showed greater left hemispheric activity, while the individuals who did not use strategies had greater right-hemispheric activations.

Revich, Alavi, Gur and Greenberg (1985) found similar results when they studied individual's performance on a tonal memory test using Positron Emission Tomography. Subjects listened to a tonal memory test and although the authors did not describe the test or method of response it was stated that the individual's task was to remember the tone patterns or sequences. Results showed that those subjects who employed an analytic strategy for remembering the tone patterns showed greater metabolic activity in the left-hemisphere. On the other hand, the subjects that did not report using a strategy showed more activity in the right-hemisphere.

Although recognition of tones is expected to be a right-hemisphere task, when tone patterns are involved which allow for the employing of strategies, then the task is more left-hemispheric. Tone patterns also require the child to attend to a signal, assign values to the stimuli, and allow for a strategy in recognizing a pattern which is helpful in processing stimuli. Language learning requires a similar sequence.

In summary, if a child does not employ a strategy in learning language, the auditory system may not be able to process the information effectively, thus a central auditory processing deficiency. Tone pattern recognition tasks may determine whether or not a child employs a strategy in processing language-related stimuli.

The need to assess central auditory processing without using tests which are influenced by a child's language skills is to be investigated. A test of auditory processing that appears to be related to language by being a left hemisphere activity (Mazziotta and Phelph, 1985: Revich, Alavi, Gur and Greenburg, 1985) but not a language task (i.e., utilizing non-speech stimuli), is the Tone Pattern Recognition Test.

Experimental questions posed in this study are as follows:

1. Do performance scores on a tone pattern recognition test differ between a group of language-learning children and a group of children with normal language skills?

2. Do any or all of the tone pattern recognition tasks statistically separate between a group of language-learning disordered children and a group of children with normal language skills?

CHAPTER II

METHODS

Although, eight-to-nine-year-old normal children and children with articulation problems were compared using tone pattern recognition tasks previously (Neeley, 1987) no studies were found in the literature concerning tone pattern recognition tests and language-learning disordered children. However, the study cited above, did show that normal eight-year-old subjects were able to complete the tone pattern recognition test.

The purpose of this study is to determine if scores on a tone pattern recognition test will statistically separate between a group of "normal language" children and a group of children identified as "language - learning disordered."

Subjects

The subjects included in this study were 17 children , (ages eight-years-four-months to nine-years-five-months) attending area schools. The control group consisted of eleven children with normal language skills who had scored at or above the fifth national stanine on the Stanford Binet Achievement Test. The achievement test was administered no more than six months prior to this study. The experimental group consisted of six children identified as language-disordered in or before the first grade and who were currently receiving language therapy. Since this group was receiving language therapy, they were not required to take the Stanford Binet Achievement Test. The experimental group was confirmed by quotients of 90 or less on the listening, speaking and total spoken language portions of the Test of Language Development (TOLD). All subjects had normal intelligence according to the school psychologist. Control group subjects were matched for sex, and race with the experimental group ,so all subjects met the following criteria:

(1). All subjects passed a pure tone screening test at 25dB at 500, 1000, 2000, 4000 Hz.

(2). All subjects had normal intelligence as determined by achievement tests administered by the school system.

(3). All subjects were in appropriate grade placement for age.

Description of Tasks

The Tone Pattern Recognition Test consisted of six sets of tone patterns. Each test set consisted of 50 auditorially presented stimuli and was preceded by 10 demonstration items. Two computer generated tones of 1000Hz and 500 Hz with approximately the same duration (200 msec or longer) were combined to form two, three, and four tone sequences. The tones were separated by 200-to-500 msec, depending on the level of difficulty, with one-to-three second intervals between sets. (see Table 1) The subtests range from one-to-five minutes in length and progressed in difficulty from easier to most difficult.

Table 1. Summary of the tone pattern recognition subtests.

Stimuli consisted of 500 and 1000 Hz tones. Ranges of durations, Inter Stimuli Intervals (ISI) and Intervals between patterns or sequences are shown.

Name	Tone Description	Task
1. oddball	Tones with a duration of 240-288msec were presented in random order with a high-low ratio of 80-20. ISI was between 1584-1608msec.	Circle the tone (500Hz)
2. two pairs of tones (four tones)	two pairs of tones with a duration of 240-288msec are presented in sequence, with an ISI of 408-456 msec between pairs and 3336 msec between sets.	Circle the pair that is different
3. three single tones	three tones with a duration of 240-288 msec are presented in each sequence with an ISI of 504 msec, and 4080 msec between sequences .	Circle the tone that is different or are all three the same?
4. four tones	four tones with a duration of 240-288 msec are presented in sequence with an ISI of408-480 msec and 3408 msec between sequences.	Which tone is different?

Table 1 (Continued)

Name	Tone Description	Task
5. two tones	two tones with a duration of 288-336 msec are presented in sequence with an ISI of 528 msec and 4152 msec between patterns?	Is the second tone higher, lower, or the same as the first?
6. three tones	three tones with a duration of 240 msec are presented in sequence with an ISI of 576 msec and 4176 msec between each pattern.	Is each tone high or low?

Task one consisted of 50 tones with high (1000 Hz) (80 percent) and low (500 Hz) (20 percent) frequencies. The child was to indicate which tones were "low". Task two presented two pairs of tones, one pair was the same, the other was different and the child's task was to identify the pair that was different. The third task consisted of three tones with at least two of the three tones being the same or all three were the same. The child was asked to indicate if all were the same or which one was different. The fourth task consisted of four tones. Three were the same and one was different. The child was asked to indicate which of the four was different. The fifth task consisted of two tones. The child was asked to indicate if the second tone was higher, lower or the same as the first tone. The sixth task consisted of three tones. The child was asked to indicate if each tone was high or low.

Procedures

Six tone pattern subtests were presented via video tape on a television screen. The audio signals were tones or tone patterns, but as each tone sequence was heard, the item number of that tone or tone pattern was displayed on a video screen to assist the child in following the item number sequence on the response form. All 17 subjects were tested in a group of in a quiet environment. The tones were presented at a comfortable loudness level for everyone, in that each child was asked if the tape was too loud or too soft or when he heard it "the best". Instructions for each subtest were shown on the soft or when he heard it "the best". Instructions for each subtest were shown on the video screen and read aloud by the examiner. Following the instructions, 10 items were presented before each subtest, which identified the tone sequence (e.g. Tone 1, Tone 2) on the video monitor, to allow familiarization to stimuli and in marking the response sheet. The 50 test items were identified on the video monitor only by the item number. The subjects marked the response sheets to identify their choices.

Two subjects were randomly chosen from each group to repeat the six subtests to measure reliability.

Analysis of Data

A t-test was performed on each subtest to determine if the performance scores of the control and experimental groups differed significantly. A Pearson Product Moment Correlation Coefficient was calculated using subject's scores and their age, and then again using their scores and their sex to determine if the factors of age and sex influenced subject's scores. The percent agreement was calculated to measure intra-subject reliability using scores from the two administrations of the six tone pattern recognition tasks repeated by two subjects from each group.

CHAPTER III

RESULTS AND DISCUSSION

Results

The purpose of this study was to determine if scores on a series of pattern recognition tasks differed between a group of language-learning disordered (LLD) children and a group of children with normal language skills. The children in the normal language group were identified by scoring at or above the fifth national stanine on the vocabulary and listening comprehension sections of the Stanford Binet Achievement Test. All subjects in the language learning disordered group were identified as having a LLD before or in the first grade. The children in the experimental group were not required to take the Stanford Binet and were tested individually by the school psychologist using various materials. However, The Test of Language Development (TOLD) was used as a criterion for this study by each experimental subject having listening, speaking and spoken language quotients of 90 or less. Therefore, no child in the LLD group should have been misclassified.

Each of the seventeen subjects were required to respond to fifty items each on six tone pattern recognition tests. The subject's age, sex, Stanford Binet Achievement Test stanines (language skill section) ,TOLD quotients (Listening, Speaking and Spoken Language), total number of correct scores for each subtest, group mean scores, standard deviations, and range of scores for each subtest are shown in Table 2 and 3.

Intra-Subject Reliability

Two subjects were randomly selected from each of the two groups and retested one week from the original testing date. The results of the two individual administrations were used to determine intra-subject reliability.

To compute the percent agreement, the following formula was used:

$$\text{Percent agreement} = \frac{A}{A+D} \times 100$$

When : A = the number of agreements between the two administrations.
D = the number of disagreements between the two administrations.

Test- retest agreement for the two language learning disordered group children was 87 percent and 93 percent, while the test-retest agreement for the two normal group children was 94 percent and 99 percent. The percent agreement indicates a high reliability for both groups.

Improvement on the second administration ranged from one to six correct responses and on some tasks a decresase in performance

Table 2. Experimental subject's scores and identifying information. Arranged by Group (Grp), Experimental (E) , Subject number (ID), Age (year: month), and sex. Subjects standards score quotients on listening (L), Speaking (S) and Spoken Language (SL) subtests are shown from the Test of Language Development (TOLD). Scores for each subtest (S1-S6).

Grp	ID	AGE	SEX	L	S	SL	S1	S2	S3	S4	S5	S6
E	1	9:5	F	82	83	79	50	21	47	42	33	9
E	2	9:1	F	88	87	85	45	26	39	41	31	24
E	3	8:7	M	88	70	73	47	24	14	8	9	8
E	4	9:1	M	79	89	82	47	47	43	45	42	22
E	5	8:4	M	90	81	82	50	49	49	49	33	47
E	6	8:4	M	82	74	75	49	30	22	10	42	22

	S1	S2	S3	S4	S5	S6
Mean Scores	48.0	32.8	35.6	32.5	31.6	22.0
Standard Deviations	2.0	12.1	14.3	18.4	12.0	14.0
Range: Highest Score	50	49	49	49	42	47
Lowest Score	45	21	14	8	9	8

Table 3. Control subject's scores and identifying information. Arranged by Group, Control (C), Subject number (ID), Age (year: month) and Sex.
For Control group subjects, the stanine scores shown are from the Verbal (V) and Listening Comprehension (LC) subtests of the Stanford Binet Achievement Test. Scores for each subtest (S1-S6).

GROUP	ID	AGE	SEX	V	LC	S1	S2	S3	S4	S5	S6
C	9	8:4	F	5	6	50	50	38	39	46	39
C	10	8:2	F	5	5	50	49	42	45	28	33
C	11	9:1	F	6	9	50	50	46	46	43	44
C	12	8:7	F	5	8	50	38	46	42	49	46
C	13	9:1	F	6	7	48	49	42	39	42	42
C	14	8:9	M	7	7	49	48	45	44	41	40
C	15	8:4	M	6	8	50	47	37	31	28	29
C	16	8:1	M	5	5	47	50	45	40	36	8
C	17	8:6	M	6	8	48	47	44	34	39	26
C	18	8:8	M	5	7	50	50	48	36	39	49
C	19	8:8	M	8	6	50	50	50	45	39	49

	S1	S2	S3	S4	S5	S6
Mean Scores	49.2	48.0	43.9	40.0	38.8	36.8
Standard Deviations	1.1	3.5	3.9	4.9	6.6	12.2
Range: Highest Score	50	50	50	45	49	49
Lowest Score	47	47	37	31	28	8

was shown. However, subject # 1 improved twenty six points on subtest two, with a correct score of 21 on the first administration and a correct score of 47 on the second administration.

Statistical Analysis

Six t-tests were performed, one on each subtest, to determine if subject performances differed on individual subtests. Table 4. shows the mean scores, standard deviations and t-values for the two groups. Analysis of this data revealed statistically significant differences between group means on subtests two and six at the .05 level of confidence.

Ad hoc analysis was conducted using a Pearson Product Moment Correlation Coefficient to calculate if the factors of age and sex influenced subjects scores. The Pearson Product Moment Correlation Coefficient was calculated using individuals age and their scores and then again using their sex and their scores and finally using scores and a combination of age and sex.

Table 4. The six subtests, Mean scores, Standard deviations and t-values for the two groups.

Group	Mean	Std Dev	t-value
Subtest 1 (Oddball)			
Experimental	48.0	2.0	0.1075
Control	49.2	1.1	
Subtest 2 (Two pairs- Which pair is different?)			
Experimental	32.8	12.1	0.0013
Control	48.0	3.5	
Subtest 3 (Three single tones- Which tone is different, or are all the same?)			
Experimental	35.6	14.3	0.0873
Control	43.9	3.9	
Subtest 4 (Four single tones-Which tone is different?)			
Experimental	32.5	18.4	0.2080
Control	40.0	4.9	
Subtest 5. (Two tones- Is the second tone higher, lower, or the same as the first?)			
Experimental	31.6	12.0	0.1313
Control	38.8	6.6	
Subtest 6 (Three tones-Is each tone high or low?)			
Experimental	22.0	14.0	0.0387
Control	36.8	12.2	

Although subtest two correlation has a confidence level of .0022, which is a greater significance level than .05, it was the advice of the statistical consultant, that with such a small sample size, this T-value should not be considered significant. So subtest scores was determined not to be a function of age and/or sex. Table 5 shows the correlation and p-values of the Pearson Product Moment Correlation Coefficient.

In summary, the results of this analysis revealed that only two of the six tone pattern recognition tasks (subtests two and six) statistically separated between the language-learning disordered children and the children with normal language skills.

Table 5. The Correlation (r-value) and p-value of the Pearson Product Moment Correlation Coefficient on each subtest. As determined by subjects scores and both, age and sex.

Subtest	p-value	r-value
1	p= 0.3690	-0.14887
2	p= 0.0022	-0.47819
3	p= 0.1840	0.10899
4	p= 0.3075	0.10796
5	p= 0.3976	0.15780
6	p= 0.1508	-0.03706

Discussion

Although the mean scores for the two groups were different, with the control group subjects consistently showing a higher mean, there was a considerable amount of overlap in the range of scores between the two groups. The experimental (LLD) group children were more variable than the control (normal language) children on all subtests even though there were fewer children in the experimental group (6 subjects) than in the control group (11 subjects).

The tone pattern recognition test was found to statistically separate between the group of children identified as language learning disordered and the group of children with normal language skills on subtests two and six.

Because of the overlap in scores, the tone pattern recognition test does not appear to separate well between individual children but does separate between group performance.

Subtest one was the easiest of the six subtests and was not expected to separate between the two groups, rather it was expected to provide orientation to the remaining five tasks and allow the subjects to become accustumed to the high and low tones. Therefore it was not surprising to find the smallest standard deviation and the lowest range of scores on subtest one.

An explanation of why subtests two and six separated between the control and experimental groups may be due to the analytic strategies required of each. Subtest two presents two pairs of tones and the listener is asked to circle the pair that is different.

Therefore, the subject should be able to analyze the first two tones and then respond without listening to the second pair of tones, i.e., after listening to the first pair of tones, the listener should be able to decide if the second pair will be the same or different based on the pattern of the first pair. If the language-learning disordered child does not use the strategy of listening to only one pair of tones and predicting the pattern of the second pair, then he may be listening to all four tone prior to making his response. Subjects were not asked whether or not they used any such strategy, so that question is speculation only at this time. Three of the six subjects did well on this subtest, and three did poorly. This subtest has been shown previously to be an easy task for normal language children. On subtest two only one control group subject had more than three errors out of 50 while two LLD group subjects made three or fewer errors in 50.

Subtest six presents three tones and the subjects are asked to indicate if each tone is high or low. The subject has to analyize each tone, and remember the sequence or pattern of each item. This subtest has been shown to be the most difficult, hence, it was expected to separate between the two groups of children. The scores of one child in each group overlapped the range of scores for the other group. Table 6 shows the scores for all subjects on each subtest, arranged by number of correct responses.

Table 6. Scores for all subjects on each subtest, arranged by number of correct responses.

Subtest	Control Subjects	Experimental Subjects
1. Oddball -- Mark the low tones		
	50	50
	50	50
	50	49
	50	47
	50	47
	50	45
	50	$\overline{48.0}$ = Mean Score
	49	
	48	
	48	
	47	
	$\overline{49.2}$ = Mean Score	
2. Four Tones-(2 Pairs) Circle the pair that is different.		
	50	49
	50	47
	50	30
	50	26
	50	24
	49	22
	49	
	48	$\overline{32.8}$ = Mean Score
	47	
	47	
	38	
	$\overline{48.0}$ = Mean Score	

Table 6. (Continued)

Subtest	Control Subjects	Experimental Subjects
3. Three single tones--(Which tone is different or are all the same?)		
	50	49
	48	47
	46	43
	46	39
	45	22
	45	14
	44	
	42	$\overline{35.6}$ = Mean Score
	42	
	38	
	37	
	$\overline{43.9}$= Mean Score	
4. Four Tones--(Which tone is different.)		
	46	49
	45	45
	45	42
	44	41
	42	10
	40	8
	39	
	39	$\overline{32.5}$ = Mean Score
	36	
	34	
	31	
	$\overline{40.0}$ = Mean Score	

Table 6. (Continued)

Subtest	Control Subjects	Experimental Subjects
5. Two Tones--(Is the second tone higher, lower, or the same as the first tone?		
	49	42
	46	42
	43	33
	42	33
	41	31
	39	9
	39	
	36	31.7 = Mean Score
	36	
	28	
	28	
	38.8 = Mean Score	
6. Pinheiro. (Mark the three tones as high or low.)		
	49	47
	49	24
	46	22
	44	22
	42	9
	40	8
	39	
	33	22.0 = Mean Score
	29	
	26	
	8	
	36.8 = Mean Score	

Careful visual scrutiny was given to all subject's response forms to determine if a particular pattern of tones on any given subtest was consistently errored. It was found that on subtest five, subjects (E) # 5 and # 1 missed 7 of 8 and 8 of 8 respectively on the low-high pattern, while subject # 2 missed 10 of 17 on the high-high pattern. Subtest five had only four possible patterns, HH, LL, HL, and LH. Three of the six experimental group subjects or 50 percent had difficulty when the high tone was presented last or, in other words, 50 percent of the experimental group had more difficulty when deciding if the second tone was higher than the first tone or if both tones were high, rather than when both tones were low or the second tone was lower than the first. The control group did not appear to show a consistent pattern of error on any subtest.

The score sheet of subject #16 of the normal group was reexamined and on subtest number six, he was found to have 8 correct responses out of 50 but he had responded to 34 items out of sequence, i.e., Subject # 16 reversed 34 items of the 50, marking each high tone as low and each low tone as high. Therefore, this subject did not interpret the high tones as high and the low tones as low, but rather vice versa. If this subject was excluded from the study, the lowest score for the normal subjects would be 26 and only one of six LLD children exceeded that level of performance.

The operating characteristics of a test ,false positive and false negative classifications, measures of specificity and sensitivity, are discussed below in the case that this test may be used as an LLD screening tool. The high scores for the language-learning disordered group may be considered to be false positive responses, (normal processing abilities) while the lower scores for the normal group may be interpreted as false negative (poor processing ability) responses. For example, cut-off points were calculated by subtracting the standard deviation from the mean score for control group subjects for each subtest. When considering the designated cut-off point for each subtest, the experimental subjects were misclassified more times than the control subjects. Or, in other words, on subtests one and six the same number of subjects were misclassified, three and one respectively.

Subject #5 (E) was misclassified on each of the six subtests meaning that, he scored above the cut-off point for LLD performance and that his responses were atypical of the experimental group. However, subject #5 had the highest Listening quotient (90) of any of the experimental subjects on the Test of Language Development (TOLD). Therefore, this consistent misclassification could possibly be explained by this subject's ability to better process auditory simuli (tones).

Subjects #1 (E) and #4 (E) were also misclassified on four of the six subtests. Subject #4 was found to have the highest speaking quotient than any of the experimental subjects on the TOLD.

Subtests two and six were found to have the least misclassifications of any of the six subtests, with subtest two misclassifying subjects #4 and #5 and subtest six misclassifying #5. With the above explanations of why subject's #4 and #5 may have been misclassifyied (Due to higher quotients on the speaking or listening sections of the TOLD), then when these two subjects are eliminated, no experimental subjects were misclassified on the two subtests that were shown to statistically separate between the two groups of children.

The sensitivity of the tone pattern recognition test as a screening tool for LLD children with auditory processing difficulties has the lowest sensitivity on subtest one (range of two) and the highest sensitivity on subtest six (range of twenty-three but, only for one subject-#5). The remaining four subtests have a range of 5.5 to 15.9 for the experimental subject's scores.

A larger population of the LLD group and normal children need to be tested before one could determine the probable percentage of false classifications.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Summary

The purpose of this study was to determine if performance scores on a tone pattern recognition test differed between a group of language learning disordered children and a group of children with normal language skills.

The study included a total of seventeen children, six in an experimental (LLD) group and eleven in a control group. All subjects in the control group were identified as having normal language skills by scoring at or above the fifth national stanine on the listening comprehension and vocabulary sections of the Stanford Binet Achievement Test. The experimental group children each had a quotient of 90 or lower on the listening, speaking and spoken language sections of the Test of Language Development (TOLD). The experimental subjects had been identified as language-learning disordered prior to or in the first grade by the school psychologist. This group was not required to take the Stanford Binet Achievement Test due to receiving special services (language therapy). All subjects passed a pure tone audiometric screening task and were in appropriate grade placement for age.

Analysis of the data included a t-test for each subtest, a

Pearson Product Moment Correlation Coefficient, and the percent agreement of test-retest scores (a measure of reliability).

Results of the study indicated that group mean scores were consistently higher for the control group on each of the six subtests, but only subtests two and six statistically separated between the two groups of children. Although group membership affected subject's scores, age and sex were not shown to be factors significantly influencing scores.

Conclusions

Considering the relatively small subject population, and the results from this study, only tenative conclusions can be drawn. Two subtests, the two pairs of tones (subtest #2) and the Pinheiro (subtest #6), statistically separated between the language learning disordered children and the children with normal language skills. Within these groups, scores were not a function of age or sex. Further research is needed to provide more information about the performance of LLD children and measures of central auditory processing as the tone pattern recognition test is purported to be.

Limitations

The following limitations should be considered when interpretating the results of this study:

1. The number of subjects included in this study was small and may not be a true representation of the total populations of interest.

2. Although there was a difference in mean scores on each

subtest, only subtest two and six statistically seperated between the control and experimental groups. Therefore the tone pattern recognition test as now constituted may not be an appropriate screening tool for children having central auditory processing disorders.

3. Whether or not the children understood the directions was not officially tested.

4. The author attempted to test a larger population, but, due to lack of cooperation and time constraints in school timing, only six experimental subjects were available.

5. None of the subjects were identified as having physcial , overt neurological, or psychologically problems but there may still have been different etiologies of the language-learning disorders.

Suggestions for Further Study

With this behavioral response method it is not possible to determine whether or not the children developed a strategy in listening for patterns. A physiological (cortical) response would indicate where the child made the critical judgements , for example, on the two pairs of tones of subtest two or on the four single tones of subtest four.

Therefore, the tone pattern recognition test could be administered to a larger subject sample size and instead of a behavioral response method use a physiological response method.

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VITA

Charlene Marie Rowland was born in Chattanooga, Tennesses on August 22, 1965. She attended public school in Bridgeport, Alabama and graduated from high school in 1983. The following August she entered Northeast Alabama State Junior College, Rainsville, and graduated with an Associates degree in 1985. In August of 1985 she entered The University of Alabama, Tuscaloosa and received the Bachelor of Arts degree in Communicative Disorders in August 1987.

In the fall of 1987, the author entered Graduate school at The University of Tennessee, Knoxville. She received her Master of Arts degree in Speech pathology in December 1988.