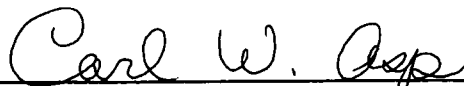
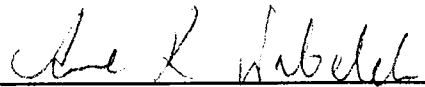


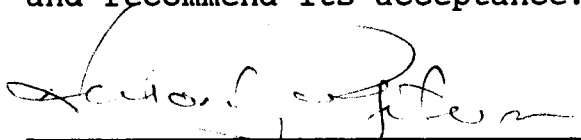
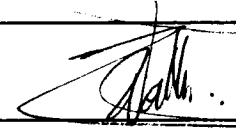
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We are submitting herewith a dissertation written by Frederick Hall entitled "Comparison of the Listening Skills of Third Grade Children with Learning Disabilities and Normal Learning Abilities for Word Identification In Noise, Digit Recall, and Imitation of Syllable Rhythm Patterns." We have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Speech and Hearing Science.

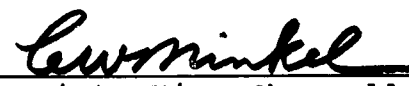
  
Carl W. Asp, Major Professor

  
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We have read this dissertation  
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12

COMPARISON OF THE LISTENING SKILLS OF  
THIRD-GRADE CHILDREN WITH LEARNING DISABILITIES  
AND NORMAL LEARNING ABILITIES FOR WORD IDENTIFICATION IN  
NOISE, DIGIT RECALL, AND IMITATION OF SYLLABLE RHYTHM PATTERNS

A Dissertation  
Presented for the  
Doctor of Philosophy Degree  
The University of Tennessee, Knoxville

Frederick Hall

May 1995

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## DEDICATION

This dissertation is dedicated in memory of my friend and professor, Dr. Sol Adler.

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To my family; Roberta, Lisa, Frederick, and Cameron for their continued and unrelenting support.

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## ABSTRACT

The Speech Perception In Noise (SPIN) test, Auditory Sequential Memory (ASM) test, and the Hall Auditory Rhythm Test (HART) were used to assess listening and imitation skills of third grade children. The third graders were identified as children with learning disabilities (subsequently called LD) and children with normal-learning abilities (subsequently called NL).

There were thirty-five LD and fifteen NL from Knox County Public Elementary Schools, Knoxville, Tennessee. All children satisfied the following criteria: (1) enrolled in third grade; (2) normal hearing; (3) type A tympanograms; (4) IQ scores of 85 or above; (5) intelligible conversational speech; (6) English as the primary language; (7) normal social behavior; and (8) not taking medication for attention or behavior problems. The LD children were identified by Knox County school personnel using the criteria for learning disability from the 1993 Tennessee State Special Education Manual. In addition, the LD were enrolled in a resource program a minimum of five hours a week.

All subjects were seen individually during two separate test sessions. Each session lasted approximately 25 minutes. During the first test session each subject was administered the SPIN and the ASM tests. During the second test session each subject was administered the HART. The HART was developed for the present study to assess children's ability to imitate

various syllable rhythm patterns. The test consisted of 5-6 syllable rhythm patterns versus 7-9 syllable rhythm patterns at either a normal speaking rate or a slow speaking rate.

Results of analyses of variance revealed a significant interaction between the two groups (LD and NL) and three tests scores (SPIN, ASM, and HART). For all three tests, the LD group performed poorer than the NL group, but the difference in scores were the greatest for the HART.

Ward's Method of Hierarchical Clustering Analysis revealed that the LD separated into two subgroups; an upper level (LD-UL) and a lower level (LD-LL). The mean scores for the three groups, NL, LD-UL, and LD-LL, and for all three tests were compared with a three-factor analysis of variance. For the SPIN test, the mean scores for the LD-UL and LD-LL subgroups were not significantly different. However, for the HART and the ASM test, the mean scores for the LD-UL and LD-LL were significantly different.

In summary, the results from this study indicated a significant difference in listening skills of children with learning disabilities and normal-learning abilities for word identification in noise, recall of digits, and imitation of syllable rhythm patterns. In addition, the LD group separated into two distinct subgroups based on listening skills. The separation of the two groups on the HART is an important finding, because the HART is a non-linguistic test that can be used with pre-school and school-age children. Of the three

tests, the SPIN and ASM were established tests; the HART was a new test. All three tests utilized in the present study can be used by appropriate public school personnel to evaluate children with learning disabilities. The implications of these findings are discussed. The implications for treatment of children with learning disabilities were reviewed.

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## CHAPTER I

### REVIEW OF LITERATURE

#### 1.1 Review of Literature

##### 1.1.1 Learning Disabilities

The field of learning disabilities (LD) has been described by a diversity of opinions about the nature of the problem, etiology, terminology, methods of assessment and treatment (Gerber & Bryen, 1981). The National Joint Committee of Learning Disabilities (NJCLD) adopted a revised definition:

learning disabilities is a general term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning or mathematical abilities. These disorders are intrinsic to the individual and are presumed to be due to central nervous system dysfunction (NJCLD, 1988, p.1).

Attempts have been made (Chermak & Musiek, 1992; Cherry & Kruger, 1983; Elliott, 1979; Elliott, Hammer, & Scholl, 1989; Ferre & Wilber, 1986; Musiek, Geurkink, & Kietel 1982; Pinheiro, 1977; Tallal, 1980) to determine the causes of the disability, to define subgroups of LD children with similar perceptual deficits and to develop guidelines for rehabilitation. Many currently used tests are very complex and cannot be performed in school settings. The kinds of tasks which may have relevance in identifying the problems exhibited by LD children are the perception of speech in poor listening conditions, auditory sequential memory tasks, and the perception/imitation of syllable rhythm patterns. These are

the tasks to be investigated in the present study assuming that a test battery of this nature may help identify a remedial direction for children with learning disabilities. Children with learning disabilities (subsequently called LD) and children with normal learning abilities (subsequently called NL) were identified in the text.

Pinheiro (1977) used a battery of central auditory processing tasks (binaural fusion, low-pass filtered words, competing sentences, simultaneous sentences, staggered spondee words and pitch patterns) to evaluate children with learning disabilities. Her results indicated a definite pattern for the LD children. All subjects had difficulty with the same tasks with scores varying only in degrees of severity. However, the simultaneous sentences and pitch patterns proved to be the most difficult of the test battery.

Ferre and Wilber (1986) evaluated central auditory processing skills within and across three groups of children on an experimental battery of central auditory processing tests. The three groups were: (1) LD children with presumed auditory impairment (LD/LD); (2) LD children with normal auditory skills (LD/N); and (3) normal learners (NL). The test battery included low-pass filtered speech, binaural fusion, time-compressed speech, and dichotic monosyllables. Ferre and Wilber (1986) results revealed that on all tests the LD/LD group mean score was significantly lower than that of the NL's and of LD's with normal auditory skills (LD/N).

Elliott and Hammer (1988) found that the performance of normally-progressing children was significantly better than that of learning disabled children for voice onset time (VOT) and place-of-articulation discrimination of syllables [ba-da-ga]. Two groups of children were tested over a three year period, one progressing normally and the other exhibiting language-learning problems. The children's ages ranged from six to nine years. Each group was tested on a set of fine-grained auditory discrimination tasks that required listening for small acoustic differences among the CV syllables. The children with language-learning problems showed significantly poorer auditory discrimination than normal children for temporally based acoustic differences. Elliott, Hammer, and Scholl (1989) used voice onset time (VOT) and place-of-articulation as measures of fine-grained auditory discrimination with consonant-vowel stimuli to correctly classify children as progressing normally in school or as demonstrating language-learning difficulties.

Children with learning disabilities (LD) frequently exhibit poor attention and have comprehension problems that interfere with their ability to gain meaning from spoken or written language (Wren, 1983). They have poor memory and inadequate strategies for organizing and using language skills (Montgomery, 1990; Parrill-Burnstein, 1981). LD children experience difficulties understanding spoken language in the classroom, and the language used around them by their

classmates (Lasky, 1983). Children diagnosed as learning disabled may demonstrate major difficulties in language use, referred to as verbal or language learning disabilities (Laughton and Hasenstab, 1986).

Recently an integrated approach involving neuropsychological information gained from assessments has provided diagnostic information with this population. Pirozzolo (1981) and Strom et al. (1987) have reported that auditory discrimination deficits have been consistently associated with learning disabled children. Therefore, it seems appropriate to examine the role of auditory processing with this population.

#### 1.1.2 Auditory Processing

Lasky and Katz (1983) refer to auditory processing as the manipulation and utilization of sound signals by the central nervous system which involves a range of activities from awareness of the presence of sound to the analysis of linguistic information. Keith (1988, p. 1218) gave a list of terms and definitions to represent those auditory processing abilities which are most frequently assessed by central auditory tests. This list is given in Appendix A.

Keith (1988) suggested that the list should not be considered complete since other authors had included additional skills as being related to auditory processing. For example, Zigmond (1968) defined two other skills as auditory processes. These were analysis and sequentializing. She

defined analysis as the process of reducing connected speech into its component parts while sequentializing was described as differentiating between two sound patterns or sequences. In a study, Hall and Asp (1994) reported that a difference existed between learning disabled children and normal learners for listening/imitation skills of syllable rhythm patterns. Handel (1989) defines rhythm as the alternation and sequence of strong and weak elements and rate as the number of syllables spoken per second. The number of elements pertains to the length of the sequence and memory is the mental ability to recall information (Keith, 1988).

Musiek, Geurkink, and Kietel (1982) assessed auditory perceptual dysfunction in children using a battery of seven central auditory processing tests (rapidly alternating speech perception, binaural fusion, low pass filtered speech, staggered spondaic word test, competing sentences, dichotic digits, and frequency patterns). The results were similar to those reported by Pinheiro (1977) and indicated that the frequency pattern test was the most sensitive for detecting auditory processing problems in children.

Attempts to understand the nature of LD children have included the application of Central Auditory Nervous System (CANS) tests to study auditory processing. Many tests used with LD children, such as, binaural fusion, low-pass filtered words, and time-compressed speech require too complex equipment for use in school settings. In addition, many of

these test such as, alternating speech perception test, simultaneous sentences, and auditory/brain response do not provide information regarding remedial strategies. Some easier to administer tests such as Speech Perception In Noise (SPIN), (Kalikow, Stevens, & Elliott, 1977; Bilger, Neutzel, Rabinowitz & Rzeczkowski, 1984), and the Auditory Sequential Memory (ASM) test (Kirk, McCarthy, & Kirk 1968) appear to be useful in the identification of specific difficulties of the LD children. The SPIN and ASM tests could be easily used in public schools.

#### 1.1.3 Speech Perception In Noise (SPIN) Test

The SPIN test was developed to asses "everyday" speech reception in adults (Kalikow, Stevens, & Elliott, 1977; Bilger, Neutzel, Rabinowitz & Rzeczkowski, 1984). In addition to measuring word intelligibility, the SPIN test measures a cognitive component of speech understanding using "high predictability" (HP) and "low predictability" (LP) sentences. The HP sentences have two or three "pointer" words that provide semantic links to the key words. The LP sentences contain no semantic clues. The 25 HP and 25 LP sentences are randomly intermixed in one SPIN test. There are 10 different SPIN test lists. Sentence length does not exceed eight syllables and the listener's task is to repeat (or write down) only the final word which is always a monosyllabic noun. The SPIN Test uses pre-recorded sentences that are spoken by a male speaker mixed with a multibabble of 12 voices presented

at a signal-to-babble ratio of +8 dB.

It has been demonstrated (Elliott, 1979, Cherry & Kruger, 1983) that LD children have greater difficulty perceiving speech in background noise than normally-developing children. Elliott (1979) evaluated the performance of children progressing normally aged 9 to 17 years on the SPIN test. Different signal-to-babble ratios were used such as -5 dB, 0 dB, and +5 dB. The children in the younger age groups performed significantly poorer than children in the older age groups for the high predictability sentences at 0 dB signal-to-babble ratio. For 0 dB and +5 dB signal-to babble ratio, she compared 9-year olds with learning problems to 9-year olds progressing normally. The results showed that the 9-year olds with learning problems performed significantly poorer than the normally progressing 9-year olds.

Cherry and Kruger (1983) compared the selective auditory attention skills of learning disabled children and normal achievers aged seven through nine years. The task consisted of pointing to the appropriate picture of a monosyllabic word presented diotically. The task was always presented first in quiet and then under three noise conditions: 1) white noise, 2) speech backwards, and 3) speech forward. The results indicated that under the three noise conditions the LD's performed significantly poorer than the normal children. In the quiet condition, the LD and normal children performed very similarly.

It was speculated that reasons for difficulties experienced by children with learning disabilities are related to lack of knowledge regarding linguistic rules (Elliott, 1979), as well as semantic distractors having a significant effect on selective auditory attention (Cherry & Kruger, 1983).

#### 1.1.4 Rate of Presentation

One of the major elements of listening and imitating speech rhythm is the rate of presentation (Darrow, 1984). Studies have demonstrated that auditory comprehension may be related to presentation rate for children with language/learning disabilities (Campbell & McNeil, 1985; Lasky & Chapandy, 1976; McNutt & Li, 1980; Tallal & Piercy, 1974).

McNutt and Li (1980) had normal learners and learning disabled children listen and repeat words at a normal rate (four syllables per second), at 60% and 30% compression, and at 30% and 60% expansion. Normal learners repeated the sentences equally well at all rates and were more accurate than the learning disabled group at each rate. The children with learning disabilities were significantly poorer at repeating the sentences at all rates than the normal children. These authors also indicated that the learning disabled children were found to have selective difficulty with rapidly presented auditory material as compared to normal children, but their performance did not improve with the slower rates of presentation. Campbell and McNeil (1985) investigated the

effects of presentation rate of sentences in children identified with a language disorder. The investigators presented sentences at a normal reading rate of speech (170 words per minute) and then at a time expanded rate of 75%. Campbell and McNeil concluded that slowing the presentation rate of the sentences significantly improved auditory comprehension. In addition, Campbell and McNeil (1985) suggested that the slower rate may allow even a disordered system to allocate the necessary attention to complete the task at a more adequate level.

#### 1.1.5 Memory

Many children with learning disabilities have poorer short-term memory than normally developing children (Torgesen, 1981). Short-term memory is the ability to hold information in the mind for a relatively short period of time before retrieval (Lerner, 1976). It has been demonstrated by Rudel & Denckla, 1974; Swanson & Trahan, 1990; Torgesen, 1988; Torgesen, Rashotte, & Portes, 1991 that children with learning disabilities perform poorly on digit span tests.

Memory is a mental ability to recall learned behavior (Berry, 1980). Memory span is the maximum number of items an individual is able to reproduce or recall in a proper sequential order (Wren, 1983). Torgesen (1981) declared that memory deficits are universal to learning disabled children. Alder (1983) indicated that the use of digit span testing was an effective way for identifying children with normal and

abnormal auditory retention abilities. Miller (1956) suggested that the memory span of adults is limited to seven unrelated items, plus or minus two and the only way in which this limit may be expanded is to recode or reorganize new information into meaningful units. Rudel and Denckla (1974) found the average Wechsler Intelligence Scale for Children (WISC) digit span scale score of 7.7 for children 10 years of age with learning disabilities to be significantly lower than the scale score of 9 to 11 for normal developing children of the same age.

Torgesen (1988) tested three groups with the same age and IQ: 1) LD children with severe performance problems on memory span tasks (LD/S); 2) LD children who did not have a memory span deficit (LD/N); and 3) normal learners (NL). His results indicated the LD/S children showed substantial performance deficits that differed from the performance of the two other groups on tasks requiring short-term retention of sequences of familiar verbal information presented aurally. However, the LD/S children performed very similar to the two other groups on tasks requiring the immediate recall of abstract (unfamiliar) visual information, on tasks that allow semantic encoding of items, or on recognition memory tasks. The LD/N children and normal learners did not differ significantly from each other on any of the task.

Swanson and Trahan (1990) found that learning disabled readers were significantly poorer than nondisabled readers, on

a memory task of recalling the last word in a series of three sentences. Torgesen (1991) investigated the effects of rate of presentation (4 items/sec vs 1 item/sec) on short-term memory skills for three different groups of children 9-11 years of age. The groups consisted of: 1) children with learning disabilities/severe (LD/S) with memory scores below the average range of 9 and 11 as measured by the Wechsler Intelligence Scale for Children Revised (WISC-R) or below the average score of 32 and 40 on the Auditory Sequential Memory test of the Illinois Test of Psycholinguistic Abilities (ITPA, Kirk, McCarthy, & Kirk, 1968); 2) children with learning disabilities/normal (LD/N) with memory performance in the normal range; and 3) normal academic achievers (N/N) making normal academic progress, as well as having performed in the normal range on the Digit Span subtest. All learning disabled children had been diagnosed as having a variety of other processing disorders involving perceptual-motor functions, language skills or attention. The LD/N and N/N were not significantly different from each other on either the rate of 4 digits/second or 1 digit/second. However, the LD/N and N/N groups were significantly different from the LD/S group on both presentation rates. Also, recall for the LD/N and N/N groups, both with normal memory, was significantly higher than that of the LD/S. All three groups (LD/N, LD/S, and N/N) scored lower for 1 digit/second compared to 4 digits/second. It can be concluded that LD/S children tend to show a deficit

with short term memory on recalling of non-linguistic items in a string of stimuli.

#### 1.1.6 Rhythm and Intonation

Rhythm and intonation of spoken language, which are two parameters of suprasegmentals, serve as the basis for listening and spoken language (Asp, 1985; Crystal, 1981; Guberina & Asp, 1981). The meaning of an utterance is transmitted using rhythm and intonation not only in infant speech but in adult spoken language as well (Guberina & Asp, 1981). Rhythm is defined most broadly by Allen and Hawkins (1980, p.227) as "the structure of sequence". The structure is composed of units which may consist of syllables, words, phrases, or paragraphs which occur in sequence (Allen & Hawkins, 1980).

Rhythm can be described as a set of relationships among units of speech. Units consist of syllables, words, phrases, or paragraphs. The most important concept regarding rhythm is that the units occur in a sequence (Allen & Hawkins, 1980). In other words, it is the structure of the sequence that determines the rhythm that we as listeners perceive.

#### 1.1.7 Perception of Rhythm

It has been suggested that our ability to perceive rhythm is innate. When we hear a sequence of pulses (clicks or a heartbeat) we hear it as rhythmic. Asp (1994) suggested, that individuals learn to internalize speech rhythms through proprioceptive perception and memory, with the vestibular

system. The perceptual responses of rhythm might be emotional, behavioral, or physiological (Handel, 1989). What musicians, carpenters, basketball players, and dancers have in common is an appreciation of rhythmic patterns. In the same way, speech rhythms emerge from various rhythmic levels; there is the rhythm of syllables, words, phrases, and sentences (Handel, 1989). We perceive spoken language as rhythmic because it is fairly regular in its sequence of sound patterns (Allen, 1975). One of the most important suprasegmental features of speech rhythm is the temporal organization of speech sounds (Darrow, 1984).

Some research studies investigated the performance and perception of rhythm between normal and hearing impaired subjects. Sterritt, Camp, and Lipman (1966) demonstrated that hard-of-hearing children's performance on a rhythm imitation task was significantly poorer than that of normal hearing children. Rileigh and Odom (1972) studied the relationship between hearing and rhythm perception. Subjects were presented with visual rhythmic patterns of varying complexities and asked to reproduce the rhythms on a telegraph key. No differences were found due to hearing status, however, normal hearing and hearing impaired subjects had different developmental rates of rhythmic skills. The results indicated that hearing deprivation delayed the developmental process for the hearing impaired, therefore, slowing down their ability to acquire rhythm patterns. Koike (1981) evaluated prelingual

deaf children's ability to categorize and imitate monosyllabic, trochaic, and spondaic stress patterns using the Modified Children's Auditory Test (MCAT). The results found no significant difference between the mean categorization scores before and after training; however, there was a statistically significant difference among either pre or post-test scores in the imitation of monosyllabic, trochaic, and spondaic stress patterns. The imitation score was the best for the monosyllabic patterns and the poorest for the trochaic patterns. Darrow (1984), studied the imitation of melodic rhythms with normal and hearing impaired children and found significant differences between the two groups. Hearing impaired children were not able to imitate melodic rhythms or rhythm patterns as well as the normal hearing children.

Shadden et al. (1980) administered the Templin-Darley Test of Articulation and the Test of Rhythm and Intonation (TRIP) to two groups of children. One group consisted of children with adequate articulation skills, while the other group consisted of children with inadequate articulation skills. However, differences between the adequate (79%) and inadequate (69%) groups in terms of the mean percent correct and the correlation between the TRIP and the Templin-Darley scores within groups were statistically nonsignificant. Tucker (1987) investigated the effect of right hemisphere damage (RHD) on imitation of the prosodic patterns of rhythm, tempo, and intonation. The Tennessee Test of Rhythm and Intonation

(T-TRIP) was presented to nine RHD adults and to nine neurologically normal adults. A statistically significant difference was found between the two groups on this imitation task. Tucker concluded that imitation of prosodic patterns consisting of linguistically nonmeaningful stimuli by right hemisphere damaged adults is significantly poorer from that of neurologically normal adults.

Perception of rhythm by children with learning disabilities has been routinely evaluated by clinicians in Knox County Schools. These clinicians observed that children with learning disabilities have difficulty understanding speech in a noisy environment, have reduced utterance length, and have problems understanding speech at different speaking rates (Kline & Thurman, 1994). The clinicians who are testing rhythm perception, also provide training to facilitate the perception of rhythm. The reports of these clinicians indicated that LD children improve in the perception of speech rhythms, and speech processing.

It has been speculated that poor perception of rhythm might be related to difficulties in perception of speech. Speech consists of rhythmic patterns that are ordered or non-ordered sequences of strong and weak elements (Fowler, 1983). The importance of rhythm and intonation to the intelligibility of speech was recognized by Alexander Graham Bell (1916, p.15):

Ordinary people who know nothing of phonetics or elocution have difficulty in understanding slow speech composed of perfect elementary sounds, while they have no difficulty in comprehending an imperfect gobble if only the accent and rhythm are natural.

#### 1.1.8 Rhythm and Intonation Tests

Two tests of rhythm and intonation were constructed in the University of Tennessee's Department of Audiology-Speech Pathology: 1) Tennessee-Test of Rhythm and Intonation Patterns (T-TRIP) and 2) Tennessee-Test for Words and Nonsense Suprasegmental Patterns (T-TWANS-P).

Koike and Asp (1981), developed the Tennessee Test of Rhythm and Intonation (T-TRIP) to measure pre-school children's (ages three to five) ability to imitate suprasegmental patterns. The test consisted of 25 items that varied in rhythm and/or intonation, and used the repeated nonsense syllable /ma/. The rhythm patterns had two levels of stress (stress and unstressed), and two levels of tempo (regular and quick). The intonation patterns were either high, medium, or low pitch with a gradual or fast rising and falling pattern. The results revealed that the mean percent correct score for the five-year-olds (86%) was significantly greater than the mean score for the three-year-olds (60%). It was determined that the degree of difficulty on rhythm patterns increased as the number of syllables for the test items increased. When rhythm patterns contained at least six syllables, the three year-olds scores ranged between 20% and 30% correct, whereas, the five year-olds scores ranged between

80% and 100%. Koike and Asp (1981) suggested the differences in performance could be attributed to the five year-olds memory span being more developed than the three year-olds. The five year-olds also scored significantly better on the tempo section than the three year-olds. Test items became more difficult as the tempo was changed from normal to quick. The mean percent correct scores for the rhythm, tempo, and intonation sections were 91, 77, and 81% for the five year-olds and 66, 33, and 60%, respectively, for the three year-olds. In conclusion, Koike and Asp (1981) suggested that younger children (three years-of-age) are still developing the ability to imitate rhythm and intonation patterns, and obviously also developing language patterns.

Erkert (1980) developed the Tennessee Test for Words And Nonsense Suprasegmental Patterns (T-TWANS-P). This test included both words and nonsense syllables that reflected the rhythm and intonation patterns of speech. Erkert's test was based on work done by Koike (1977). The word subtest consisted of ten sentences that were grouped according to 3,5,7,9, and 10 syllables, e.g., "Has daddy finished dinner?" An equivalent nonsense syllable pattern was made for each of these sentences using the nonsense syllable /ma/. The rhythm patterns had two levels of stress (stressed and unstressed) along with two levels of tempo (regular and quick). The intonation patterns had three levels of pitch (low, medium, or high).

Erkert's results were similar to those of Koike and Asp

(1981) with the mean percent correct of the five year-olds (52%) significantly better than of the three year-olds (35%) for both nonsense syllables and words. However, Erkert's study revealed that both age groups performed significantly better for imitating word patterns than nonsense syllable patterns. Thus, suggesting that the syntax and semantic cues of words facilitated perception and imitation of rhythm and intonation patterns.

In a recent pilot study, by school clinicians, the T-TRIP test items were found to be too easy for most of the LD children because the test items did not separate the LD from the normal children. However, there were more errors made for longer (9 syllables) sequences than for the shorter (3 syllables) sequences. This indicates that relatively long sequences (6 to 9 syllables) should be used to challenge subjects.

#### 1.1.9 Summary

Studies have indicated that children with LD are a heterogeneous group. Some appear to have difficulty in short-term memory, attention span, sequencing ability, temporal perception, or auditory processing. Syllable rhythm patterns have not been investigated with school-age learning disabled children although some research has been done with syllable rhythm patterns involving normal and hearing impaired children.

Speech language pathologists, special educators, resource specialists, audiologists and classroom teachers should be aware of easy-to-administer tests which will provide intervention strategies to enhance learning. A need exists for further research of auditory processing of learning disabled children and how processing deficits may be facilitated by imitation of syllable rhythm patterns. The use of imitation in treatment may be more efficacious with a better understanding of syllable rhythm in normal and disordered populations as suggested by Loeb & Allen, 1993.

## CHAPTER II

### RATIONALE, PURPOSE OF STUDY, AND RESEARCH HYPOTHESES

#### 2.1 Rationale

It has been demonstrated that some children with learning disabilities have auditory processing problems (Cherry & Kruger, 1983; Elliott, 1979; Elliott, Hammer, & Scholl, 1989; Ferre & Wilber, 1986; Musiek et al., 1982; Pinherio, 1977). Current tests, such as binaural fusion, low-pass filtered words, competing sentences, and simultaneous sentences, used for testing the Central Auditory Nervous System (CANS) in children have provided inconclusive results. Separation of children with learning disabilities from normal learners has not always been accomplished. Furthermore, none of the above tests and such tests as aural reflex test, auditory brainstem response, or pitch patterns provide information regarding remediation techniques. CANS tests are very specialized and generally require specialized expertise and a test booth to administer. Therefore, these tests are not practical for public school settings. In addition, public school clinicians regard CANS tests to be part of a test battery generally requiring the expertise of an audiologist. The present study was designed to determine what type of information the SPIN test, ASM test and HART provide. Also, to assess how this information can be useful as a test battery. The three selected tests are easy to administer and their results can provide directions regarding rehabilitation.

## 2.2 Purpose of the Study

The purposes of this study were as follows:

- 1) To assess children with learning disabilities and normal learners listening skills using the Speech Perception In Noise (SPIN) and Auditory Sequential Memory (ASM) tests.
- 2) To design and utilize the Hall Auditory Rhythm Test (HART) to assess children with learning disabilities and normal learners ability to imitate spoken syllable rhythm patterns with different rates and numbers of elements.
- 3) To determine if a relationship exists among the test scores of the SPIN, ASM, and HART.

## 2.3 Research Hypotheses

- 1) With respect to the word identification in sentences presented at +8 dB signal-to-babble ratio, there will be a significant difference in word identification scores (percent correct on the SPIN test) between children with learning disabilities (LD) and normal learners (NL).
- 2) With respect to short-term memory recall with digits, there will be a significant difference between memory scores (percent correct on the ASM test) between children with learning disabilities (LD) and normal learners (NL).

3) With respect to the listening/imitation of syllable rhythm patterns, there will be a significant difference in syllable rhythm pattern scores (percent correct on the HART), between children with learning disabilities (LD) and normal learners (NL).

4) With respect to the listening/imitation of syllable rhythm patterns, there will be an interaction (percent correct on the HART) among: A) three groups [\*lower level (LD-LL) upper level (LD-UL), and normal learners (NL)]; B) two rates (normal and slow); and C) numbers of elements (5-6 and 7-9).

5) With respect to the listening/imitation of syllable rhythm patterns, there will be a significant difference in syllable rhythm pattern scores (percent correct on the HART) for each of the following main factors:

- A) Groups (\*lower level (LD-LL), upper level (LD-UL), and normal learners (NL);
- B) Speaking rates (normal and slow); and
- C) number of elements (5-6 and 7-9).

Research hypotheses 1, 2, and 3 will be analyzed using a one-factor analysis of variance (ANOVA). Hypotheses 4 and 5 will be tested using a three-factor analysis of variance (ANOVA), (Bruning & Kintz, 1977).

\*represents a subgroup of the LD subjects based on a hierarchical clustering analysis

## CHAPTER III

### METHODS

This study was designed to assess word identification in noise, short-term memory recall of digits, and imitation of syllable speech rhythm patterns of children with learning disabilities and normal-learners.

#### 3.1 Subjects

Subjects selected for this study were thirty-five children with learning disabilities (LD) and fifteen normal-learners (NL). All subjects were identified from eleven different Knox County Public Elementary Schools, Knoxville, Tennessee (Appendix B). All subjects satisfied the following criteria:

- 1) enrolled in third grade;
- 2) had normal-hearing determined by pure-tone testing at 25 dB HL at 1000, 2000, and 4000 Hz.;
- 3) had normal typanograms at time of testing;
- 4) had general intelligence in the average range (full scale IQ score of 85 or above) as determined by the Wechsler Intelligence Scale for Children-3 (WISC-3) or by the classroom teacher's assessment.
- 5) had intelligible conversational speech as judged by the examiner;
- 6) spoke standard English and resided in a household where standard English was the first language;
- 7) were not receiving any prescribed medication; and

8) had normal social behavior in the classroom as judged by the classroom teacher

#### 3.1.1 Learning Disabled

The experimental subjects for this study were thirty-five children with learning disabilities (LD). These children were identified by the school principal and the resource teacher. The children with learning disabilities met the following criteria:

- 1) were enrolled for special education services according to the Tennessee State Special Education Manual (1993) (see Appendix C);
- 2) were in a regular classroom but enrolled in a resource program for a minimum of five hours per week.

#### 3.1.2 Normal Learners

The control subjects for this study were fifteen normal-learners as judged by their classroom teacher. Normal learners had general intelligence in the average range (85 or above) as determined by the classroom teacher's assessment and were reading at grade level.

### 3.2 Pilot Study I

Hall and Asp (1993) completed a pilot study to determine the appropriate methods and procedures needed to administer a rhythm test. Four children with learning disabilities (LD) and nine normal learners (NL), between the ages of five and twelve participated in this pilot study. A speech rhythm pattern test of 20 items was created to evaluate the listening/imitation

responses of the two groups. The rhythm patterns contained 5-6 and 7-9 elements. The overall test score for the LD group was 45% compared to 77% for the normal learners. On part I (5-6 elements) the learning disabled group scored 60% and the normal learners scored 92%. On part II (7-9 elements) the LD's scored 30% and the normal learners scored 62%. For both the learning disabled and normal learner the 10 to 12 year-olds scored higher, than the five to six and seven to nine year-olds, on both parts of the speech rhythm test.

The results from this pilot study indicated that differences existed between learning disabled children and normal learners for listening/imitation skills of speech rhythm patterns. As the number of elements increased, the task became more difficult for both groups.

### 3.3 Pilot Study II

Hall (1994) completed a second pilot study to determine if the rate at which the stimuli were presented would affect LD children's ability to imitate rhythm patterns. Five children with learning disabilities, between the ages of nine and ten, participated in this pilot study. The Hall Auditory Rhythm Test (HART) was administered and scored by the public school resource specialist. Forty items divided equally among 5-6 and 7-9 elements were played back at a normal and slow conversational rate to each subject from a Panasonic cassette tape recorder, model number RQ-323AS and presented through earphones.

The five LD subjects obtained a mean score of 75%, with a range of scores from 43% to 83%. For the 5-6 elements, the mean score was 86% for the normal and 80% for the slow rate. For the 7-9 elements, the mean score was 78% for the normal and 48% for the slow rate.

The results of pilot study II substantiates the results of pilot study I, indicating that the number of elements increased the task difficulty for children with learning disabilities. In addition, the slow rate produced poorer scores (6% and 30% poorer) than the normal rate. It is speculated that the scores for the slow rate and greater number of elements were affected by the time required for processing in short-term memory.

#### 3.4 Hall Auditory Rhythm Test (HART)

Based on pilot studies I and II, a new speech auditory rhythm test (see Appendix D) was developed and identified as the Hall Auditory Rhythm Test (HART). The test used the research data of Rook (1993), who evaluated children with learning disabilities using rhythm items. The HART was designed for the purpose of placing an inexpensive assessment tool at the disposal of public school clinicians. The test items of the HART were recorded by a male talker (the experimenter). The male talker was chosen because the previously used tests, T-TRIP AND T-TWANS-P were also recorded by male talkers. The tape recording was done in a sound-treated booth. The test items were recorded with a Panasonic

tape recorder, model number RQ-323AS, and a Electrovoice microphone, model RE 20. The test items were then dubbed onto language master cards using a Bell & Howell Language Master, model number 717, to allow randomization of the items.

#### 3.4.1 Model of HART

The research model of the HART involves two channels of communication, listening and imitating. Test scores on the HART allow clinicians and teachers to assess the following: 1) listening process, that is, the ability to listen and recognize rhythm patterns; 2) auditory processing, that is, the ability to attend, discriminate, organize, sequence and comprehend the auditory rhythm; and 3) imitation, that is, the ability to respond vocally with the appropriate rhythm patterns.

#### 3.4.2 Test Construction

The HART was designed to determine a child's ability to perceive and imitate speech rhythms based on nonsense syllables. The HART assesses listening, imitation abilities and short-term memory. The HART provides a framework within which to observe and evaluate a child, and to use the test results to recommend remedial procedures to improve the child's skills.

#### 3.4.3 Description of HART

The HART consists of 40 test items of randomized rhythm patterns, ranging from five to nine elements for each rhythm pattern. The rhythm patterns are non-linguistic and are a

combination of long and short consonant-vowel syllables. The nonsense syllables /baaa/ and /b^/ were selected because they appear early in speech development, they are easy to produce, and contain low-frequency energy. Suprasegmental information in speech (rhythm, intonation, pitch, stress, speaker identity, and others) is carried by low frequency energy (Guberina & Asp, 1981). The rhythm patterns increase in difficulty when the number of elements are changed from five to nine, and when the speaking rate is changed. The difficulty of rhythm patterns may be altered by positions of long and short syllables. An error analysis from the earlier pilot studies indicated that the rhythm patterns beginning with the long syllables /baaa/ were easier to perceive than beginning with the short syllables /b^/.

### 3.5 Speaking and Reading Rates

The selected speaking rates are based on the rates found in conversational speech. Reading rates, which are generally based on reading of paragraphs and sentences, range from 170 to 210 words per minute, which is approximately 2.8 to 3.5 words per second (Kent, 1994) or 3.7 to 4.6 syllables per second. Normal conversational rate constitutes 5 spoken syllables per second (Asp, 1985) while slow conversational rate is 2-3 spoken syllables per second (McNutt & Chia-Yen Li, 1980). For the HART, the normal speaking rate was assigned 5 syllables per second and the slow rate was assigned 2 syllables per second.

### 3.6 Procedures

All subjects were seen individually during two separate test sessions. Each session lasted approximately 25 minutes. During the first test session, each subject was administered a pure-tone screening hearing test, a tympanogram, and two nonaudiometric tests: 1) the Speech Perception In Noise (SPIN) Test; and 2) the Auditory Sequential Memory (ASM) Subtest of the Illinois Test of Psycholinguistic Abilities (ITPA). During the second test session, each subject was administered the Hall Auditory Rhythm Test (HART). To maintain the attention of each subject during all tests, the investigator provided visual reinforcement by periodically placing a star on a 3x5 inch index card prepared for each subject. The star was to reinforce the subject's attention to task and not to indicate correct or incorrect responses. At the completion of all tests the stars were exchanged for a small toy.

#### 3.6.1 Speech Perception In Noise (SPIN)

The SPIN test (Kalikow, Stevens & Elliott, 1977; Bilger, Neutzel, Rabinowitz & Rzeczkowski, 1984), (see Appendix E). was selected because the sentence material, which is presented in the presence of a mixture of 12 multibabble background voices, is more representative of everyday communication than words or syllables. The SPIN test includes "high predictability" (HP) and "low predictability" (LP) sentences which simulate everyday communication situations in which the available contextual information varies. The maximum length of

each sentence is eight syllables.

Each subject was tested in a quiet room within the school building. A Panasonic RQ-323AS cassette tape recorder was used to present the pre-recorded SPIN test, binaurally, through Rona Kern LEVCO tip ,G' headsets. The SPIN was presented at a most comfortable loudness of 70 dB SPL. Each subject was administered 10 sentences selected from the practice test list. This was followed by the presentation of form number one of the SPIN test (see Appendix F). Both the practice and test sentences were presented as recommended by Bilger et al. (1984), at a pre-recorded signal-to-babble ratio of +8 dB. They cite Pearsons, Bennett and Fidell (1977) who suggested that +8 dB signal-to-noise ratio represents the median value encountered in real life situations. Subjects were required to repeat the final word of each test sentence. The SPIN test requires scoring of only the final/key word. Scores represent words identified correctly in each of the 50 sentences. The examiner tape recorded the responses and marked each oral response as correct or incorrect on a score sheet.

#### 3.6.2 Auditory Sequential Memory Test (ASM)

The ASM test was administered to each subject, from a Bell & Howell Language Master, model number 717, in a quiet room within the school building. The ASM was presented binaurally through Rona Kern LEVO tip ,G' headsets, at 70 dB SPL.

The Auditory Sequential Memory subtest from the ITPA (see Appendix G) was selected to evaluate each subject's short-term memory. This task required the subjects to repeat increasingly longer sequences of digits presented at a uniform rate of 2 per second (Kirk, McCarthy, & Kirk 1968). Scores represent the total number of points accumulated on the twenty-eight item test. The examiner tape recorded the responses and marked each oral response as correct or incorrect on a score sheet.

### 3.6.3 Hall Auditory Rhythm Test (HART)

The pre-recorded taped Hall Auditory Rhythm Test (HART), which is a listening/imitation test, was administered to each subject individually from a Bell & Howell Language Master, model number 717 in a quiet room within the school building. The HART was presented binaurally through Rona Kern LEVO tip ,G' headsets, at 70 dB SPL. All subjects were instructed to imitate each rhythm pattern sequence twice, therefore, allowing subjects a second opportunity to accurately imitate the test item if the first response was incorrect. A test item was correct if either response was correct, and incorrect if both responses were incorrect.

The 40 items had 5-6 or 7-9 elements presented at a normal and slow rate. Administration of the HART was divided into four subtests plus a practice section as follows:

Practice: Four practice items.

Subtest I: the first 10 test items in the rhythm section containing 5-6 elements spoken at a normal speaking rate.

Subtest II: items 11 through 20 containing 7-9 elements spoken at a normal speaking rate.

Subtest III: items 21 through 30 containing 5-6 elements spoken at a slow speaking rate.

Subtest IV: items 31 through 40 containing 7-9 elements spoken at a slow speaking rate.

Each subject was introduced to the listening/imitation task with four practice items. The practice items consisted of 3-4 elements and were presented randomly at a normal and slow rate. These practice items which were easier than the test items, allowed the subjects to become familiar with the test procedures. The forty test items were randomized (e.g., 40,1,12,3,35,etc.) and presented one at a time. The following instructions were given to each subject for the practice and test items:

"You will hear different speech patterns. All of the speech patterns will be the syllable /b^/. Your job is to listen carefully and repeat each pattern after you hear it. You will hear each pattern two times. After I play each pattern, I will point to you. That is your signal to be like a "copy cat" and say the same pattern you hear on each card. Now remember, listen carefully, wait until I point to you, and then say the same thing that you hear on each card. Are you ready?"

#### 3.6.4 Scoring of HART

Each subjects' response was scored by the examiner as correct (C) if the rhythm patterns were imitated correctly e.g., the same number of elements, rate, and pattern as the test item, otherwise, the response was scored incorrect (I). Each test item was presented twice to insure the subject had an opportunity to respond correctly. The first and second responses were scored separately. For a test item to be correct at least one of the responses had to be correct. A percentage score was calculated for each section of 10 items along with a total percent score of the 40 items of the entire test.

During the test session, both the stimulus and response were tape recorded using a Panasonic cassette tape recorder, model number RQ-323AS and a Electrovoice microphone, model RE20. Two panel clinicians experienced with administering and scoring speech rhythm patterns were selected to score five randomly selected subjects. This was done to check the reliability of the scoring procedures for the HART. The scoring was based on the tape recorded responses. The panel clinicians were instructed to use the following key for scoring:

1) The child's response is correct if the pattern of the first or second response is exactly the same as the test item, with the same number of elements, rate, and pattern.

e.g., stimulus baaa b^ baaa; response baaa b^ baaa.

2) The child's response is incorrect if the number of elements, rate, or pattern is different from the test item.

e.g., different patterns: stimulus bΛ baaa bΛ baaa;

response baaa bΛ baaa

e.g., more syllables: stimulus bΛ bΛ bΛ;

response bΛ bΛ bΛ bΛ

3) Item is incorrect if the pattern is repeated exactly like the stimulus and has the same number of elements, but the rate is different from the test item. Scores represent the percentage of the responses imitated correctly of the 40 test items.

Scoring of the HART required practice listening and making judgements as to whether a child's response was correct or incorrect. The most difficult to judge was the speaking rate. The response speaking rate which was not exactly the same as the stimulus rate could be judged as correct. Therefore, experience with determining a slow versus a normal speaking rate was necessary for scoring of the HART.

## CHAPTER IV

### RESULTS

#### 4.1 Test-Retest Reliability

Test-retest measures were obtained for five of the fifty subjects for the Speech Perception In Noise (SPIN) test, Auditory Sequential Memory (ASM) test, and the Hall Auditory Rhythm Test (HART). Three of the five subjects were children with learning disabilities (LD) and two were children with normal learning abilities (NL). For the five subjects, a Pearson Product-Moment Correlation indicated a reliability coefficient of 0.93 for the SPIN test, 0.98 for the ASM test, and 0.94 for the HART. The test-retest reliability was considered to be quite adequate and repeatable for all three tests.

#### 4.2 Interjudge Reliability

For the SPIN and the ASM tests, the subject's response was a spoken word and a repetition of a series of numbers, respectively. Each response was judged to be either correct or incorrect. The judgements were easy and repeatable. Therefore, the tester's interjudge reliability was not measured for the SPIN or the ASM tests. It was assumed to be satisfactory for both tests.

For the HART, the tester scored each response (imitation) as correct or incorrect. These judgements required more skill, so the tester's judgements needed to be verified. The tester's judgements of the five randomly selected subjects (3 LD's and

2 NL's) were compared with judgements of a panel of experts. The panel consisted of two skilled public school clinicians experienced in listening, judging and scoring syllable rhythm patterns. The two panel members together judged each response of the five subjects from the audio tape recordings. The interjudge agreements were computed using the total number of agreements divided by the total number of items. The five tester-panel agreements for the five subjects had a mean value of 86%, with individual subject agreements of 70, 80, 83, 98, and 100% (see Appendices H1-H5).

The tester-panel scores were also compared for each of the five subjects. These comparisons were 30 vs 30%, 28 vs 28%, 78 vs 80%, 58 vs 35%, and 68 vs 43%. For the first three subjects, two comparisons were identical and one was 2% different. However, the last two subjects (one LD and one NL), the test scores had a 25% and a 23% difference, with the tester judgements being higher than the panel. It was not clear why this difference occurred. It appeared that the test scores of some subjects may be different when different judges are used. The tester judged each subject's response while seated opposite the subject. The panel, on the other hand, listened and judged from an audio recording that had each stimulus-response pair. The different procedures could have contributed to these differences. The HART scores may be more reliable only within one tester. Therefore, only the tester's judgements were used for all the statistical analyses. In

conclusion, both the test-retest and tester-panel agreements verified that the judging and scoring of the HART was considered to be reliable for the tester listening.

#### 4.3 Analysis of Data

The raw data, means, standard errors, and range of scores, for the SPIN, ASM, and HART tests for both LD and NL groups are presented in Tables I and II, respectively. Research hypotheses 1, 2, and 3 were analyzed using a one-factor analysis of variance (ANOVA), with JMP (1994), statistical package for a Macintosh computer. Table III summarizes the ANOVA results for the SPIN test, ASM test, and HART.

##### 4.2.1 Hypothesis 1

Statistical Analysis. Research hypothesis number one stated there is a significant difference between LD and NL group scores for word identification at +8 dB signal-to-babble ratio (percent correct on the SPIN test). The ANOVA revealed that the LD's scored significantly lower (6%) on the SPIN, with a mean score of 79%, compared to a mean score of 85% for NL is  $[F(1,48)=10.94;p=0.0018]$ . These results indicate that the LD group had significantly poorer speech perception of words with background noise compared to the NL group. Figure 1 graphically displays results for the LD and NL groups on the SPIN test. For Figure 1 and other figures of this type, the long horizontal line indicates the mean score for the groups. For each group, the solid circle inside the diamond is the

TABLE I

SCORES IN PERCENT CORRECT FOR CHILDREN WITH LEARNING DISABILITIES (LD). SPEECH PERCEPTION IN NOISE (SPIN); AUDITORY SEQUENTIAL MEMORY (ASM); HALL AUDITORY RHYTHM TEST (HART); I (5-6 ELEMENTS AT A NORMAL RATE); II (7-9 ELEMENTS AT A NORMAL RATE); III (5-6 ELEMENTS AT A SLOW RATE); IV (7-9 ELEMENTS AT A SLOW RATE)

## H A R T

| Subj        |   | Gender | Age    | SPIN | ASM  | I     | II    | III   | IV    | Mean |
|-------------|---|--------|--------|------|------|-------|-------|-------|-------|------|
| ID#         | M | F      | Yrs/Mo |      |      | (5-6) | (7-9) | (5-6) | (7-9) |      |
| L1          | x |        | 9/09   | 80   | 50   | 50    | 40    | 30    | 20    | 35.0 |
| L2          | x |        | 9/03   | 76   | 40   | 80    | 0     | 60    | 20    | 40.0 |
| L3          |   | x      | 8/07   | 82   | 36   | 60    | 40    | 10    | 0     | 27.5 |
| L4          |   | x      | 7/10   | 78   | 77   | 90    | 60    | 90    | 60    | 75.0 |
| L5          | x |        | 8/06   | 82   | 36   | 30    | 0     | 30    | 0     | 15.0 |
| L6          | x |        | 9/00   | 80   | 43   | 80    | 40    | 50    | 20    | 47.5 |
| L7          | x |        | 8/05   | 68   | 36   | 60    | 40    | 40    | 10    | 37.5 |
| L8          | x |        | 8/10   | 76   | 43   | 90    | 70    | 60    | 40    | 65.0 |
| L9          |   | x      | 8/10   | 76   | 50   | 80    | 50    | 80    | 10    | 55.0 |
| L10         |   | x      | 8/05   | 70   | 29   | 30    | 10    | 40    | 0     | 20.0 |
| L11         |   | x      | 8/06   | 66   | 50   | 100   | 70    | 80    | 10    | 65.0 |
| L12         | x |        | 8/03   | 68   | 43   | 50    | 30    | 30    | 10    | 30.0 |
| L13         | x |        | 9/04   | 70   | 48   | 50    | 30    | 20    | 0     | 25.0 |
| L14         |   | x      | 9/10   | 92   | 41   | 40    | 20    | 40    | 10    | 27.5 |
| L15         | x |        | 8/03   | 86   | 61   | 90    | 50    | 70    | 0     | 52.5 |
| L16         | x |        | 8/04   | 86   | 36   | 30    | 10    | 20    | 10    | 17.5 |
| L17         | x |        | 8/08   | 84   | 95   | 80    | 30    | 60    | 40    | 52.5 |
| L18         |   | x      | 9/05   | 82   | 34   | 70    | 30    | 30    | 10    | 35.0 |
| L19         | x |        | 8/07   | 74   | 30   | 40    | 0     | 30    | 10    | 20.0 |
| L20         |   | x      | 8/03   | 72   | 46   | 50    | 0     | 20    | 0     | 17.5 |
| L21         |   | x      | 9/02   | 74   | 36   | 20    | 10    | 20    | 0     | 12.5 |
| L22         | x |        | 9/00   | 70   | 61   | 80    | 60    | 70    | 10    | 55.0 |
| L23         |   | x      | 9/02   | 78   | 36   | 30    | 20    | 10    | 10    | 17.5 |
| L24         | x |        | 8/09   | 84   | 52   | 80    | 60    | 80    | 10    | 57.5 |
| L25         | x |        | 9/00   | 88   | 48   | 70    | 30    | 10    | 0     | 27.5 |
| L26         | x |        | 9/04   | 86   | 27   | 60    | 10    | 30    | 10    | 27.5 |
| L27         | x |        | 8/02   | 86   | 46   | 70    | 50    | 50    | 20    | 45.5 |
| L28         |   | x      | 8/09   | 84   | 50   | 70    | 30    | 50    | 20    | 42.5 |
| L29         | x |        | 9/04   | 86   | 36   | 20    | 20    | 10    | 0     | 12.5 |
| L30         | x |        | 9/04   | 84   | 36   | 60    | 40    | 10    | 10    | 30.0 |
| L31         | x |        | 8/04   | 74   | 43   | 20    | 0     | 30    | 0     | 12.5 |
| L32         |   | x      | 8/08   | 78   | 45   | 50    | 10    | 60    | 10    | 32.5 |
| L33         | x |        | 8/07   | 84   | 39   | 20    | 10    | 20    | 0     | 12.5 |
| L34         |   | x      | 8/05   | 68   | 46   | 90    | 70    | 70    | 40    | 67.5 |
| L35         |   | x      | 8/06   | 80   | 43   | 80    | 40    | 50    | 20    | 47.5 |
| Total 21 14 |   |        |        |      |      |       |       |       |       |      |
| Mean        |   |        | 8.8    | 78.6 | 45.0 | 59.1  | 30.8  | 41.7  | 12.6  | 36.0 |
| Std Error   |   |        |        | 1.1  | 2.2  | 4.0   | 3.7   | 4.0   | 2.3   | 3.0  |
| Range       |   |        | 7/10   | 66.0 | 27.0 | 20.0  | 0     | 10.0  | 0     | 12.5 |
|             |   |        | to     | to   | to   | to    | to    | to    | to    | to   |
|             |   |        | 9/09   | 92.0 | 95.0 | 100   | 70.0  | 90.0  | 60    | 75.0 |

TABLE II

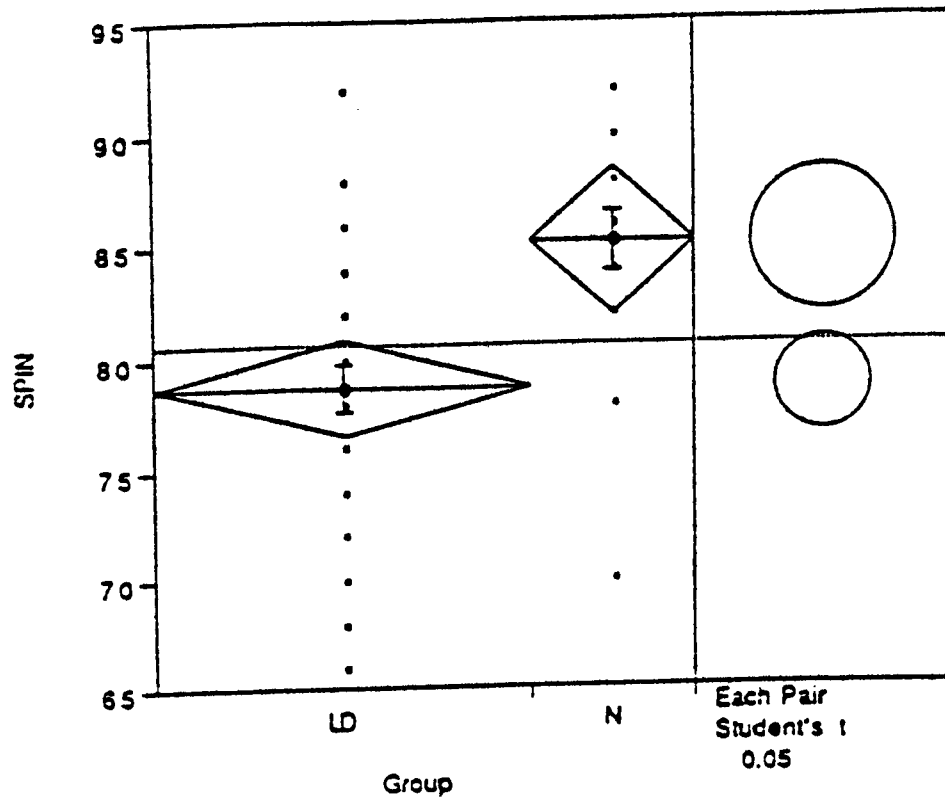
SCORES IN PERCENT CORRECT FOR CHILDREN WITH NORMAL LEARNING ABILITIES (NL). SPEECH PERCEPTION IN NOISE (SPIN); AUDITORY SEQUENTIAL MEMORY (ASM); HALL AUDITORY RHYTHM TEST (HART); I (5-6 ELEMENTS AT A NORMAL RATE); II (7-9 ELEMENTS AT A NORMAL RATE); III (5-6 ELEMENTS AT A SLOW RATE); IV (7-9 ELEMENTS AT A SLOW RATE)

## H A R T

| Subj      | Gender | Age | SPIN   | ASM  | I     | II    | III   | IV    | Mean |      |
|-----------|--------|-----|--------|------|-------|-------|-------|-------|------|------|
| ID#       | M      | F   | Yrs/Mo |      | (5-6) | (7-9) | (5-6) | (7-9) |      |      |
| N1        | x      |     | 9/00   | 92   | 64    | 70    | 80    | 60    | 30   | 60.0 |
| N2        | x      |     | 8/04   | 90   | 57    | 60    | 60    | 60    | 50   | 60.0 |
| N3        | x      |     | 8/09   | 84   | 43    | 30    | 30    | 40    | 0    | 25.0 |
| N4        |        | x   | 8/01   | 84   | 55    | 100   | 70    | 80    | 20   | 67.5 |
| N5        |        | x   | 8/04   | 86   | 43    | 100   | 60    | 60    | 40   | 65.0 |
| N6        |        | x   | 8/11   | 86   | 54    | 80    | 70    | 60    | 30   | 60.0 |
| N7        | x      |     | 8/04   | 88   | 52    | 80    | 40    | 40    | 30   | 47.5 |
| N8        | x      |     | 8/00   | 88   | 36    | 50    | 10    | 60    | 20   | 35.0 |
| N9        | x      |     | 8/05   | 70   | 52    | 90    | 50    | 50    | 20   | 52.5 |
| N10       |        | x   | 8/06   | 78   | 54    | 80    | 60    | 50    | 0    | 47.5 |
| N11       | x      |     | 8/10   | 90   | 63    | 90    | 50    | 70    | 20   | 57.5 |
| N12       | x      |     | 8/06   | 82   | 54    | 60    | 40    | 70    | 10   | 45.0 |
| N13       | x      |     | 8/06   | 86   | 80    | 100   | 80    | 90    | 40   | 77.5 |
| N14       | x      |     | 9/02   | 86   | 66    | 100   | 90    | 80    | 50   | 80.0 |
| N15       |        | x   | 8/04   | 88   | 82    | 90    | 80    | 70    | 50   | 72.5 |
| Total     |        |     | 10     | 5    |       |       |       |       |      |      |
| Mean      |        |     | 8.4    | 85.2 | 57.0  | 80.0  | 60.0  | 65.3  | 26.7 | 58.2 |
| Std Error |        |     |        | 1.4  | 3.2   | 5.6   | 5.5   | 3.5   | 4.3  | 3.9  |
| Range     |        |     | 8/00   | 70.0 | 36.0  | 30.0  | 10.0  | 40.0  | 0    | 25.0 |
|           |        |     | to     | to   | to    | to    | to    | to    | to   | to   |
|           |        |     | 9/02   | 92.0 | 82.0  | 100   | 90.0  | 90.0  | 15.0 | 80.0 |

TABLE III  
RESULTS OF ONE-FACTOR ANOVA'S BETWEEN LD and NL  
FOR THE SPIN, ASM, AND HART

|      | df | MS     | F     | p        |
|------|----|--------|-------|----------|
| SPIN | 1  | 453.4  | 10.94 | 0.0018   |
| ASM  | 1  | 1504.8 | 8.92  | 0.0044   |
| HART | 1  | 5152.6 | 17.33 | < 0.0001 |



| Means and Std Deviations |        |         |         |         |        |
|--------------------------|--------|---------|---------|---------|--------|
| Level                    | Number | Mean    | Std Dev | Std Err | Mean   |
| LD                       | 35     | 78.6286 | 6.80435 |         | 1.1501 |
| N                        | 15     | 85.2000 | 5.44059 |         | 1.4048 |

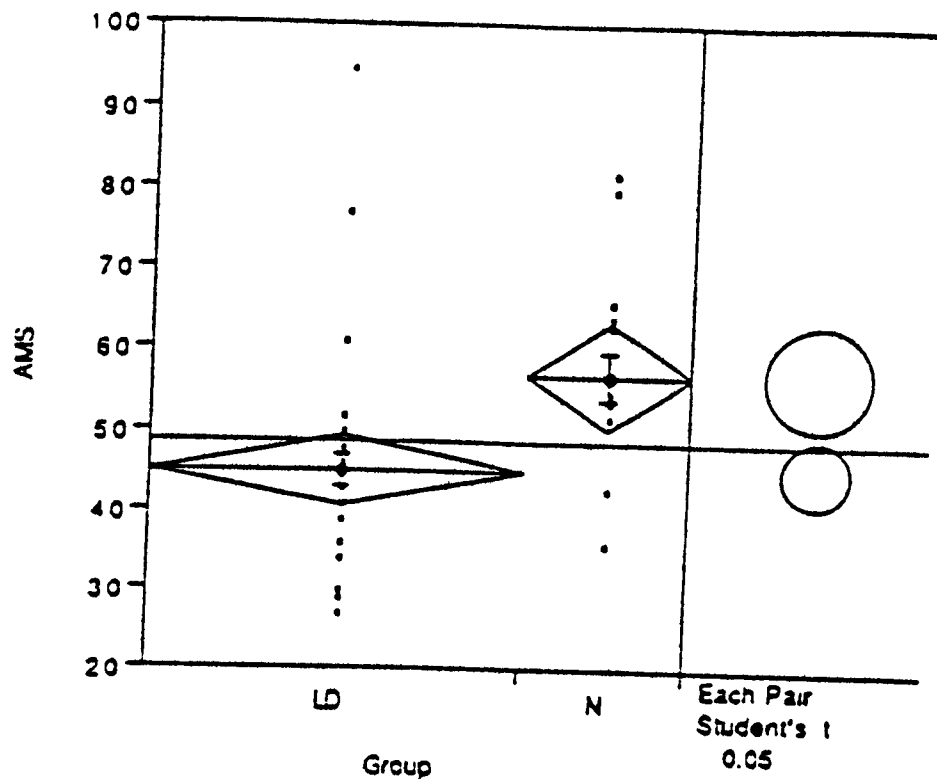
| Means Comparisons |  |
|-------------------|--|
|-------------------|--|

Figure 1. Percent correct scores for the two groups on the SPIN. Diamonds represent 95% confidence interval for the mean. Circles indicate results of the post hoc analysis.

mean, and the short horizontal lines within the diamond represent the standard error. The spread of scores are indicated by the solid squares above and below the diamond. Some squares represent more than one score. The long horizontal line within the diamond represents the variability within the group. The diamond represents the 95% confidence interval of the mean for each group. In the right panel, the circles are visual representations for each group with the center of the circles corresponding to the mean and the diameter of the circles indicating a 95% confidence interval for the mean. The comparison of the means are also displayed in the bottom part of some of the figures.

#### 4.2.2 Hypothesis 2

Statistical Analysis. Research hypothesis number two stated there is a significant difference between LD and LN group scores for short-term memory recall of digit (percent correct on the ASM test). The ANOVA revealed that the LD group scored significantly lower (12%) on the ASM, with a mean score of 45%, compared to a mean score of 57% for the NL group [ $F(1,48)=8.92;p=0.0044$ ]. These results indicate that the LD group had significantly poorer short-term memory recall for digits than the NL group. Figure 2 , which has the same format as Figure 1, displays the results for the LD and NL groups on the AMS test.



| Means and Std Deviations |        |         |         |         |        |  |
|--------------------------|--------|---------|---------|---------|--------|--|
| Level                    | Number | Mean    | Std Dev | Std Err | Mean   |  |
| LD                       | 35     | 45.0286 | 13.1294 |         | 2.2193 |  |
| N                        | 15     | 57.0000 | 12.6322 |         | 3.2616 |  |

Means Comparisons

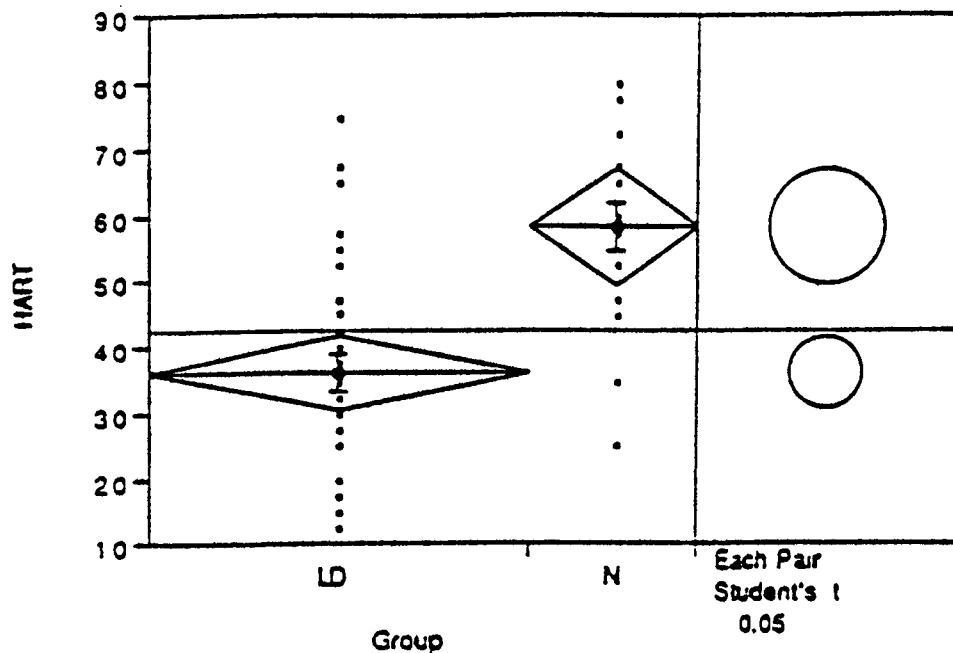
Figure 2. Percent correct scores for the two groups on the ASM. Diamonds represent 95% confidence interval for the mean. Circles indicate results of the post hoc analysis.

#### 4.2.3 Hypothesis 3

Statistical Analysis. Research hypothesis number three stated there is a significant difference between LD and NL group scores for listening/imitation of syllable rhythm patterns (percent correct on the HART). The ANOVA revealed that the LD group scored significantly lower (22%) on the HART, with a mean score of 36%, compared to a mean score of 58% for the NL group [ $F(1,48)=17.33;p<0.0001$ ]. These results indicate that the LD group had significantly poorer listening/imitation skills compared to the NL group. Figure 3, which has the same format as Figure 1, displays the results for the LD and NL groups on the HART. In Table III, the level was highly significant for the HART, because of the 22% difference between the groups.

The interaction between the two groups (LD and NL) and the three tests (SPIN, ASM, and HART) was significant [ $F(2,96)=5.36;p=0.0062$ ] (see Table IV for two-factor ANOVA). This significant interaction indicated that the two groups scored differently on the three tests. This interaction was not an original research hypothesis, but was considered important to report. Figure 4 shows the mean scores for the groups and three tests. It can be seen that the greatest difference in scores for the two groups was on the HART.

To examine the four subtests of the HART, a one-factor analysis of variance was performed on the data for the two groups, and the four HART subtests. The results of the



| Means and Std Deviations |        |         |         |         |      |
|--------------------------|--------|---------|---------|---------|------|
| Level                    | Number | Mean    | Std Dev | Std Err | Mean |
| LD                       | 35     | 36.0143 | 18.0067 | 3.0437  |      |
| N                        | 15     | 58.1667 | 15.2206 | 3.9299  |      |

| Means Comparisons |  |  |  |  |  |
|-------------------|--|--|--|--|--|
|-------------------|--|--|--|--|--|

Figure 3. Percent correct scores for the two groups on the HART. Diamonds represent 95% confidence interval for the mean. Circles indicate results of the post hoc analysis.

TABLE IV  
RESULTS OF A TWO-FACTOR ANOVA  
BETWEEN GROUPS AND TESTS

| Source:                    | df | MS      | F      | p      |
|----------------------------|----|---------|--------|--------|
| Groups<br>(LD vs NL)       | 1  | 5796.3  | 22.12  | 0.0001 |
| Tests<br>(SPIN, ASM, HART) | 2  | 15280.3 | 124.61 | 0.0001 |
| Interaction                | 2  | 657.2   | 5.36   | 0.0062 |

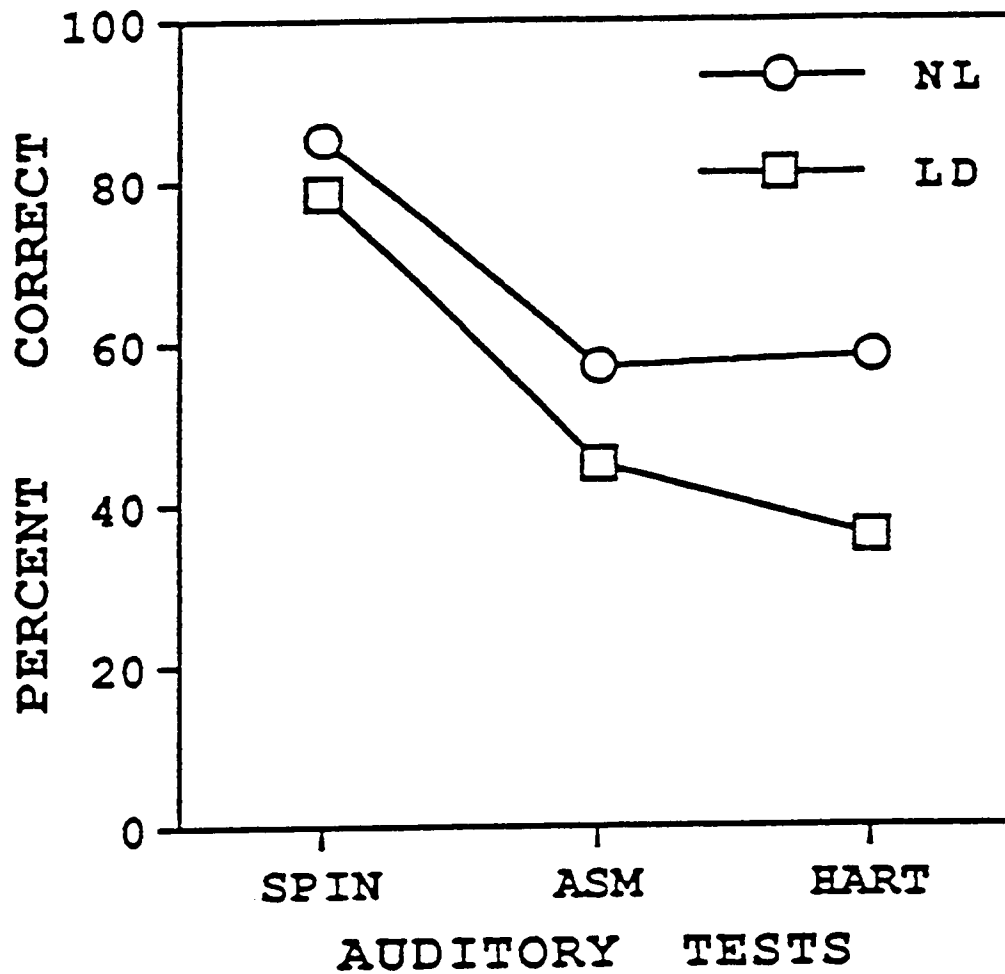


Figure 4. Percent correct mean scores for the LD and NL groups on the SPIN, ASM, AND HART

analysis are shown in Table V and the mean scores for the groups and four subtests are shown in Figure 5. The main effects for groups [ $F(1,192)=47.63;p<0.0001$ ] and subtests [ $F(3,192)=48.46;p<0.0001$ ] were significant and the interaction was not significant [ $F(3,192)=0.97;p=0.4084$ ]. These results indicated that the two groups performed similarly on all four subtests, which suggested that each of the four subtests separated the LD group from the NL group.

#### 4.3 Subgrouping of Children with Learning Disabilities

Examination of the test scores for each subject in the two groups, indicated larger variability for the LD group than for the NL group. Further analyses of the LD group scores on the SPIN, ASM, and HART tests were conducted with a Hierarchical Clustering Analysis using Ward's Method (Aldenderfer & Blashfield, 1984). This investigation revealed that the LD group formed two distinct subgroups, an upper level (LD-UL) and a lower level (LD-LL). Figure 6 shows the dendrogram for the clustering of the LD group into these two subgroups. Sixteen LD subjects were in the upper level. These were subjects, which were identified by their assigned numbers of 1,32,2,6,35,...17. Nineteen LD subjects were in the lower level. These were subjects with assigned numbers of 3,30,18,26,...23. These subject numbers are the same numbers as those in Table I.

TABLE V  
RESULTS OF 2 FACTOR ANOVA  
FOR TWO GROUPS AND FOUR SUBTESTS OF HART

| Source:                      | df | MS      | F     | p       |
|------------------------------|----|---------|-------|---------|
| Groups<br>(LD vs NL)         | 1  | 20196.2 | 47.63 | <0.0001 |
| Subtests<br>(I, II, III, IV) | 3  | 20548.5 | 48.46 | <0.0001 |
| Interaction                  | 3  | 410.9   | 0.97  | 0.4084  |

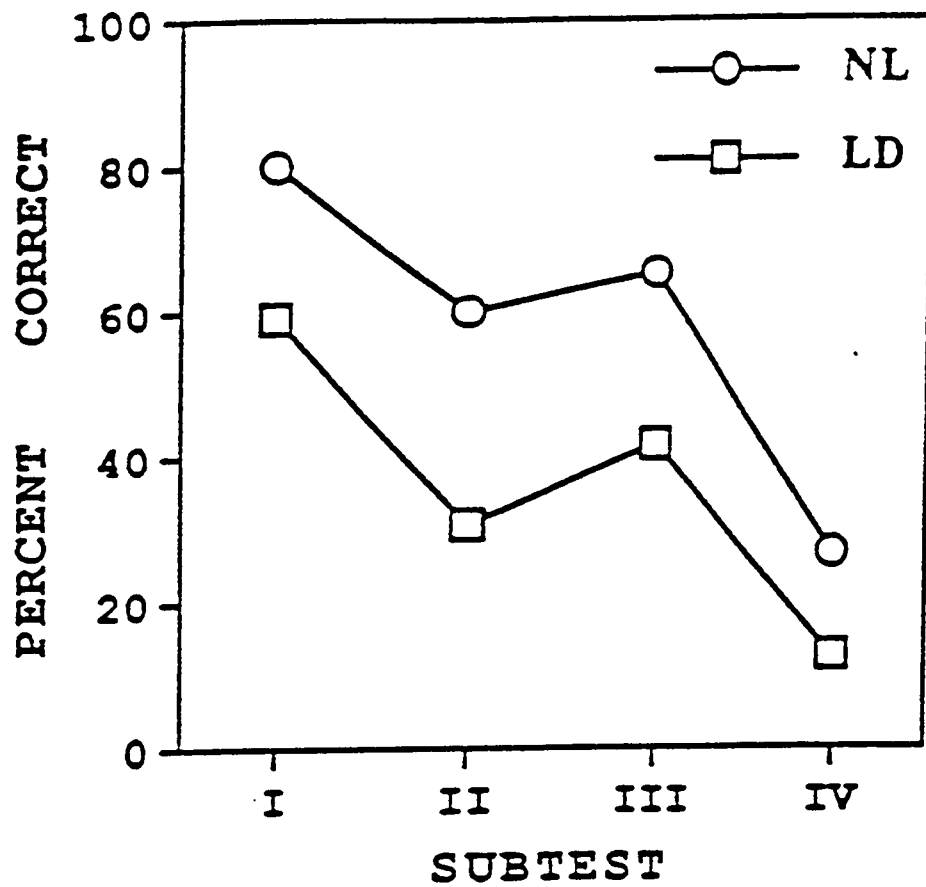


Figure 5. Percent correct scores for two groups on the subtests of the HART

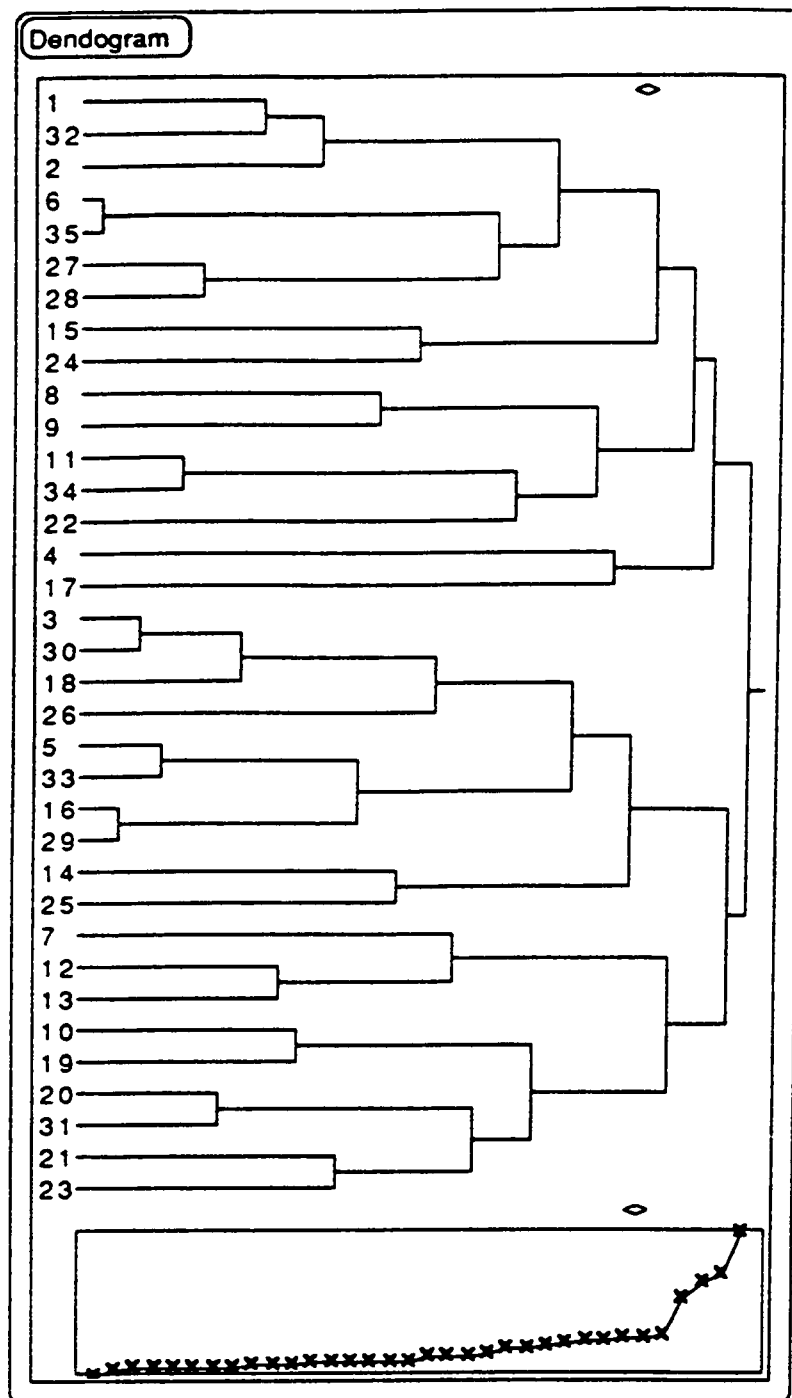


Figure 6. Clustering of LD's into two subgroups from the combined mean scores on the SPIN, ASM, and HART. Numbers 1,32,2,6,...17 represent the subjects of LD-UL group. Numbers 3,30,18,26,...23 represent the subjects of the LD-LL group. These numbers were used for subject identification.

The data for the three groups, the NL group and the two LD subgroups, LD-UL and LD-LL, are shown in Tables II, VI and VII, respectively. The data presented in Tables VI and VII were based on the analysis from Figure 6. Data from the SPIN test, ASM test, and HART were submitted to three separate one-factor analysis of variance (ANOVA). The ANOVA results revealed significant differences between the three groups (LD-LL, LD-UL, and NL) on all three tests, for the SPIN  $[F(2,47)=5.4;p=0.0076]$ ; the ASM  $[F(2,47)=15.0;p<0.0001]$ ; and the HART  $[F(2,47)=46.4;p<0.0001]$ . The mean scores are in Table VIII, and the results of the three separate one-factor ANOVA's for the three groups are in Table IX.

For the SPIN test, a post hoc Tukey-Kramer analysis (JMP, 1994) showed a significant ( $p<0.05$ ) difference between the mean score for the NL group and the mean score for either the LD-UL or LD-LL groups. However, the LD-UL and LD-LL were not significant from each other ( $p>0.05$ ). For the ASM test and HART, post hoc Tukey-Kramer analyses, showed that either the NL or the LD-UL groups were significantly different ( $p<0.05$ ) from the scores for the LD-LL group. However, the LD-UL group was not different from the NL group ( $p>0.05$ ). Figures 7-9, which have the same format as Figure 1, display the results for the UL, LL and NL groups on the SPIN test, ASM test, and HART, respectively.

TABLE VI

SCORES IN PERCENT CORRECT FOR CHILDREN CLUSTERED INTO THE UPPER LEARNING DISABLED (LD-UL) GROUP. SPEECH PERCEPTION IN NOISE (SPIN); AUDITORY SEQUENTIAL MEMORY (ASM); HALL AUDITORY RHYTHM TEST (HART); I (5-6 ELEMENTS AT A NORMAL RATE); II (7-9 ELEMENTS AT A NORMAL RATE); III (5-6 ELEMENTS AT A SLOW RATE); IV (7-9 ELEMENTS AT A SLOW RATE)

| Subj<br>ID# | Gender |   | Age<br>Yrs/Mo | SPIN | ASM  | HART       |             |              |             | Mean |
|-------------|--------|---|---------------|------|------|------------|-------------|--------------|-------------|------|
|             | M      | F |               |      |      | I<br>(5-6) | II<br>(7-9) | III<br>(5-6) | IV<br>(7-9) |      |
| L1          | x      |   | 9/09          | 80   | 50   | 50         | 40          | 30           | 20          | 35.0 |
| L2          | x      |   | 9/03          | 76   | 40   | 80         | 0           | 60           | 20          | 40.0 |
| L4          |        | x | 7/10          | 78   | 77   | 90         | 60          | 90           | 60          | 75.0 |
| L6          | x      |   | 9/00          | 80   | 43   | 80         | 40          | 50           | 20          | 47.5 |
| L8          | x      |   | 8/10          | 76   | 43   | 90         | 70          | 60           | 40          | 65.0 |
| L9          |        | x | 8/10          | 76   | 50   | 80         | 50          | 80           | 10          | 55.0 |
| L11         |        | x | 8/06          | 66   | 50   | 100        | 70          | 80           | 10          | 65.0 |
| L15         | x      |   | 8/03          | 86   | 61   | 90         | 50          | 70           | 0           | 52.5 |
| L17         | x      |   | 8/08          | 84   | 95   | 80         | 30          | 60           | 40          | 52.5 |
| L22         | x      |   | 9/00          | 70   | 61   | 80         | 60          | 70           | 10          | 55.0 |
| L24         | x      |   | 8/09          | 84   | 52   | 80         | 60          | 80           | 10          | 57.5 |
| L27         | x      |   | 8/02          | 86   | 46   | 70         | 50          | 50           | 20          | 45.5 |
| L28         |        | x | 8/09          | 84   | 50   | 70         | 30          | 50           | 20          | 42.5 |
| L32         |        | x | 8/08          | 78   | 45   | 50         | 10          | 60           | 10          | 32.5 |
| L34         |        | x | 8/05          | 68   | 46   | 90         | 70          | 70           | 40          | 67.5 |
| L35         |        | x | 8/06          | 80   | 43   | 80         | 40          | 50           | 20          | 47.5 |
| Total       | 9      | 7 |               |      |      |            |             |              |             |      |
| Mean        |        |   | 8/09          | 78.2 | 53.7 | 78.7       | 45.6        | 63.1         | 21.8        | 52.2 |
| Std Error   |        |   |               | 1.5  | 3.5  | 4.0        | 3.2         | 2.4          | 1.1         | 1.8  |
| Range       |        |   | 7/10          | 66   | 40   | 50         | 0           | 30           | 0           | 32.5 |
|             |        |   | to            | to   | to   | to         | to          | to           | to          | to   |
|             |        |   | 9/09          | 86   | 95   | 100        | 70          | 90           | 60          | 75.0 |

TABLE VII

SCORES IN PERCENT CORRECT FOR CHILDREN CLUSTERED INTO THE LOWER LEARNING DISABLED (LD-LL) GROUP. SPEECH PERCEPTION IN NOISE (SPIN); AUDITORY SEQUENTIAL MEMORY (ASM); HALL AUDITORY RHYTHM TEST (HART); I (5-6 ELEMENTS AT A NORMAL RATE); II (7-9 ELEMENTS AT A NORMAL RATE); III (5-6 ELEMENTS AT A SLOW RATE); IV (7-9 ELEMENTS AT A SLOW RATE)

| Subj ID#   | Gender |   | Age Yrs/Mo | SPIN | ASM  | HART    |          |           |          | Mean |
|------------|--------|---|------------|------|------|---------|----------|-----------|----------|------|
|            | M      | F |            |      |      | I (5-6) | II (7-9) | III (5-6) | IV (7-9) |      |
| L3         |        | x | 8/07       | 82   | 36   | 60      | 40       | 10        | 0        | 27.5 |
| L5         | x      |   | 8/06       | 82   | 36   | 30      | 0        | 30        | 0        | 15.0 |
| L7         | x      |   | 8/05       | 68   | 36   | 60      | 40       | 40        | 10       | 37.5 |
| L10        |        | x | 8/05       | 70   | 29   | 30      | 10       | 40        | 0        | 20.0 |
| L12        | x      |   | 8/03       | 68   | 43   | 50      | 30       | 30        | 10       | 30.0 |
| L13        | x      |   | 9/04       | 70   | 48   | 50      | 30       | 20        | 0        | 25.0 |
| L14        |        | x | 9/10       | 92   | 41   | 40      | 20       | 40        | 10       | 27.5 |
| L16        | x      |   | 8/04       | 86   | 36   | 30      | 10       | 20        | 10       | 17.5 |
| L18        |        | x | 9/05       | 82   | 34   | 70      | 30       | 30        | 10       | 35.0 |
| L19        | x      |   | 8/07       | 74   | 30   | 40      | 0        | 30        | 10       | 20.0 |
| L20        |        | x | 8/03       | 72   | 46   | 50      | 0        | 20        | 0        | 17.5 |
| L21        |        | x | 9/02       | 74   | 36   | 20      | 10       | 20        | 0        | 12.5 |
| L23        |        | x | 9/02       | 78   | 36   | 30      | 20       | 10        | 10       | 17.5 |
| L25        | x      |   | 9/00       | 88   | 48   | 70      | 30       | 10        | 0        | 27.5 |
| L26        | x      |   | 9/04       | 86   | 27   | 60      | 10       | 30        | 10       | 27.5 |
| L29        | x      |   | 9/04       | 86   | 36   | 20      | 20       | 10        | 0        | 12.5 |
| L30        | x      |   | 9/04       | 84   | 36   | 60      | 40       | 10        | 10       | 30.0 |
| L31        | x      |   | 8/04       | 74   | 43   | 20      | 0        | 30        | 0        | 12.5 |
| L33        | x      |   | 8/07       | 84   | 39   | 20      | 10       | 20        | 0        | 12.5 |
| Total 12 7 |        |   |            |      |      |         |          |           |          |      |
| Mean       |        |   | 8/10       | 78.9 | 37.6 | 42.6    | 18.4     | 23.6      | 4.7      | 22.3 |
| Std Error  |        |   |            | 1.7  | 1.3  | 4.0     | 3.2      | 2.4       | 1.1      | 1.8  |
| Range      |        |   | 8/03       | 68.0 | 27.0 | 20.0    | 0        | 10.0      | 0        | 12.5 |
|            |        |   | to         | to   | to   | to      | to       | to        | to       | to   |
|            |        |   | 9/10       | 92.0 | 48.0 | 70.0    | 40.0     | 40.0      | 10       | 37.5 |

TABLE VIII

PERCENT CORRECT MEAN SCORES FOR THREE GROUPS ON THE  
SPIN, ASM, AND HART. NORMAL LEARNERS (NL), UPPER  
LEVEL (LD-UL), AND LOWER LEVEL LEARNING DISABLED (LD-LL)

|    | SPIN | ASM  | HART |
|----|------|------|------|
| NL | 85.2 | 57.0 | 58.0 |
| UL | 78.2 | 53.7 | 52.2 |
| LL | 78.9 | 37.6 | 22.3 |

TABLE IX  
RESULTS OF 3 ONE-FACTOR ANOVA'S BETWEEN  
GROUPS FOR EACH OF THE THREE TESTS

|      | df | MS      | F    | p       |
|------|----|---------|------|---------|
| SPIN | 2  | 457.6   | 5.4  | 0.0076  |
| AMS  | 2  | 3746.6  | 15.0 | <0.0001 |
| HART | 2  | 12891.9 | 46.4 | <0.0001 |

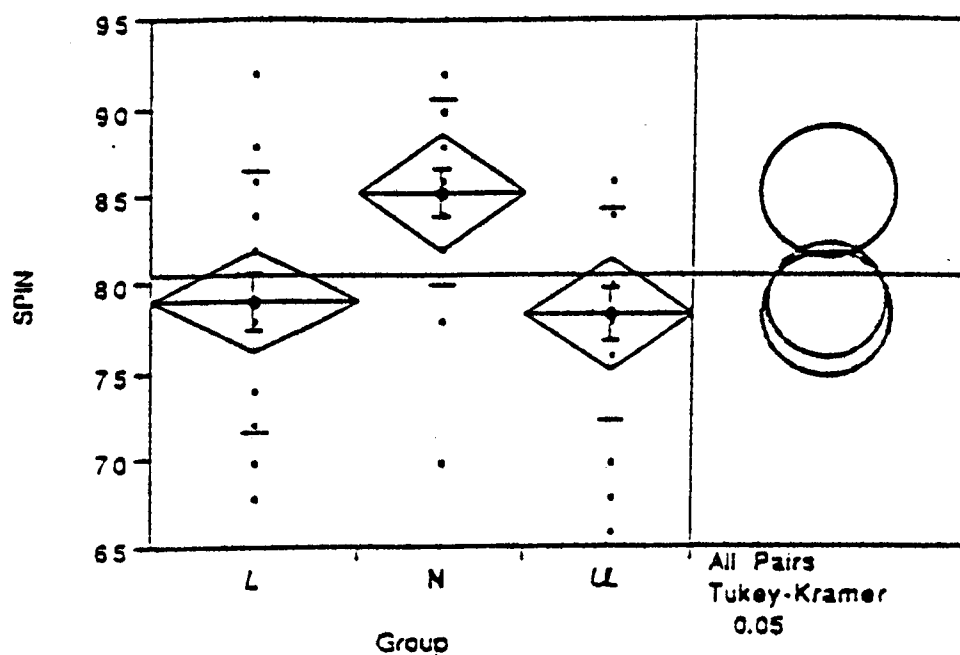


Figure 7. Percent correct scores for the three groups on the SPIN. Diamonds represent 95% confidence interval for the mean. Circles indicate results of the post hoc analysis.

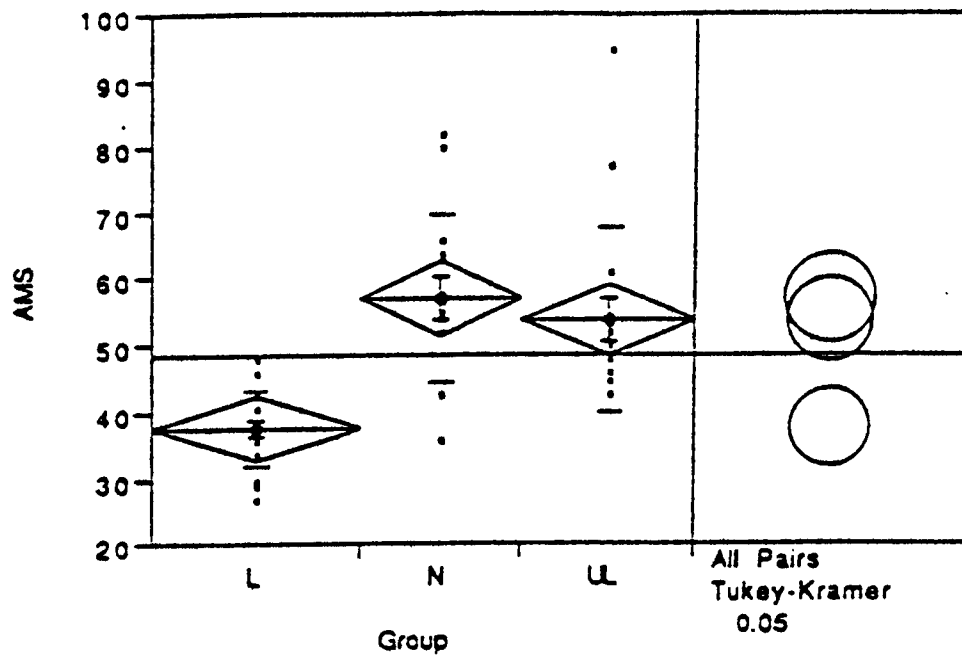


Figure 8. Percent correct scores for the three groups on the ASM. Diamonds represent 95% confidence interval for the mean. Circles indicate results of the post hoc analysis.

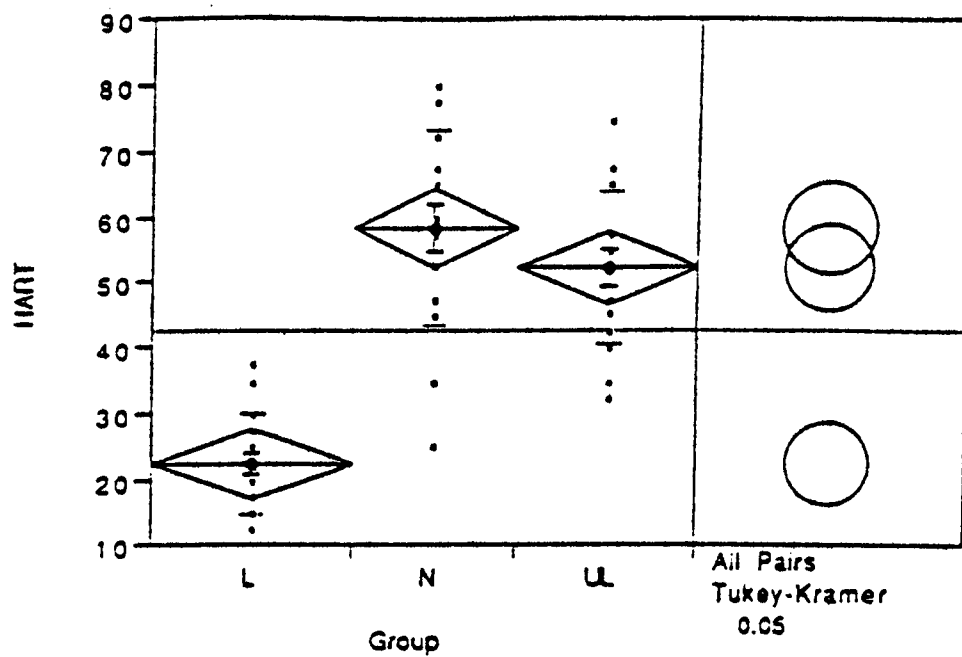


Figure 9. Percent correct scores for the three groups on the HART. Diamonds represent 95% confidence interval for the mean. Circles indicate results of the post hoc analysis.

#### 4.3.1 Hypothesis 4, Interactions for Three Groups

Statistical Analysis. Research hypothesis four was tested using a three-factor analysis of variance (ANOVA) (Bruning and Kintz, 1987). Table X summarizes the results for the three main effects and the interactions.

Research hypothesis number four stated there is an interaction among the three groups (LD-LL, LD-UL, and NL), speaking rates (slow and normal), and number of elements (5-6 and 7-9) on the HART. The three-factor interaction of groups, rates, and elements, was not significant [ $F(2,188)=2.4$ ;  $p=0.0923$ ]. However, the results from the analysis revealed a significant two-factor interaction between groups and number of elements [ $F(2,188)=4.1$ ;  $p=0.0166$ ]. Figure 10 shows the mean scores for the three groups for both 5-6 and for 7-9 elements. For the elements-group interaction, the 7-9 elements separated the mean scores into three groups, whereas the 5-6 elements did not. It appeared that the more elements (7-9) are needed to identify the three groups. It appeared that the analysis of the three-groups revealed something different from the earlier two-group analysis. This appeared to be an important finding. The two-factor interactions, of groups and rates and of rates and number of elements, were not significant.

TABLE X

SUMMARY OF THE RESULTS OF ANALYSIS OF VARIANCE  
FOR INTERACTION FOR GROUPS (LD-LL, LD-UL, AND NL),  
SPEAKING RATES (NORMAL AND SLOW), AND  
NUMBER OF ELEMENTS (5-6 AND 7-9)

| Source              | df | SS      | F     | p        |
|---------------------|----|---------|-------|----------|
| Groups (G)          | 2  | 51413.3 | 101.5 | < 0.0001 |
| Rates (R)           | 1  | 19804.3 | 78.2  | < 0.0001 |
| Interaction (G*R)   | 2  | 494.9   | 0.9   | 0.3783   |
| Elements (E)        | 1  | 42693.3 | 168.6 | < 0.0001 |
| Interaction (G*E)   | 2  | 2120.0  | 4.1   | 0.0166   |
| Interaction (R*E)   | 1  | 637.3   | 2.5   | 0.1143   |
| Interaction (G*R*E) | 2  | 1221.8  | 2.4   | 0.0923   |

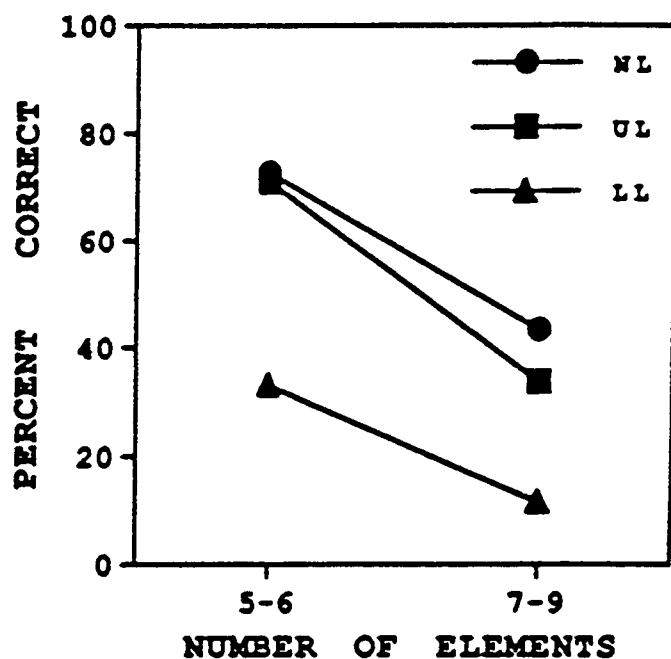


Figure 10. Percent correct mean scores as functions of number of elements in the HART for three groups, NL (normal learners), UL (upper level LD), and LL (lower level LD).

#### 4.3.2 Hypothesis 5, Main Effects for the Three Groups

Statistical Analysis. Research hypothesis five was tested using a three-factor analysis of variance (ANOVA) (Bruning and Kintz, 1987). Table X shows the results for main effects and interactions.

Research hypothesis number five stated there is a significant difference in the syllable rhythm pattern scores of the HART between (1) the groups (LD-LL, LD-UL, and NL); (2) the speaking rates (slow and normal); and (3) the number of elements (5-6 and 7-9). Results from the analysis revealed significant effects of the three groups [ $F(2,188)=101.5;p<0.0001$ ]; speaking rates [ $F(1,188)=78.2;p<0.0001$ ] and number of elements [ $F(1,188)=168.6;p<0.0001$ ]. The mean group scores for two rates, and two different numbers of elements are in Tables XI and XII, respectively. The raw data are in Tables, II, VI, and VII. The mean score for 7-9 elements (30%) was poorer (29%) than the mean score for the 5-6 elements (59%). The mean score for slow rate (34%) was poorer (20%) than for the normal rate (54%). Both more elements (7-9) and slower rate produced significantly poorer scores. It appeared that elements and rate are important factors for testing with the HART.

MEAN SCORES (PERCENT CORRECT) FOR NORMAL AND SLOW SPEAKING  
RATES FOR THE NL, LD-UL, AND LD-LL GROUPS

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TABLE XII

MEAN SCORES (PERCENT CORRECT) FOR 5-6 AND 7-9 ELEMENTS  
FOR THE NL, LD-UL, AND LD-LL GROUPS

|       | 5-6            | 7-9            |
|-------|----------------|----------------|
| NL    | 72.2           | 43.3           |
| LD-UL | 70.9           | 33.7           |
| LD-LL | 33.1           | 11.5           |
|       | $\bar{X}=58.9$ | $\bar{X}=29.5$ |

## CHAPTER V

### DISCUSSION

In the present investigation, word identification in sentences with noise (SPIN), auditory sequential memory for spoken digits (ASM), and listening/imitation of syllable rhythm patterns (HART) were found to be significantly poorer for children with learning disabilities (LD) than for children with normal learning abilities (NL). The LD group was further separated into two; upper level (LD-UL) and a lower level (LD-LL) subgroups. The results indicate that LD children with learning disabilities have significant difficulty with listening skills. The LD-LL had lower scores than the LD-UL. The discussion will highlight some important findings of the study.

#### 5.1 Word Perception In Sentences With Noise

In the present study, the LD group scored significantly lower than the NL group on the SPIN test, when identifying words in sentences, with a +8 dB speech-to-babble ratio. Elliott (1979), also reported a significant difference between SPIN scores with a +5 dB speech-to-babble ratio for children with learning disabilities and normal learners. The results of the present study and Elliott's study agreed that LD's scored poorer than NL's on the SPIN test; the difference was eight percent (8%) in the present study and six (6%) in Elliott's study. It appeared that the SPIN, which is an accepted research test, was an effective tool for assessing listening

skills in children with learning disabilities. It is important that two separate studies showed the same results.

The LD's in Elliott's study were nine-year olds who were identified by the teachers as LD or NL only after the testing was completed. In the present study, the third grade (7 years 10 months to 9 years 10 months) children with LD were identified prior to testing by the resource specialist and school principal. It appeared that in both studies the results were very similar, i.e., the LD's performed poorer than the NL's. The test scores did not appear to be affected, if the tester was aware of the child's learning disability before testing.

For the high predictability (HP) sentences, (see Figure 11), the mean group scores of Hall's and Elliott's studies were very similar for the LD group and the NL group. The 3-dB difference (8 vs 5 dB) in speech-to-babble ratio did not appear to affect the scores of the two groups.

For the low predictability (LP) sentences, (see Figure 11), both groups in both studies scored lower on the LP sentences than for the HP sentences. However, in the present study, the mean group scores were 15% lower, whereas they were 30% lower in the Elliott's study. It appeared that the mean scores for the LP sentences were adversely affected by the poorer signal-to-babble ratio in the Elliott's study, because Elliott's mean scores were lower than in the present study. Elliott (1979) speculated that the poorer scores of children

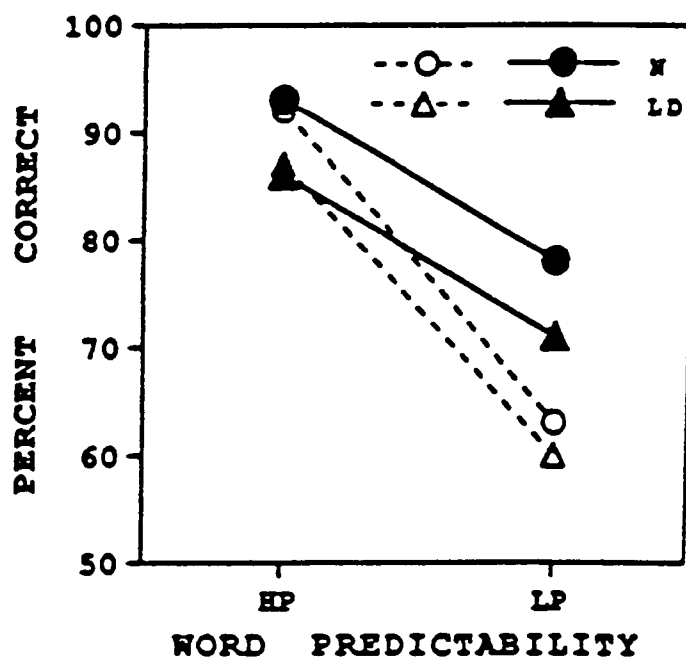


Figure 11. SPIN test scores on high predictability (HP) and low predictability (LP) sentences for children with learning disabilities (LD) and normal learners (NL). Elliott's (1979) data (---) for speech-to-babble ratio of +5 dB and Hall's (1994) data (—) for speech-to-babble ratio of +8 dB.

with learning disabilities were attributed to their lack of knowledge for linguistic and syntactic contingencies of language.

In some classrooms, the signal-to-noise ratio may be very low, even lower than +5 dB in Elliott's study and the +8 in the present study. The results of both studies indicated that in poor listening conditions children with learning disabilities appeared to have greater difficulties in understanding words than children with normal learning abilities. These difficulties appeared to be even greater for the LD-LL subgroup in the present study.

#### 5.2 Auditory Sequential Memory For Spoken Digits

In the present study, significant differences were found between the LD and NL groups on the ASM test. The LD group scored 12% lower than the NL group on the recall of spoken digits. The significant difference between the two groups indicated that the LD's were poorer than the NL group for immediate recall of digits. The results from the present study agree with Rudel and Denckla results (1974) and Torgesen results (1991), both studies reported a significant difference between LD's and NL children, ten years-of age, for immediate recall of digits. Both studies indicated that LD's had poorer short-term memory than NL's for immediate recall of digits. Swanson and Trahan (1990) found significant differences between learning disabled readers and normal readers on a memory task of recalling the last word in a series of three sentences.

For examining speaking rates, McNutt and Li (1980) found LD children were significantly poorer than NL at repeating words presented at normal rate (four syllables per second), at 60 and 30% compression, and at 30 and 60% expansion. Campbell and McNeil (1985) concluded that slowing the rate of presentation of linguistic stimuli, such as words in sentences improved auditory comprehension for children classified with language/learning disorders. However, slowing the rate of digit presentation did not improve performance of LD children. Torgesen (1991) presented digits using two different rates, four digits per second and one digit per second. In the present study, digits were presented at a single rate of two per second; the scores were 45% and 57% for the LD and NL groups, respectively.

The group mean difference in the present study was 12% for items presented at two digits per second. Torgesen's group mean difference for severe learning disabled children (LD/S) and normal learners (NL) was 23% and 24% for digits presented at four per second and at one digit per second, respectively. It appeared that in Torgesen (1991) study the results were not noticeably affected by the rate of presentation. The significant difference between the groups, in both the present study and Torgesen study, was apparently attributed to poorer than normal short-term memory by children with learning disabilities for immediate recall of digits. The LD/S group in the Torgesen study, scored noticeably lower (27% and 21%) at

4 digits per second and 1 digit per second than the LD group (45%), but closer to the LD-LL group (38%), in the present study, although the scores for the NL groups were similar in both studies. The very low scores in the Torgesen (1991) study, were probably attributed to the more severe learning disability then in the present study.

The ASM test is designed to test auditory short-term memory for immediate recall of different number of digits. The ASM test is a part of a linguistic battery test. It is assumed that most school children know digits by the time they reach the second or third grade. The ASM test is limited to testing digit recall for only school age children, with sufficient linguistic abilities.

### 5.3 Hall Auditory Rhythm Test

In the present study, significant differences were found between the mean scores for LD and NL groups on the HART. The LD group scored 22% lower than the NL group. The HART was developed to determine a child's ability to perceive and imitate the nonsense syllable /ba/ in rhythm patterns with different rates and numbers of elements. Because the nonsense syllable /ba/ is non-linguistic, the HART can be used to test younger children, including preschoolers. However, the ASM test is a linguistic test, and cannot be used to test younger children than school age.

The score on the HART separated the LD group from the NL group. For both groups, the scores for the slow rate were

poorer than for the normal rate, and the scores for more (7-9) elements were poorer than for less (5-6) elements. Therefore, this suggests that listening and imitating syllable rhythm patterns with different elements and rates is a viable tool for assessing auditory processing skills in children with learning disabilities.

The significant interaction between the two groups (LD and NL) and the three tests (SPIN, ASM, and HART) indicated that the means differed for the two groups on each test. The greatest difference between the group means was on the HART (see Figure 4). Therefore, suggesting that the HART was the most difficult of the three tests for children with learning disabilities.

#### 5.4 Two Levels of LD

A Hierarchical Clustering Analysis performed on scores of all three tests indicated that the LD's separated statistically into two groups; an upper level (LD-UL) and a lower level (LD-LL) group. The mean scores for the three groups, LD-UL, LD-LL and NL, and for the three tests were compared. The SPIN (Figure 7) did not separate the LD-UL from the LD-LL group. This result suggested that word identification in a +8 signal-to-babble ratio was not a viable tool for separating the two subgroups of LD's. Based on the mean scores of the ASM test and HART, testing rhythm and memory, separated the LD's into two distinct subgroups (Figures 8 and 9, respectively). However, the scores of the

ASM test and HART did not separate the LD-UL from the NL group. It appeared that LD-UL were similar to the NL group. The results from the ASM test is in a agreement with Torgesen (1991) who separated LD's into two groups based on the scores from the Digit Span subtest of the Wechsler Intelligence Scale for Children Revised (WISC-R) or the Auditory Sequential Memory test (ASM).

Two other studies have been found in which LD's were subgrouped. Ferre and Wilber (1986) classified two different groups of children: 1) children with learning disabilities with auditory impairment (LD/LD); and 2) children with learning disabilities with no auditory impairment (LD/N).

Torgesen (1991) classified LD's as: 1) learning disabled with normal digit span memory (LD/N); and 2) learning disabled with severe digit span memory (LD/S).

A significant interaction was found for the three groups (NL, LD-UL, and LD-LL) and number of elements on the HART, indicating that the mean scores for the three groups differed more on the 7-9 elements than on the 5-6 elements. Therefore, the use of more elements can be used to separate the LD-LL from the LD-UL subgroup. There was no significant interaction found for groups and speaking rates; speaking rates and number of elements; and groups, speaking rates, and number of elements. However, there was a significant main effect found for speaking rates (normal vs slow); poorer scores were obtained for the slow than the normal rate. Speaking at a

slower rate appeared to have a negative affect on the performance of the LD group. Teachers and clinicians should note this finding; speaking rates are important in speaking to and assessing LD children.

The present study, as well as earlier studies separated LD's into two subgroups based on their listening performance. This suggested that the HART and/or the ASM test should be considered when evaluating listening/imitating skills of children with learning disabilities. The two levels of LD's (LD-LL and LD-UL) suggested that the therapy to improve listening may have to be different for the LD-LL and the LD-UL subgroups.

#### 5.5 Correlation Between HART, ASM, and SPIN

The Spearman Rank-Order Correlation analysis (see Table XIII) indicated a significant ( $p < 0.0001$ ) positive correlation ( $r = +0.74$ ) between scores of the ASM test and the HART (see Figure 12). A significant positive correlation indicated that both the HART and ASM test scores changed in the same direction for both LD and NL groups. However, the  $r = +0.74$  has an  $r^2$  value of only 0.55. For the ASM and HART scores, this indicated that only 55% of the variance was in common and was predictable. The common factor may be the memory tested by both tests. Forty five percent was not accounted for, which may be attributed to different rates, elements, and different rhythm patterns which had to be imitated in the HART. Even though the HART is more difficult than the ASM test to

administer, it provided additional information, and it can be used with preschoolers. Thus, the HART should be considered for evaluating listening skills of children with learning disabilities. However, the use of the entire test battery (SPIN, ASM, and HART) may provide a clearer diagnosis of listening problems, than using only a single test.

For both the HART ( $r=+0.20$ ) and ASM ( $r=+0.23$ ) scores, there was lack of a significant correlation with the SPIN scores. This suggested that the memory and rhythm patterns of the HART, and the memory of the ASM test are testing different listening skills, than word identification in sentences with noise.

## 5.6 Implication for Treatment

### 5.6.1 Indirect Treatment With No Therapy

In the public schools, some children with learning disabilities (LD) may also have a central auditory processing disorder (CAPD). The educational diagnosis is limited to learning disabilities, while the medical diagnosis is limited to CAPD. The private medical-clinics have shown that CAPD can be reliably detected in school-age children (Musiek, et. al., 1982; Keith, 1984; Pinheiro and Musiek, 1985).

Traditionally, treatment of children with diagnosed CAPD has used an indirect treatment model designed to improve speech-to-noise ratios in the classrooms, i.e., reduction of background noise, preferential seating, and/or use of FM or other assistive listening devices (Chermak and Musiek, 1992).

The indirect treatment did not include a clinician helping to improve the child's listening skills. There appeared to be no data that indicated a significant improvement in listening abilities from indirect treatments. It was postulated that the direct treatment that includes therapy for improving the child's listening skills would minimize or eliminate listening difficulties of some LD children.

#### 5.6.2 Direct Treatment With Therapy

In the public schools, children labeled as LD are traditionally referred to resource rooms for direct treatment and/or speech-language therapy. However, this treatment plan does not include therapy to improve listening skills. A direct treatment with therapy has been developed by Guberina and Asp, (1981); and Asp et al. (1990), and showed a significant improvement in listening skills for hearing impaired children. A similar treatment plan has been implemented to improve the listening and spoken skills of children with CAPD and/or LD.

TABLE XIII  
SPEARMAN RANK-ORDER CORRELATION FOR THE  
SPIN, ASM, AND HART TESTS

| Nonparametric Measures of Association |          |              |           |  |    |    |    |    |   |   |   |   |   |
|---------------------------------------|----------|--------------|-----------|--|----|----|----|----|---|---|---|---|---|
| Variable by                           | Variable | Spearman Rho | Prob> Rho |  | -8 | -6 | -4 | -2 | 0 | 2 | 4 | 6 | 8 |
| AMS                                   | SPIN     | 0.2320       | 0.1049    |  |    |    |    |    |   |   |   |   |   |
| HART                                  | SPIN     | 0.2009       | 0.1619    |  |    |    |    |    |   |   |   |   |   |
| HART                                  | AMS      | 0.7436       | 0.0000    |  |    |    |    |    |   |   |   |   |   |

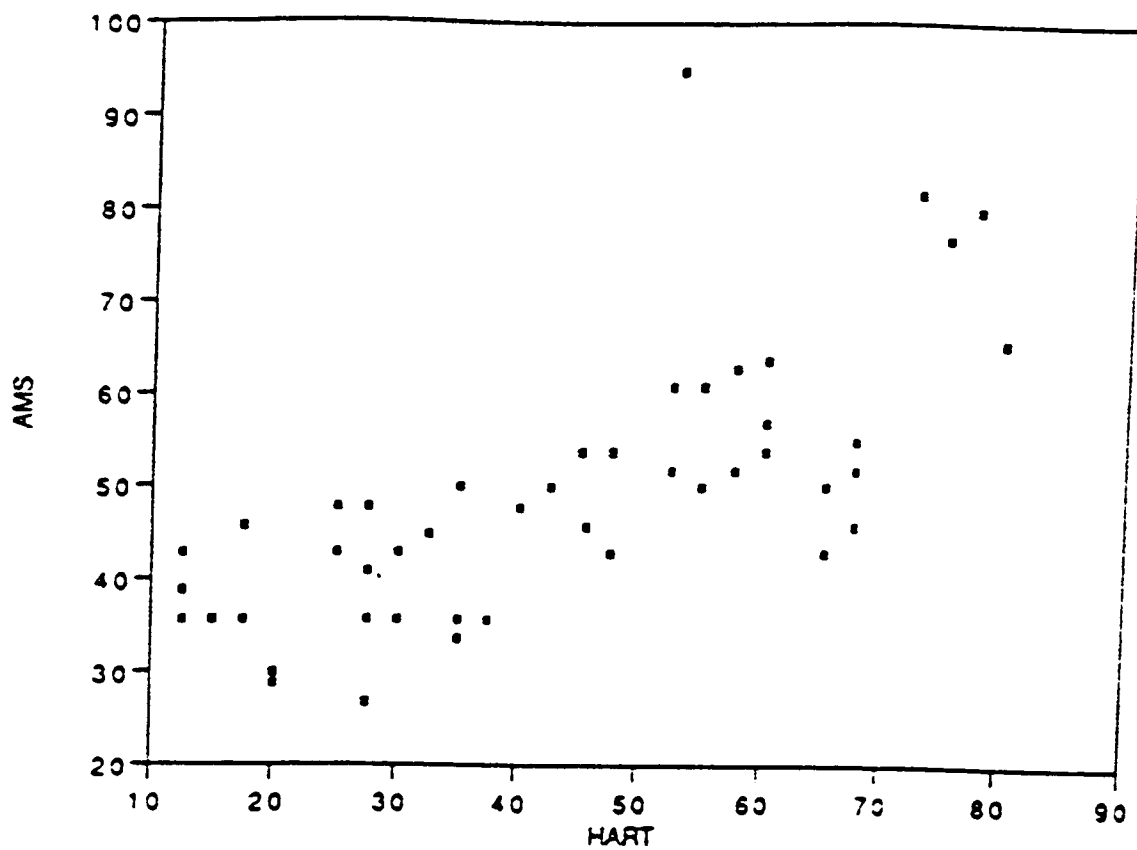


Figure 12. Scatter plot representing the relationship between the ASM test scores (ordinate) and the HART scores (abscissa).

The treatment consists of combining movements and rhythm patterns with filtered speech signals, to improve children's listening skills. The private medical-clinic study (Earl, Asp, and Rook, 1991; Earl and Rook, 1994) for children with CAPD, demonstrated that direct therapy improved listening skills. Also, a public school study (Kline, 1994) of children with LD, demonstrated that the new direct treatment with therapy improved listening skills, as well as educational test scores.

Recently, the new direct treatment plan with therapy for some LD children was implemented in Knox County Public Schools. These selected LD children were considered "failures" under the conventional treatment model of phonetic placement and same/different sound identification tasks used by speech-language pathologist in Knox County Schools. The new direct treatment with therapy is provided by Hearing Services, which emphasizes improving listening skills in children with learning disabilities. This direct intervention approach is a new public school model that appears to show great promise for the future.

## CHAPTER VI

### SUMMARY AND CONCLUSIONS

The following conclusions were drawn from this study.

(1) Children with learning disabilities (LD) performed significantly poorer than children with normal learning abilities (NL) in:

- (a) identifying spoken words in sentences with noise;
- (b) recalling sequences of digits;
- (c) imitating syllable rhythm patterns.

The results of the tests indicate that the children with learning disabilities have poorer listening skills than normal learners. The results of (a) and (b) are in agreement and verifies the results of earlier studies. The results of (c), and the combination of (a), (b), and (c) in the present study are new findings for assessment of children's learning disabilities.

(2) Children with learning disabilities separated statistically into two distinct subgroups; upper level (LD-UL) and lower level (LD-LL) of listening skills on the ASM test and the HART, but not on the SPIN test. Even though LD-UL and LD-LL children have the same educational classification of LD, they appear to have different abilities to recall digits and to imitate syllable rhythm patterns. The separation of children with learning disabilities into two subgroups appears to be useful for the design and/or treatment strategies for

children with learning disabilities.

#### 6.1 Future Research

1. Validity of the HART should be assessed for evaluating the listening skills of children with other types of disorders, such as phonologically impaired children, children with fluency disorders, and children who are language impaired.
2. The HART could be used to determine the performance of children with learning disabilities who are on medication, LD children who are not on medication, children classified as having a central auditory processing disorder, and children classified as having an attention deficit disorder.
3. The HART could be used to assess possible improvement from direct treatment with therapy.

#### 6.2 Limitations of this Study

1. One limitation of this study was the lack of interjudge agreement in the HART scores between the tester and the panel for two subjects. Possibly, the scoring procedure and criteria should be modified on the HART. Also, training of the tester to establish a criteria for judging of speaking rate (slow or normal), may improve the interjudge agreement for different testers scoring the HART.

2. Another limitation of this study was that the LD subjects tested may be an exceptional group, because they were not on medication. From the tester's experience in the present study, it was estimated that 60-75% of LD's in Knox County Public Schools were on medication. Therefore, it is not known if the data collected is applicable for those children with learning disabilities who are on medication.

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## APPENDICES

## Appendix A

### Definitions of Auditory Processing Abilities

"Localization. The ability to locate auditorily the source of sound. This ability requires binaural hearing."

"Binaural Synthesis. The ability to centrally integrate incomplete stimulus patterns presented simultaneously or alternately to opposite ears."

"Figure Ground. The ability to identify a primary signal or message in the presence of competing sounds. This term was initially used in relation to vision. Auditorily, the task may be more difficult, because both the primary and competing sounds change their acoustic features continually over time. Auditory figure ground can be a monaural or a binaural task."

"Binaural Separation. The ability to listen with one ear while ignoring stimulation of the opposite ear. Dichotic listening, as a binaural separation task, requires the listener to attend to, and report back, different signals presented simultaneously to two ears."

"Memory. The ability to store and to recall auditory stimuli, including the ability to recall the length or number of auditory stimuli; and sequential memory, or the ability to recall the exact order of auditory stimuli presented."

"Blending. The ability to form words out of separately articulated phonemes."

"Discrimination. The ability to determine whether two acoustic stimuli are the same or different. In speech, auditory discrimination is the ability to recognize fine differences that exist among phonemes."

"Closure. The ability to perceive the whole (word or message) when parts are omitted."

"Attention. The ability to persist in listening over a reasonable period."

"Association. The ability to establish correspondence between a nonlinguistic sound and source."

"Cognition. The ability to establish a correspondence between a linguistic sound and its meaning. Cognition is the highest level of auditory perception and results from a summation of all auditory (and all sensory) tasks."

## APPENDIX B

### List of Knox County Public Schools And Number of Subjects Participating In Study

| <u>Schools</u>              | <u>Number of Subjects</u> |
|-----------------------------|---------------------------|
| Farragut Intermediate       | Two (LD)                  |
| Cedar Bluff Intermediate    | Three (LD) and Seven (NL) |
| Pond Gap Elementary         | One (LD)                  |
| Inskip Elementary           | Six (LD)                  |
| Shannondale Elementary      | Eight (NL)                |
| Halls Elementary            | Five (LD)                 |
| Chilhowee Intermediate      | Seven (LD)                |
| Sara Moore Green Elementary | Two (LD)                  |
| Brickey Elementary          | Two (LD)                  |
| Karns Intermediate          | Four (LD)                 |
| Fountain City Elementary    | Three (LD)                |

## Appendix C

### Specific Learning Disability

#### Definition

A child who has a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken, or written, which may manifest itself in significant difficulties in the acquisition and use of listening, speaking, reading, writing, spelling or performing mathematical calculations is considered to have a specific learning disability.

#### Criteria

A child exhibits a significant discrepancy between achievement and cognitive/intellectual functioning when provided with learning experiences appropriate for the individual's age and ability levels.

A significant discrepancy is defined as a difference of more than one standard deviation between cognitive/intellectual functioning and measured achievement in one or more of the following areas:

- \* Listening comprehension,
- \* Oral expression,
- \* Basic reading skill,
- \* Reading comprehension,
- \* Written expression
- \* Mathematics calculation,
- \* Mathematics reasoning.

In cases where the specialists determine that assessment measures did not accurately reflect the discrepancy between academic functioning and intellectual functioning, appropriate documentation must be used to verify the discrepancy.

Although a learning disability may occur with other impairments, a child may not be identified as having a specific learning disability if the discrepancy between ability and achievement is primarily the result of one of the following:

- \* A visual, hearing, or motor impairment;
- \* Mental retardation;
- \* Emotional disturbance;
- \* Environmental, cultural or economical disadvantage;
- \* Insufficient teaching.

## Evaluation Procedures

The following assessment procedures must be utilized:

Assessment of the child's cognitive/intellectual functioning with an individual evaluation by a certified school psychologist, licensed psychologist, or a licensed psychological examiner utilizing appropriate procedures.

Assessment of achievement with individually administered tests in the areas of suspected learning disability by appropriately qualified personnel.

Documented observations of classroom behaviors and academic performances by both the regular classroom teacher and at least one other assessment specialist. In the case of a child of less than school age or out of school, an assessment specialist shall observe the child in an environment appropriate for a child of that age.

Assessment Specialists-The following persons shall be involved in the assessment of learning disabilities:

The child's regular teacher;

A certified school psychologist, licensed psychological examiner, or a licensed psychologist;

Other specialists such as speech/language teachers or pathologists or special education teachers as designated by the M-Team Chairperson.

(Special Education Manual, 1993).

# Appendix D

## HALL AUDITORY RHYTHM TEST (HART)

Subject No. \_\_\_\_\_

Total Test Score\_\_\_\_\_

### RHYTHM PATTERNS-PRACTICE

|                                                  | <u>Score (C/I)</u> |     | <u>error type</u>               |
|--------------------------------------------------|--------------------|-----|---------------------------------|
|                                                  | 1st                | 2nd | (omit/added elements)<br>(rate) |
| 1. <u>baaa</u> <u>baaa</u> <u>baaa</u>           | —                  | —   | _____ (normal)                  |
| 2. <u>b^</u> <u>b^</u> <u>b^</u> <u>b^</u>       | —                  | —   | _____ (slow)                    |
| 3. <u>b^</u> <u>baaa</u> <u>baaa</u>             | —                  | —   | _____ (slow)                    |
| 4. <u>baaa</u> <u>b^</u> <u>baaa</u> <u>baaa</u> | —                  | —   | _____ (normal)                  |

Percent Correct \_\_\_\_\_

### TEST ITEMS

#### PART I (Normal Rate)

#### RHYTHM PATTERNS- FIVE TO SIX ELEMENTS

|                                                                       | <u>Score (C/I)</u> |     | <u>error</u>  |
|-----------------------------------------------------------------------|--------------------|-----|---------------|
|                                                                       | 1st                | 2nd | omitted added |
| 1. <u>baaa</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u>            | —                  | —   | _____         |
| 2. <u>b^</u> <u>baaa</u> <u>b^</u> <u>baaa</u> <u>b^</u>              | —                  | —   | _____         |
| 3. <u>b^</u> <u>baaa</u> <u>baaa</u> <u>b^</u> <u>b^</u>              | —                  | —   | _____         |
| 4. <u>b^</u> <u>b^</u> <u>b^</u> <u>b^</u> <u>baaa</u>                | —                  | —   | _____         |
| 5. <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u>              | —                  | —   | _____         |
| 6. <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u>    | —                  | —   | _____         |
| 7. <u>b^</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>baaa</u>    | —                  | —   | _____         |
| 8. <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u>    | —                  | —   | _____         |
| 9. <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>baaa</u> <u>b^</u>    | —                  | —   | _____         |
| 10. <u>baaa</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> | —                  | —   | _____         |

Percent Correct \_\_\_\_\_

PART II (Normal Rate)  
RHYTHM PATTERNS- SEVEN TO NINE ELEMENTS

Score (C/I) error  
 1st 2nd omitted added

- |                                                                                                       |       |
|-------------------------------------------------------------------------------------------------------|-------|
| 11. <u>baaa</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u>                       | — — — |
| 12. <u>bΛ</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u>                         | — — — |
| 13. <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u>             | — — — |
| 14. <u>baaa</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u>                       | — — — |
| 15. <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u>                       | — — — |
| 16. <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>bΛ</u>               | — — — |
| 17. <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u>   | — — — |
| 18. <u>bΛ</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>baaa</u> <u>baaa</u> | — — — |
| 19. <u>bΛ</u> <u>baaa</u> <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u>                       | — — — |
| 20. <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u> <u>bΛ</u> <u>bΛ</u> <u>baaa</u> <u>baaa</u>           | — — — |

Percent Correct \_\_\_\_\_

PART III (Slow Rate)  
RHYTHM PATTERNS- FIVE TO SIX ELEMENTS

|     |                                                                   | <u>Score (C/I)error</u> |     |               |
|-----|-------------------------------------------------------------------|-------------------------|-----|---------------|
|     |                                                                   | 1st                     | 2nd | omitted added |
| 21. | <u>baaa</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u>           | —                       | —   | —             |
| 22. | <u>b^</u> <u>baaa</u> <u>b^</u> <u>baaa</u> <u>b^</u>             | —                       | —   | —             |
| 23. | <u>b^</u> <u>baaa</u> <u>baaa</u> <u>b^</u> <u>b^</u>             | —                       | —   | —             |
| 24. | <u>b^</u> <u>b^</u> <u>b^</u> <u>b^</u> <u>baaa</u>               | —                       | —   | —             |
| 25. | <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u>             | —                       | —   | —             |
| 26. | <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u>   | —                       | —   | —             |
| 27. | <u>b^</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>baaa</u>   | —                       | —   | —             |
| 28. | <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u>   | —                       | —   | —             |
| 29. | <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>baaa</u> <u>b^</u>   | —                       | —   | —             |
| 30. | <u>baaa</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> | —                       | —   | —             |

Percent Correct \_\_\_\_\_

PART IV (Slow Rate)

RHYTHM PATTERNS- SEVEN TO NINE ELEMENTS

Score (C/I)error

1st 2nd omitted added

- |                                                                                                       |       |       |       |
|-------------------------------------------------------------------------------------------------------|-------|-------|-------|
| 31. <u>baaa</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u>                       | _____ | _____ | _____ |
| 32. <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u>                         | _____ | _____ | _____ |
| 33. <u>b^</u> <u>baaa</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u>             | _____ | _____ | _____ |
| 34. <u>baaa</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>b^</u> <u>baaa</u>                       | _____ | _____ | _____ |
| 35. <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u>                       | _____ | _____ | _____ |
| 36. <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u>               | _____ | _____ | _____ |
| 37. <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>b^</u> <u>baaa</u>   | _____ | _____ | _____ |
| 38. <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>baaa</u> <u>baaa</u> | _____ | _____ | _____ |
| 39. <u>b^</u> <u>baaa</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u>                       | _____ | _____ | _____ |
| 40. <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>b^</u> <u>b^</u> <u>baaa</u> <u>baaa</u>           | _____ | _____ | _____ |

Percent Correct \_\_\_\_\_

# Appendix E R-SPIN PRACTICE LIST

| NAME                                                   | DATE |       |
|--------------------------------------------------------|------|-------|
| 1. SHE HAD SPOKEN ABOUT THE <u>SCAR</u> .              | 1.   | _____ |
| 2. CAMELS STORE WATER IN THEIR <u>HUMPS</u> .          | 2.   | _____ |
| 3. MR. SMITH MIGHT DISCUSS THE <u>MILL</u> .           | 3.   | _____ |
| 4. I BUILT THE MODEL FROM A <u>KIT</u> .               | 4.   | _____ |
| 5. THE LOUD NOISE MADE HIM JUMP WITH <u>FRIGHT</u> .   | 5.   | _____ |
| 6. RUTH COULDN'T KNOW ABOUT THE <u>SHRIMP</u> .        | 6.   | _____ |
| 7. WE WERE DISCUSSING THE <u>GAS</u> .                 | 7.   | _____ |
| 8. SHE'S BEEN CONSIDERING THE <u>CONE</u> .            | 8.   | _____ |
| 9. THE WINNING CARD WAS AN <u>ACE</u> .                | 9.   | _____ |
| 10. TOM WORE A TIE AND A WHITE <u>SHIRT</u> .          | 10.  | _____ |
| 11. I'M GLAD TOM ASKED ABOUT THE <u>SPOUT</u> .        | 11.  | _____ |
| 12. HER SKIN BROKE OUT IN A <u>RASH</u> .              | 12.  | _____ |
| 13. PAUL HEARD THEY ASKED ABOUT THE <u>RICE</u> .      | 13.  | _____ |
| 14. THE CHILD THREW BREAD CRUMBS TO THE <u>DUCKS</u> . | 14.  | _____ |
| 15. PAUL CHOPPED DOWN THE TREE WITH HIS <u>AX</u> .    | 15.  | _____ |
| 16. THEY WANT TO SPEAK ABOUT THE <u>TRASH</u> .        | 16.  | _____ |
| 17. HE'S AS STUBBORN AS A <u>MULE</u> .                | 17.  | _____ |
| 18. PAUL IS CONSIDERING THE <u>DRILL</u> .             | 18.  | _____ |
| 19. THE WOMAN TALKS ABOUT THE <u>BEACH</u> .           | 19.  | _____ |
| 20. HOSPITALS SHOULD BE FREE OF <u>GERMS</u> .         | 20.  | _____ |
| 21. YOU SHOULD DISCUSS THE <u>FLUTE</u> .              | 21.  | _____ |
| 22. LET'S SLIDE DOWN THE HILL ON THE <u>SLED</u> .     | 22.  | _____ |
| 23. HE WEIGHED THE MEAT ON A <u>SCALE</u> .            | 23.  | _____ |
| 24. PAUL WANTS TO THINK ABOUT THE <u>PALM</u> .        | 24.  | _____ |
| 25. SHE WAS INTERESTED IN THE <u>SOAP</u> .            | 25.  | _____ |
| 26. YOU LED THEM ON A MERRY <u>CHASE</u> .             | 26.  | _____ |
| 27. THE SWIMMER WAS ATTACKED BY <u>SHARKS</u> .        | 27.  | _____ |
| 28. MISS WHITE SPOKE ABOUT THE <u>SAUCE</u> .          | 28.  | _____ |
| 29. STAINLESS STEEL WILL NEVER <u>RUST</u> .           | 29.  | _____ |
| 30. HE'S CONSIDERED THE <u>ITCH</u> .                  | 30.  | _____ |
| 31. SHE HAD A PROBLEM WITH THE <u>PLUMS</u> .          | 31.  | _____ |
| 32. THE ROBBER COMMITTED A <u>CRIME</u> .              | 32.  | _____ |
| 33. THE SECRET MESSAGE WAS IN <u>CODE</u> .            | 33.  | _____ |
| 34. BROIL THE STEAK ON A CHARCOAL <u>GRILL</u> .       | 34.  | _____ |
| 35. HE'S BEEN DISCUSSING THE <u>ACHE</u> .             | 35.  | _____ |
| 36. RUTH SAT ON THE LIVING ROOM <u>COUCH</u> .         | 36.  | _____ |
| 37. BILL SHOULD HAVE CONSIDERED THE <u>HOOD</u> .      | 37.  | _____ |
| 38. A BEE CAN GIVE A PAINFUL <u>STING</u> .            | 38.  | _____ |
| 39. THEY ARE CONSIDERING THE <u>CURL</u> .             | 39.  | _____ |
| 40. NANCY HAD KNOWN ABOUT THE <u>COUGH</u> .           | 40.  | _____ |
| 41. JANE HEARD HE CALLED ABOUT THE <u>BUS</u> .        | 41.  | _____ |
| 42. THE SOAP WASHED AWAY THE <u>DIRT</u> .             | 42.  | _____ |
| 43. HE'S DISCUSSING THE <u>GIFT</u> .                  | 43.  | _____ |
| 44. JANE WAS DRESSED IN A SKIRT AND <u>BLOUSE</u> .    | 44.  | _____ |
| 45. SHE IS CONSIDERING THE <u>SHELF</u> .              | 45.  | _____ |
| 46. ANIMALS ARE KEPT IN THE <u>ZOO</u> .               | 46.  | _____ |
| 47. HARRY WAS DISCUSSING THE <u>MAIL</u> .             | 47.  | _____ |
| 48. HIS FACE WAS CONCEALED BY A <u>MASK</u> .          | 48.  | _____ |
| 49. HALF A QUART IS A <u>PINT</u> .                    | 49.  | _____ |
| 50. RUTH IS CONSIDERING THE <u>CLOWN</u> .             | 50.  | _____ |

# Appendix F R-SPIN FORM #1

| NAME _____                                         | DATE _____ |       |
|----------------------------------------------------|------------|-------|
| 1. HIS PLAN MEANT TAKING A BIG <u>RISK</u> .       | 1.         | _____ |
| 2. STIR YOUR COFFEE WITH A <u>SPOON</u> .          | 2.         | _____ |
| 3. MISS WHITE WON'T THINK ABOUT THE <u>CRACK</u> . | 3.         | _____ |
| 4. HE WOULD THINK ABOUT THE <u>RAG</u> .           | 4.         | _____ |
| 5. THE PLOW WAS PULLED BY AN <u>OX</u> .           | 5.         | _____ |
| 6. THE TRAIN WAS POWERED BY THE <u>STEAM</u> .     | 6.         | _____ |
| 7. THE OLD MAN TALKED ABOUT THE <u>LUNGS</u> .     | 7.         | _____ |
| 8. I WAS CONSIDERING THE <u>CROOK</u> .            | 8.         | _____ |
| 9. LET'S DECIDE BY TOSSING A <u>COIN</u> .         | 9.         | _____ |
| 10. THE DOCTOR PRESCRIBED THE <u>DRUG</u> .        | 10.        | _____ |
| 11. BILL MIGHT DISCUSS THE <u>FOAM</u> .           | 11.        | _____ |
| 12. NANCY DIDN'T DISCUSS THE <u>SKIRT</u> .        | 12.        | _____ |
| 13. HOLD THE BABY ON YOUR <u>LAP</u> .             | 13.        | _____ |
| 14. BOB HAS DISCUSSED THE <u>SPLASH</u> .          | 14.        | _____ |
| 15. THE DOG CHEWED ON THE <u>BONE</u> .            | 15.        | _____ |
| 16. RUTH HOPES HE HEARD ABOUT THE <u>HIPS</u> .    | 16.        | _____ |
| 17. THE WAR WAS FOUGHT WITH ARMORED <u>TANKS</u> . | 17.        | _____ |
| 18. SHE WANTS TO TALK ABOUT THE <u>CREW</u> .      | 18.        | _____ |
| 19. THEY HAD A PROBLEM WITH THE <u>CLIFF</u> .     | 19.        | _____ |
| 20. THEY DRANK A WHOLE BOTTLE OF <u>GIN</u> .      | 20.        | _____ |
| 21. YOU HEARD JANE CALLED ABOUT THE <u>VAN</u> .   | 21.        | _____ |
| 22. THE WITNESS TOOK A SOLEMN <u>OATH</u> .        | 22.        | _____ |
| 23. WE COULD CONSIDER THE <u>FEAST</u> .           | 23.        | _____ |
| 24. BILL HEARD WE ASKED ABOUT THE <u>HOST</u> .    | 24.        | _____ |
| 25. THEY TRACKED THE LION TO HIS <u>DEN</u> .      | 25.        | _____ |
| 26. THE COW GAVE BIRTH TO A <u>CALF</u> .          | 26.        | _____ |
| 27. I HAD NOT THOUGHT ABOUT THE <u>GROWL</u> .     | 27.        | _____ |
| 28. THE SCARF WAS MADE OF SHINY <u>SILK</u> .      | 28.        | _____ |
| 29. THE SUPER HIGHWAY HAS SIX <u>LANES</u> .       | 29.        | _____ |
| 30. HE SHOULD KNOW ABOUT THE <u>HUT</u> .          | 30.        | _____ |
| 31. FOR DESSERT HE HAD APPLE <u>PIE</u> .          | 31.        | _____ |
| 32. THE BEER DRINKERS RAISED THEIR <u>MUGS</u> .   | 32.        | _____ |
| 33. I'M GLAD YOU HEARD ABOUT THE <u>BEND</u> .     | 33.        | _____ |
| 34. YOU'RE TAKING ABOUT THE <u>POND</u> .          | 34.        | _____ |
| 35. THE RUDE REMARK MADE HER <u>BLUSH</u> .        | 35.        | _____ |
| 36. NANCY HAD CONSIDERED THE <u>SLEEVES</u> .      | 36.        | _____ |
| 37. WE HEARD THE TICKING OF THE <u>CLOCK</u> .     | 37.        | _____ |
| 38. HE CAN'T CONSIDER THE <u>CRIB</u> .            | 38.        | _____ |
| 39. HE KILLED THE DRAGON WITH HIS <u>SWORD</u> .   | 39.        | _____ |
| 40. TOM DISCUSSED THE <u>HAY</u> .                 | 40.        | _____ |
| 41. MARY WORE HER HAIR IN <u>BRAIDS</u> .          | 41.        | _____ |
| 42. SHE'S GLAD JANE ASKED ABOUT THE <u>DRAIN</u> . | 42.        | _____ |
| 43. BILL HOPES PAUL HEARD ABOUT THE <u>MIST</u> .  | 43.        | _____ |
| 44. WE'RE LOST SO LET'S LOOK AT THE <u>MAP</u> .   | 44.        | _____ |
| 45. NO ONE WAS INJURED IN THE <u>CRASH</u> .       | 45.        | _____ |
| 46. WE'RE SPEAKING ABOUT THE <u>TOLL</u> .         | 46.        | _____ |
| 47. MY SON HAS A DOG FOR A <u>PET</u> .            | 47.        | _____ |
| 48. HE WAS SCARED OUT OF HIS <u>WITS</u> .         | 48.        | _____ |
| 49. WE SPOKE ABOUT THE <u>KNOB</u> .               | 49.        | _____ |
| 50. I'VE SPOKEN ABOUT THE <u>PILE</u> .            | 50.        | _____ |

## Appendix G

### AUDITORY SEQUENTIAL MEMORY (ASM)

Basal: 3 consecutive successes  
Ceiling: 2 consecutive failures

DEMONSTRATION: Ss below 6-0 begin with Demo I.  
For Ss 6-0 and above there is no Demo item, but the test (item 3) may be used as a Demo when necessary.

E says, LISTEN SAY "2-2." If S is not successful, E uses single digits, then returns to "2-2" and "2-1". When S is successful, E begins test items.

Test: Ss below 4-0 begin with Item 1 and proceed item by item.  
Ss 4-0 to 6-0 begin with items 1 and 2 and follow Sampling Procedure.  
Ss 6-0 and above begin with Items 3 and 4 and follow Sampling Procedure.

For all Ss, E may preface each item with: LISTEN. SAY "9-1" (or "8-1-1"). If S does not repeat a sequence successfully on the first trial, E says, NOT QUITE. LISTEN AGAIN (and repeats the sequence). When S is successful (on either first or second trial), E proceeds to the next appropriate item (see E manual for Sampling Procedure for Ss 4-0 and above).

#### Demonstration

- a. 2-2
- b. 2-1

|               | 1st   | 2nd   |                     | 1st   | 2nd   |
|---------------|-------|-------|---------------------|-------|-------|
| 1. 9-1        | _____ | _____ | 15. 7-4-8-3-5-5     | _____ | _____ |
| 2. 7-9        | _____ | _____ | 16. 2-9-6-1-8-3     | _____ | _____ |
| 3. 8-1-1      | _____ | _____ | 17. 5-2-4-9-3-6     | _____ | _____ |
| 4. 6-4-9      | _____ | _____ | 18. 4-7-3-8-1-5     | _____ | _____ |
| 5. 5-2-8      | _____ | _____ | 19. 6-9-5-7-2-8     | _____ | _____ |
| 6. 2-7-3-3    | _____ | _____ | 20. 3-6-1-9-2-7-7   | _____ | _____ |
| 7. 6-3-5-1    | _____ | _____ | 21. 5-3-6-9-7-8-2   | _____ | _____ |
| 8. 8-2-9-3    | _____ | _____ | 22. 8-1-6-2-5-9-3   | _____ | _____ |
| 9. 1-6-8-5    | _____ | _____ | 23. 2-7-4-1-8-3-6   | _____ | _____ |
| 10. 4-7-3-9-9 | _____ | _____ | 24. 4-9-6-3-5-7-1   | _____ | _____ |
| 11. 6-1-4-2-8 | _____ | _____ | 25. 3-1-9-2-7-4-8-8 | _____ | _____ |
| 12. 1-5-2-9-6 | _____ | _____ | 26. 9-6-3-8-5-1-7-2 | _____ | _____ |
| 13. 7-3-1-8-4 | _____ | _____ | 27. 4-7-3-1-6-2-9-5 | _____ | _____ |
| 14. 5-9-6-2-7 | _____ | _____ | 28. 8-2-5-9-3-6-4-1 | _____ | _____ |

# APPENDIX H1

## SUMMARY OF JUDGEMENT AGREEMENTS ON THE HART BETWEEN TESTER AND EXPERT

| Subject #27 (LD)<br>Test Item # | Tester's<br>Judgement                            | Expert's<br>Judgement |
|---------------------------------|--------------------------------------------------|-----------------------|
| 1.                              | C                                                | I                     |
| 2.                              | C                                                | C                     |
| 3.                              | C                                                | I                     |
| 4.                              | C                                                | C                     |
| 5.                              | I                                                | I                     |
| 6.                              | I                                                | I                     |
| 7.                              | I                                                | I                     |
| 8.                              | C                                                | C                     |
| 9.                              | I                                                | I                     |
| 10.                             | I                                                | C                     |
| 11.                             | I                                                | I                     |
| 12.                             | I                                                | I                     |
| 13.                             | I                                                | I                     |
| 14.                             | C                                                | I                     |
| 15.                             | C                                                | C                     |
| 16.                             | I                                                | I                     |
| 17.                             | I                                                | I                     |
| 18.                             | I                                                | I                     |
| 19.                             | I                                                | C                     |
| 20.                             | C                                                | C                     |
| 21.                             | C                                                | I                     |
| 22.                             | C                                                | C                     |
| 23.                             | I                                                | I                     |
| 24.                             | I                                                | C                     |
| 25.                             | I                                                | I                     |
| 26.                             | I                                                | I                     |
| 27.                             | I                                                | C                     |
| 28.                             | C                                                | C                     |
| 29.                             | I                                                | I                     |
| 30.                             | I                                                | I                     |
| 31.                             | I                                                | I                     |
| 32.                             | C                                                | C                     |
| 33.                             | I                                                | I                     |
| 34.                             | I                                                | I                     |
| 35.                             | I                                                | I                     |
| 36.                             | I                                                | I                     |
| 37.                             | I                                                | I                     |
| 38.                             | I                                                | I                     |
| 39.                             | I                                                | I                     |
| 40.                             | I                                                | I                     |
| Total Test Score                | 30%                                              | 30%                   |
| <u>Total # of agreements</u>    | 32 = 80% agreement for Interjudge<br>reliability |                       |
| Total # of items                |                                                  |                       |

# APPENDIX H2

## SUMMARY OF JUDGEMENT AGREEMENTS ON THE HART BETWEEN TESTER AND EXPERT

| Subject #4 (NL)<br>Test Item # | Tester's<br>Judgement | Expert's<br>Judgement |
|--------------------------------|-----------------------|-----------------------|
| 1.                             | C                     | I                     |
| 2.                             | C                     | C                     |
| 3.                             | C                     | C                     |
| 4.                             | C                     | C                     |
| 5.                             | C                     | C                     |
| 6.                             | C                     | I                     |
| 7.                             | C                     | C                     |
| 8.                             | C                     | C                     |
| 9.                             | C                     | C                     |
| 10.                            | C                     | C                     |
| 11.                            | C                     | C                     |
| 12.                            | C                     | I                     |
| 13.                            | C                     | I                     |
| 14.                            | C                     | C                     |
| 15.                            | C                     | C                     |
| 16.                            | I                     | I                     |
| 17.                            | I                     | I                     |
| 18.                            | C                     | I                     |
| 19.                            | I                     | I                     |
| 20.                            | C                     | I                     |
| 21.                            | C                     | C                     |
| 22.                            | C                     | C                     |
| 23.                            | C                     | C                     |
| 24.                            | C                     | I                     |
| 25.                            | C                     | C                     |
| 26.                            | C                     | C                     |
| 27.                            | C                     | I                     |
| 28.                            | C                     | I                     |
| 29.                            | I                     | I                     |
| 30.                            | I                     | C                     |
| 31.                            | I                     | I                     |
| 32.                            | C                     | I                     |
| 33.                            | I                     | I                     |
| 34.                            | I                     | I                     |
| 35.                            | I                     | I                     |
| 36.                            | I                     | I                     |
| 37.                            | C                     | I                     |
| 38.                            | I                     | I                     |
| 39.                            | I                     | I                     |
| 40.                            | I                     | I                     |

|                  |       |       |
|------------------|-------|-------|
| Total Test Score | 67.5% | 42.5% |
|------------------|-------|-------|

|                              |                                          |
|------------------------------|------------------------------------------|
| <u>Total # of agreements</u> | <u>28</u> = 70% agreement for Interjudge |
| Total # of items             | 40 reliability                           |

### APPENDIX H3

#### SUMMARY OF JUDGEMENT AGREEMENTS ON THE HART BETWEEN TESTER AND EXPERT

| Subject #15 (NL)<br>Test Item # | Tester's<br>Judgement             | Expert's<br>Judgement |
|---------------------------------|-----------------------------------|-----------------------|
| 1.                              | C                                 | C                     |
| 2.                              | C                                 | C                     |
| 3.                              | C                                 | C                     |
| 4.                              | C                                 | C                     |
| 5.                              | C                                 | C                     |
| 6.                              | C                                 | C                     |
| 7.                              | C                                 | C                     |
| 8.                              | C                                 | C                     |
| 9.                              | C                                 | C                     |
| 10.                             | C                                 | C                     |
| 11.                             | C                                 | C                     |
| 12.                             | C                                 | C                     |
| 13.                             | C                                 | C                     |
| 14.                             | C                                 | C                     |
| 15.                             | C                                 | C                     |
| 16.                             | I                                 | I                     |
| 17.                             | I                                 | I                     |
| 18.                             | C                                 | C                     |
| 19.                             | C                                 | C                     |
| 20.                             | C                                 | C                     |
| 21.                             | C                                 | C                     |
| 22.                             | C                                 | C                     |
| 23.                             | C                                 | C                     |
| 24.                             | C                                 | C                     |
| 25.                             | C                                 | C                     |
| 26.                             | C                                 | C                     |
| 27.                             | C                                 | C                     |
| 28.                             | C                                 | C                     |
| 29.                             | C                                 | C                     |
| 30.                             | I                                 | I                     |
| 31.                             | I                                 | I                     |
| 32.                             | I                                 | I                     |
| 33.                             | C                                 | C                     |
| 34.                             | I                                 | I                     |
| 35.                             | C                                 | C                     |
| 36.                             | C                                 | C                     |
| 37.                             | C                                 | C                     |
| 38.                             | I                                 | I                     |
| 39.                             | I                                 | C                     |
| 40.                             | I                                 | I                     |
| Total Test Score                | 77.5%                             | 80%                   |
| Total # of agreements           | 39 = 98% agreement for Interjudge |                       |
| Total # of items                | 40 reliability                    |                       |

# APPENDIX H4

## SUMMARY OF JUDGEMENT AGREEMENTS ON THE HART BETWEEN TESTER AND EXPERT

| Subject #40 (LD)<br>Test Item # | Tester's<br>Judgement | Expert's<br>Judgement |
|---------------------------------|-----------------------|-----------------------|
| 1.                              | C                     | C                     |
| 2.                              | C                     | C                     |
| 3.                              | I                     | I                     |
| 4.                              | C                     | C                     |
| 5.                              | C                     | C                     |
| 6.                              | I                     | I                     |
| 7.                              | I                     | I                     |
| 8.                              | C                     | C                     |
| 9.                              | C                     | C                     |
| 10.                             | C                     | C                     |
| 11.                             | C                     | C                     |
| 12.                             | I                     | I                     |
| 13.                             | I                     | I                     |
| 14.                             | I                     | I                     |
| 15.                             | C                     | C                     |
| 16.                             | I                     | I                     |
| 17.                             | I                     | I                     |
| 18.                             | I                     | I                     |
| 19.                             | I                     | I                     |
| 20.                             | C                     | C                     |
| 21.                             | C                     | C                     |
| 22.                             | I                     | I                     |
| 23.                             | I                     | I                     |
| 24.                             | I                     | I                     |
| 25.                             | I                     | I                     |
| 26.                             | I                     | I                     |
| 27.                             | I                     | I                     |
| 28.                             | I                     | I                     |
| 29.                             | I                     | I                     |
| 30.                             | I                     | I                     |
| 31.                             | I                     | I                     |
| 32.                             | I                     | I                     |
| 33.                             | I                     | I                     |
| 34.                             | I                     | I                     |
| 35.                             | I                     | I                     |
| 36.                             | I                     | I                     |
| 37.                             | I                     | I                     |
| 38.                             | I                     | I                     |
| 39.                             | I                     | I                     |
| 40.                             | I                     | I                     |
| Total Test Score                | 27.5%                 | 27.5%                 |

Total # of agreements      40 = 100% agreement for Interjudge  
Total # of items              40      reliability

# APPENDIX H5

## SUMMARY OF JUDGEMENT AGREEMENTS ON THE HART BETWEEN TESTER AND EXPERT

| Subject #39 (LD)<br>Test Item # | Tester's<br>Judgement             | Expert's<br>Judgement |
|---------------------------------|-----------------------------------|-----------------------|
| 1.                              | C                                 | I                     |
| 2.                              | C                                 | C                     |
| 3.                              | C                                 | C                     |
| 4.                              | C                                 | C                     |
| 5.                              | C                                 | C                     |
| 6.                              | I                                 | I                     |
| 7.                              | C                                 | C                     |
| 8.                              | C                                 | C                     |
| 9.                              | C                                 | C                     |
| 10.                             | I                                 | I                     |
| 11.                             | I                                 | I                     |
| 12.                             | C                                 | I                     |
| 13.                             | C                                 | I                     |
| 14.                             | C                                 | C                     |
| 15.                             | C                                 | C                     |
| 16.                             | I                                 | I                     |
| 17.                             | I                                 | I                     |
| 18.                             | I                                 | I                     |
| 19.                             | I                                 | I                     |
| 20.                             | C                                 | C                     |
| 21.                             | C                                 | C                     |
| 22.                             | C                                 | I                     |
| 23.                             | C                                 | C                     |
| 24.                             | C                                 | C                     |
| 25.                             | I                                 | I                     |
| 26.                             | C                                 | I                     |
| 27.                             | C                                 | I                     |
| 28.                             | C                                 | C                     |
| 29.                             | C                                 | I                     |
| 30.                             | I                                 | I                     |
| 31.                             | I                                 | I                     |
| 32.                             | C                                 | C                     |
| 33.                             | I                                 | I                     |
| 34.                             | I                                 | I                     |
| 35.                             | I                                 | I                     |
| 36.                             | I                                 | I                     |
| 37.                             | I                                 | I                     |
| 38.                             | I                                 | I                     |
| 39.                             | I                                 | I                     |
| 40.                             | I                                 | I                     |
| Total Test Score                | 57.5%                             | 35%                   |
| Total # of agreements           | 33 = 83% agreement for Interjudge |                       |
| Total # of items                | 40 reliability                    |                       |

## VITA

Frederick Hall was born in Canastota, New York on October 21, 1948. After graduating from High School in 1966, he attended State University of New York at Morrisville for two years. He transferred to Utah State University where he received his Bachelor of Science degree in Speech Pathology in 1970. He continued his studies and received his Master of Science degree with a major in Communication Disorders from Utah State University in 1972. After many years of teaching, he changed careers and became a professional singer performing in Las Vegas for several years. After two years as a traveling musician, he re-entered the field of Speech-Language Pathology. In 1991, he was admitted to the University of Tennessee for the Ph.D. degree in Speech Pathology. In May of 1995, he received the Ph.D. from the University of Tennessee. Frederick Hall is currently a research assistant professor at the University of Massachusetts at Amherst.