To the Graduate Council:

I am submitting herewith a thesis written by Diane Leigh Williams entitled "Suprasegmental Patterns and Word Intelligibility of Hearing-Impaired Children Trained with the Verbotonal Method." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts, with a major in Speech Pathology.

Carl W. Asp, Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

Thesis
78
W651
cop. 3

SUPRASEGMENTAL PATTERNS AND WORD INTELLIGIBILITY OF HEARING-IMPAIRED CHILDREN TRAINED WITH THE VERBO-TONAL METHOD

A Thesis

Presented for the

Master of Arts

Degree

The University of Tennessee, Knoxville

Diane Leigh Williams

March 1978

1355691

ACKNOWLEDGMENTS

I wish to acknowledge and sincerely thank the following persons for their help in the preparation of this study:

Dr. Carl W. Asp, chairman, for his guidance, time and effort toward the completion of this study.

Dr. Patrick J. Carney and Dr. Harold A. Peterson, the members of this committee, for their advice and attempts to improve this work.

Virginia L. Williams, Leslee H. Archer, Betty D. Coleman, Vivian Kirkpatrick, and John D. Tonkovich for evaluating the responses to the TRIP.

Joanna Dickerman, Martha N. McClellan and Theronne B. Singletary for analyzing the responses to the word intelligibility test.

Vicki Neal for her support and encouragement during the past year.

And Mr. and Mrs. Robert C. Williams, my parents, for their constant love and support.

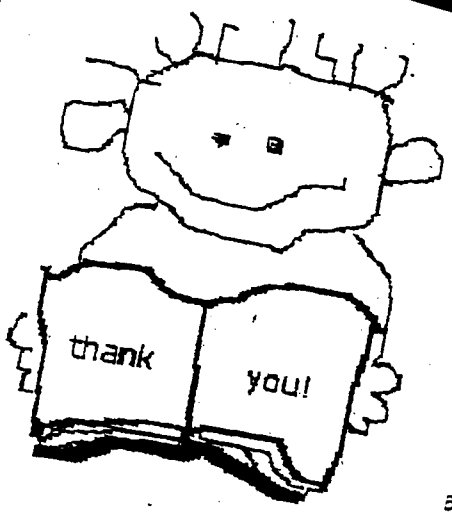
ABSTRACT

The purpose of this study was to evaluate the supra-segmental patterns of fourteen hearing-impaired children, who were at different levels of training in the Verbo-tonal method. The Test of Rhythm and Intonation Patterns (TRIP) consisted of 25 prerecorded items with the nonsense syllable /ma/ repeated with variations in rhythm, tempo and/or intonation. The children imitated the pattern they heard. The children's responses were recorded and judged by a panel of five judges. For a word intelligibility test, the children named 23 pictures. Their responses were recorded and judged by a panel of three judges. Phonetic transcriptions were made of each child's 23 responses as a measure of phoneme intelligibility. Intelligence quotients and language ages for each child were obtained from the child's records.

The TRIP scores were not significantly related to the chronological ages, hearing levels or intelligence quotients of the hearing-impaired children. The TRIP scores were significantly related to the language ages, and word intelligibility scores. Word intelligibility was significantly related to phoneme intelligibility; however, a comparison of individual subjects indicated that both suprasegmental skills and phoneme intelligibility appear to affect word intelligibility.

TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
II.	METHODS AND PROCEDURES	4
	Subjects	4
	Suprasegmental Test	4
	Testing Procedures	6
	Word Intelligibility Test	8
	Phonetic Transcription	11
	Intelligence Quotients and Language Ages	11
III.	RESULTS	13
	Reliability	13
	Correlation between the TRIP and Other Measures	14
	TRIP Subtests and Item Analysis	17
	Word Intelligibility, Phoneme Intelligibility and TRIP Scores	24
IV.	DISCUSSION	26
BIBLIOGRAPHY		29
APPENDIXES		35
	APPENDIX A	36
	APPENDIX B	37
	APPENDIX C	44
	APPENDIX D	45
	APPENDIX E	46
	APPENDIX F	47
VITA		48



LIST OF TABLES

PAGE

ages and Sound Pressure Levels
es for Trip Administration 5

2. Identifying Data and Test Scores for Each Subject 15

3. Correlations of Five Measures with the TRIP Scores 16

4. Number of Syllables and Percent Correct for Each Test Item in the TRIP 19

5. Ages and Test Scores for Placement Levels in the Verbo-tonal Program 20

6. Percent Agreement between the Examiner and the Panel for the Judgment of the Subjects' Responses to the Test Items on the TRIP 45

7. Percent Correct for Each Test Item for Subjects Who Could Produce Five or Fewer Syllables 46

8. Percent Correct for Each Test Item for Subjects Who Could Produce Greater than Five Syllables . . 47

CHAPTER I

INTRODUCTION

Several studies have reported that errors of rhythm, intonation and duration affect the speech intelligibility of hearing-impaired children (Hudgins, 1946; John and Howarth, 1965; Hood and Dixon, 1969). The interaction between speech intelligibility and the suprasegmental aspects of voice quality, pitch, intonation, stress and rate is not clear (Smith, 1975). Research is needed on suprasegmental patterns and their influence on the intelligibility of speech of hearing-impaired children.

In an attempt to evaluate suprasegmental patterns, some tests have been developed. Stark and Levitt (1974) designed a test to evaluate the suprasegmental features of stress, pause and rising intonation. For this test, the hearing-impaired children read statements marked for different suprasegmental features. In 1977, Koike developed the Test of Rhythm and Intonation Patterns (TRIP) which uses a prerecorded nonsense syllable in different suprasegmental patterns. He tested the ability of normal-hearing children to produce an oral imitation of these patterns.

The Verbo-tonal method emphasizes the development of "normal" suprasegmental patterns by altering the parameters of pitch, loudness, tension, pause, duration, intonation and

rhythm. Body movements and rhythmical stimulation are used to improve speech production and auditory perception. The emphasis is on the "indirect" correction of the suprasegmental speech patterns so that the natural flow of speech will be maintained. For example, the correct physiological tension for articulation can be taught indirectly by creating the correct tension in large body movements (Asp, 1975). The development of the suprasegmentals increases the child's intelligibility (Asp, 1973).

In the Verbo-tonal Program at the University of Tennessee, hearing-impaired children are grouped into three levels based on their ability to produce and perceive supra-segmental and segmental speech patterns. Other factors such as age, language development, intelligence scores and social development are also considered. Those that develop good speaking and listening skills are mainstreamed in public schools. Mainstreamed children are considered level IV.

The purpose of this study was to evaluate the supra-segmental patterns of hearing-impaired children, who were at different levels of training in the Verbo-tonal method. The TRIP appeared to be an appropriate instrument for measuring these patterns. The following questions were asked: Is there a correlation between the suprasegmental scores (TRIP) and

(a) the chronological ages;

(b) the pure-tone averages for the better ear;

(c) the intelligence quotients, as measured by the Leiter International Performance Scale;

(d) the language ages, as measured by the Preschool Language Scale; and,

(e) the word intelligibility scores of hearing-impaired children who were at different levels of training in the Verbo-tonal method.

(See Appendix A for Definition of Terms and Appendix B for Review of Literature.)

CHAPTER II

METHODS AND PROCEDURES

Subjects

The subjects were fourteen hearing-impaired children, who ranged in age from three years, eleven months to twelve years, nine months, and had a mean age of seven years, ten months. Seven were male, and seven were female. Each child had received at least six months of daily training in the Verbo-tonal Aural Habilitation Program at the University of Tennessee. Three frequency pure-tone averages for the better ear ranged from 57 to 95 dB, with a mean of 79 dB HTL (see Table 1). The children were selected on the basis of availability and willingness to cooperate with the testing procedures.

Suprasegmental Test

The Test of Rhythm and Intonation Patterns (TRIP) (Koike, 1977) consisted of twenty-five prerecorded test items produced by an adult male speaker. For each test item, the nonsense syllable /mɑ/ was repeated with variations in rhythm, tempo and/or intonation. The test was divided into three parts. In Part I (items 1-14), the rhythm was varied by changing the tempo and/or stress. In Part II (items 15-17), tempo was increased from one to three syllables. In Part III

TABLE 1

PURE-TONE AVERAGES AND SOUND PRESSURE LEVELS
AT THE EARPHONES FOR TRIP ADMINISTRATION

Subjects	Pure-tone Average (dB)* Better Ear	Sound Pressure Level (dB) Better Ear
1	62	109
2	80	115
3	95	120
4	82	117
5	73	114
6	65	109
7	88	112
8	90	114
9	78	112
10	88	120
11	57	112
12	77	112
13	87	120
14	80	110
$\bar{x}$	79	114
SD	11.2	3.9
Range	57∿95	109∿120

*Three-frequency (500, 1000 and 2000Hz).

(items 18-25), the intonation pattern changed for each item while the rhythm patterm was different for every other test item (see Figure 1).

Testing Procedures

Each child was tested in a quiet room while seated on the floor facing the examiner. The test stimuli were presented from a tape recorder (Sony, Model TC-800) and amplified through an auditory training unit (Suvag, Model I). The Suvag I had a flat electrical frequency response extending from 1/2 Hz to 20,000 Hz. Output transducers included binaural earphones (Koss, Model K-6LC) and a bone vibrator (Suvag Vibar) taped to the child's wrist.

For the older children, the most comfortable loudness level was set individually by each child. For the younger children, each earphone was set at the level used in daily classroom activities. The sound pressure at the level of the earphones for each child is listed in Table 1.

For the training session, five prerecorded items, 1, 2, 3, 4 and 13, were presented for each child. Each child had to indicate he understood what was expected of him. For testing, each item was presented twice with the child responding separately to each presentation. The fifty stimulus-response pairs for each child were recorded (Technics, Model 671A). The examiner did not give any additional

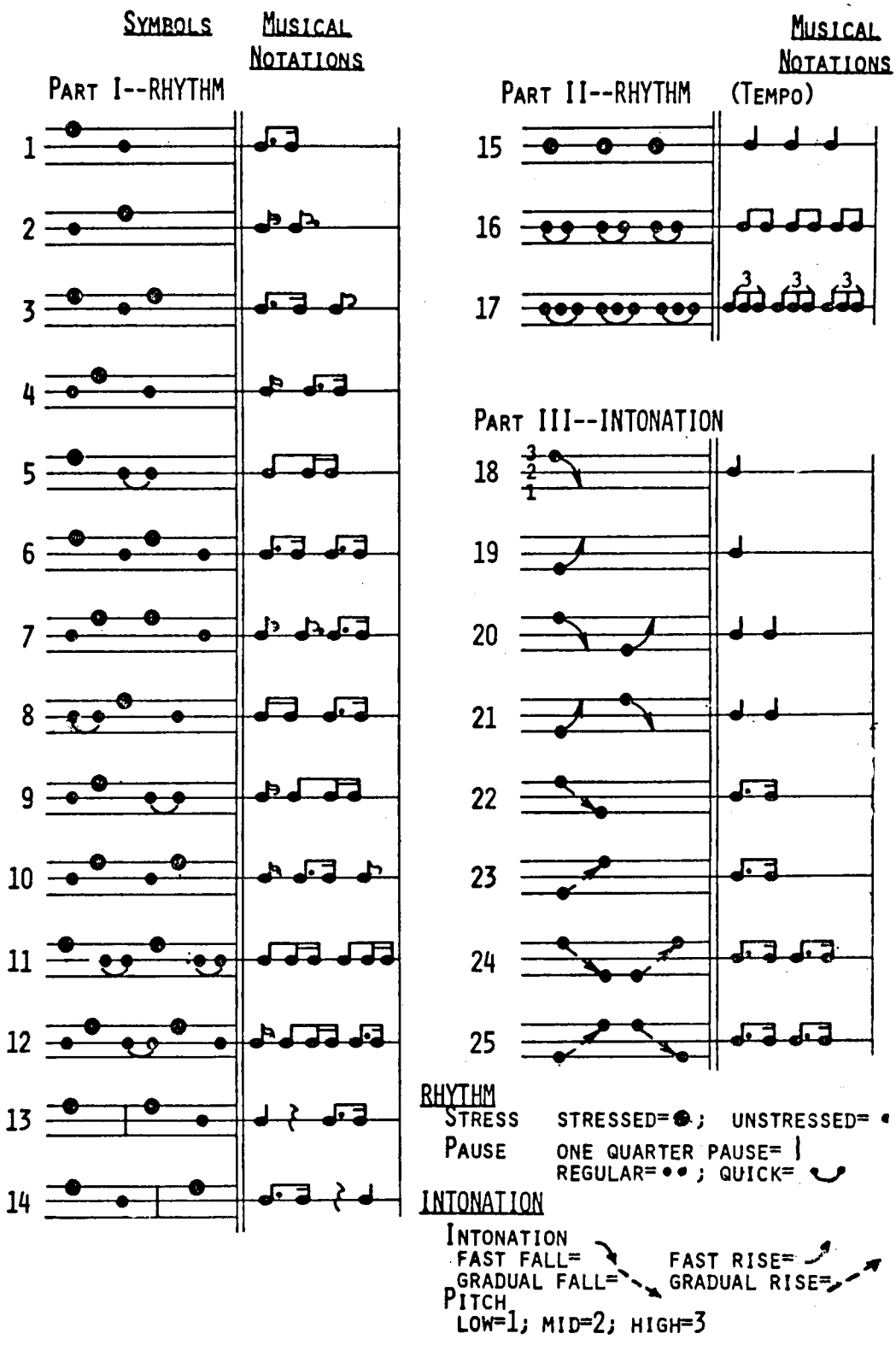


Figure 1. A test of rhythm and intonation patterns (TRIP).

auditory or visual cues during the testing procedure. Instrumentation used for testing is shown in Figure 2.

The examiner scored each response as correct or incorrect as it related to the suprasegmental pattern of the stimulus. The criteria for a correct response was the correct use of stress, pause, tempo, intonation and number of syllables.

If at least one of the two responses was judged correct, the test item was correct. The criterion measure for the TRIP was the percent correct for the twenty-five test items.

Then, the recorded stimulus-response pairs of the fourteen subjects were presented in random-order to a panel of five listeners. Three of the listeners were experienced Verbo-tonal clinicians; the other two were speech pathologists with a Certificate of Clinical Competency. The panel had hearing acuity less than 25 dB (ANSI, 1969) bilaterally at 250, 500, 1000, 2000 and 4000 Hz. The listeners used the same criteria as the examiner to judge each response as correct or incorrect. A response was considered correct if at least three of the listeners judged it as correct. The criterion measure for each child was the percent correct for the twenty-five test items as scored by the panel.

Word Intelligibility Test

To determine if a test word was within a child's vocabulary, each picture was presented and the child named

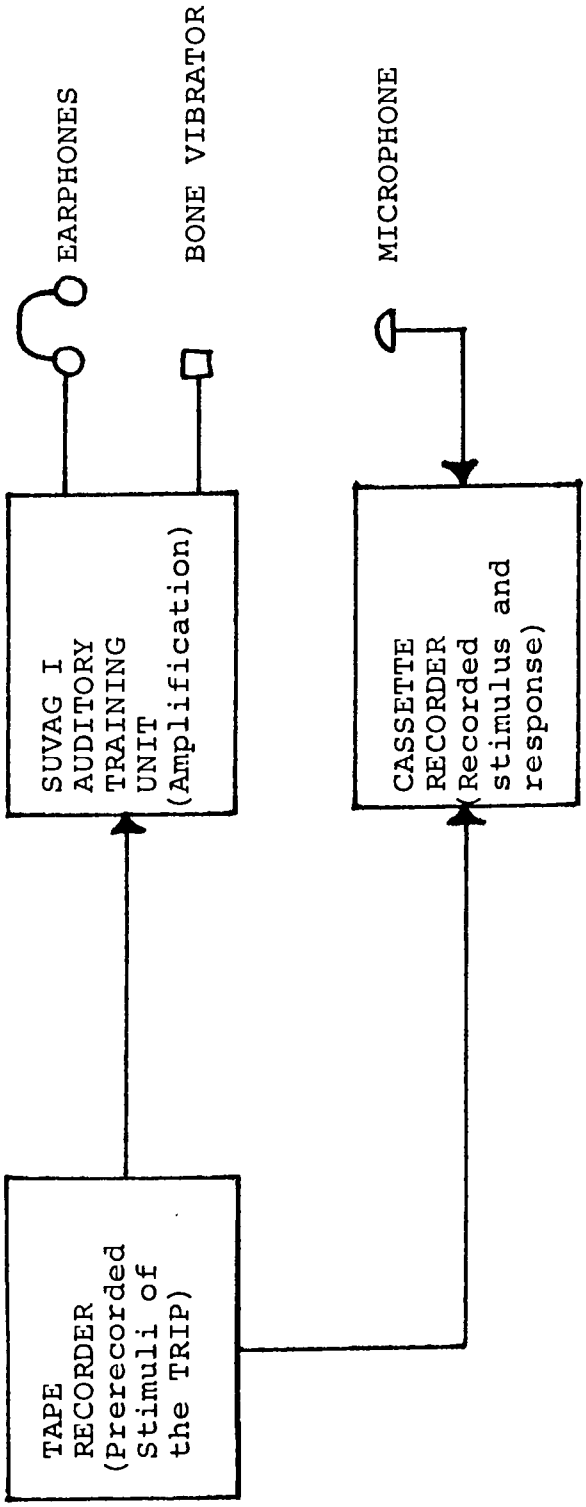


Figure 2. Block diagram of instrumentation used to administer TRIP stimuli and to record responses to TRIP and word intelligibility test.

it. If the child did not know a word, the examiner trained the child by describing the pictured item and having him repeat the test word several times. Each picture was presented two more times to determine if the child had learned the test word. Five of the fourteen children failed to correctly name all of the pictures spontaneously, but produced them imitatively.

After the pretesting was completed, the twenty-three test pictures (Goldman-Fristoe Test of Articulation, 1972) were presented to each child in a random order (see Appendix C). The child named each picture as it was presented. For a word failed in pretesting, the examiner said it without any visual cues and the child imitated it. Each of the child's responses was recorded (Technics, model 671A).

The recorded responses of the fourteen children were judged by a second panel of three listeners who had a Certificate of Clinical Competency in Speech Pathology and normal hearing acuity (less than 25 dB bilaterally at 250, 500, 1000, 2000 and 4000 Hz). The panel did not know the children.

The judges wrote the word which they heard. If two out of three were correct, the response was considered correct. The criterion measure for each child was the percent correct for the twenty-three test items.

The judges also indicated the certainty of their judgment by assigning a number between one and five to each

response. Number one indicated the least amount of confidence and five indicated the most confidence. If the judges were unable to understand a child's response, the response was assigned a value of one. The confidence rating for each child was an average of the ratings for all twenty-three words.

Phonetic Transcription

In order to measure the phoneme intelligibility of each child, the examiner made a broad phonetic transcription of each child's twenty-three responses. Each transcription was compared to the stimulus to determine the number of phonemes that were correctly produced by the child. The percentage of phonemes correctly produced was computed for each child.

Intelligence Quotients and Language Ages

The intelligence quotient and language age for each child were obtained from the child's records. Each intelligence quotient was measured with Leiter International Performance Scale. The Preschool Language Scale (Zimmerman, Steiner and Evatt, 1969) was used to determine the language age for each child. These tests had been administered by Verbo-tonal clinicians in the latter part of the 1976-1977 school year. Since some of the children were no longer enrolled in the Verbo-tonal program, this information was not available for all of the subjects. The conclusions

which can be made about the relationship between the TRIP scores and the language ages are limited, since these scores were obtained at different times.

CHAPTER III

RESULTS

Reliability

Pairs of subjects were selected randomly for evaluating reliability. Intrajudge agreements for the five judges were 80, 82, 90, 92 and 96 percent, respectively, for judging Subjects 1 and 7. Interjudge agreements ranged from 70 to 82 percent for judging Subjects 2 and 14. The test-retest agreement was 90 percent for Subjects 5 and 13 together.

For individual test items, the mean percent of agreement between the examiner and the panel was 90 percent. (See Appendix D.) Koike (1977), Shadden et al. (1977) and Tonkovich et al. (1977) reported similar results. This suggests that the examiner is capable of judging the children's responses at the time of testing. However, for the statistical analyses, the judgments of the panel were used.

Two subjects were randomly selected for evaluating reliability for the following measures. For the word intelligibility test, the three judges had intrajudge agreements of 83, 85 and 89 percent, respectively, for the responses of Subjects 4 and 10. Interjudge agreements ranged from 87 to 93 percent for judging Subjects 7 and 9. The test-retest agreement was 86 percent for Subjects 5 and

13 together. The intrajudge agreement for phoneme intelligibility as transcribed by the examiner was 85 percent for Subjects 3 and 12.

The results for intrajudge agreement and test-retest suggested that repeatability was adequate for the TRIP, word intelligibility and phonetic transcriptions. The interjudge agreements were lower for the TRIP than for the word intelligibility scores; however, both were considered adequate for this study.

Correlation between the TRIP and Other Measures

The chronological age, the sex, the pure-tone average, the intelligence quotient, the language age, the etiology of hearing loss and the length of time in Verbo-tonal training for each subject are shown in Table 2. The TRIP score, the word intelligibility score and the phoneme intelligibility for each subject are also shown in Table 2. Correlations of ages, pure-tone averages, intelligence quotients, language ages, and word intelligibility scores with the TRIP scores are displayed in Table 3.

The correlation coefficients were not significant between the TRIP scores and chronological ages ($r = 0.39$; $df = 12$; $p > .05$), or the TRIP scores and pure-tone averages ($r = -0.40$; $df = 12$; $p > .05$). These suggested that performance on the TRIP was not significantly related to age or hearing level.

TABLE 2

IDENTIFYING DATA AND TEST SCORES
FOR EACH SUBJECT

Sub.	Age (Years-Months)	Sex	HTL*	I.Q.	Language Age	Etiol.	Time in Therapy (Years-Months)	Trip** (%)	Word Intell.** (%)	Phoneme Intell. (%)
1	3-11	M	62	84	2-3	Unkn.	0-9	48	52	52
2	5-4	M	80	110	1-10	Unkn.	1-6	20	20	45
3	5-8	M	95	113	3-2	Unkn.	3-1	20	9	25
4	5-8	F	82	119	3-8	Pren. Infec.	3-0	92	61	69
5	5-10	F	73	88	3-5	Anox.	2-0	16	22	47
6	6-9	M	65	140	-	Hered.	0-9	100	100	94
7	6-10	F	88	119	4-3	Unkn	1-1	36	70	71
8	8-3	M	90	107	4-6	Menin.	4-9	40	22	61
9	8-6	F	78	126	6-8	Unkn.	0-8	92	100	99
10	8-11	F	88	71	4-6	Unkn.	2-2	40	52	69
11	9-9	M	57	-	-	Unkn.	2-4	88	100	98
12	9-10	F	77	-	-	Prem.	3-9	92	100	96
13	11-9	F	87	98	6-1	Rub.	3-8	80	91	90
14	12-9	M	80	-	5-8	Rub.	3-4	56	91	93
$\bar{x}$	7-9	-	79	107	4-2	-	2-1	58.6	63.6	72
SD	-	-	11.2	20.1	18.3	-	-	31.4	34.5	23.8
Range	3-11∿12-9	-	57∿95	71∿140	1-10∿6-8	-	0-8∿4-9	12∿100	9∿100	25∿99

*Pure-tone average for the better ear.

**As judged by a panel.

TABLE 3

CORRELATIONS OF FIVE MEASURES
WITH THE TRIP SCORES*

Measures	r	df	p
Chronological age	0.39	12	>.05
Pure-tone average	-0.40	12	>.05
Intelligence quotient	0.52	9	>.05
Language age	0.63	9	<.05
Word Intelligibility	0.86	12	<.001

*As judged by the panel.

The correlation coefficient between the TRIP scores and the intelligence quotients was not significant ($r = 0.52$; $df = 9$; $p > .05$). This agrees with the results of previous investigations that, at least within the "normal" range, intelligence scores are unrelated to speech skills (Winitz, 1969; Smith, 1975).

The TRIP scores and the language age scores were significantly correlated ($r = 0.63$; $df = 9$; $p < .05$). These results suggest a significant relationship between supra-segmental skills and language skills for hearing-impaired children who are trained with the Verbo-tonal method. The subjects ranged from three years, eleven months to twelve years, nine months of age. Koike (1977) reported a significant correlation between the TRIP scores and the receptive language scores for normal-hearing three-year-olds, but not for five-year-olds.

The TRIP scores and the word intelligibility scores were also significantly correlated ($r = 0.86$; $df = 12$; $p < .001$). This indicates a relationship between imitation of rhythm and intonation patterns and intelligibility of words.

TRIP Subtests and Item Analysis

For the present study, the percent correct and number of syllables for each test item on the TRIP are shown in

Table 4. The mean percent correct for the three subtests were similar: 57 percent for rhythm, 57 percent for tempo and 62 percent for intonation. In comparison, normal-hearing three and five-year olds scored higher on the rhythm subtest than on the tempo or intonation subtests (Koike, 1977).

Table 5 shows the TRIP scores, the word intelligibility scores and the phoneme intelligibility scores according to achievement level in the Verbo-tonal program. The range of TRIP scores for level IV (56 to 100) was similar to the range (60 to 100) for normal-hearing five-year-olds (Koike, 1977). The scores of these two groups were similar for the three subtests (see Figure 3). Hearing-impaired children who are trained with the Verbo-tonal method have suprasegmental skills that are similar to normal-hearing five-year-olds.

The individual items on the TRIP were not equally difficult for the hearing-impaired children. The degree of difficulty varied for the number of syllables, tempo, rhythm pattern, pause and intonation pattern.

Number of syllables. Two Verbo-tonal clinicians estimated the number of syllables each child could produce in daily therapy. For children who produced five or fewer syllables in therapy, the difficulty of the test items on the TRIP increased as the number of syllables increased.

TABLE 4

NUMBER OF SYLLABLES AND PERCENT CORRECT FOR EACH TEST ITEM IN THE TRIP

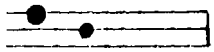
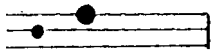
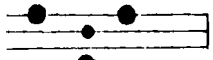
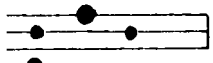
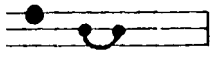
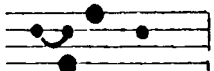
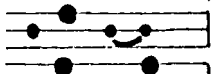
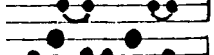
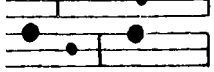
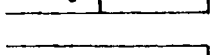
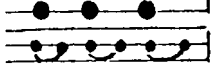
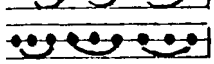
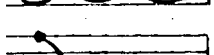
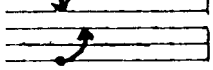
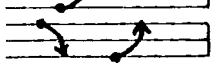
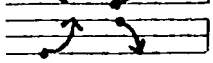
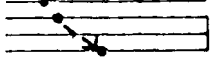
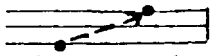
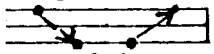
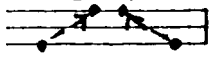
Part		Test Items	Number of Syllables	Percent Correct
I Rhythm	1.		2	86
	2.		2	57
	3.		3	43
	4.		3	79
	5.		3	57
	6.		4	79
	7.		4	29
	8.		4	71
	9.		4	50
	10.		4	64
	11.		6	20
	12.		6	50
	13.		3	57
	14.		3	50
II Tempo	15.		3	71
	16.		6	79
	17.		9	21
III Intonation	18.		1	71
	19.		1	57
	20.		2	43
	21.		2	50
	22.		2	100
	23.		2	64
	24.		4	43
	25.		4	71

TABLE 5

AGES AND TEST SCORES FOR PLACEMENT LEVELS
IN THE VERBO-TONAL PROGRAM

Subjects	Age	TRIP* (%)	Word Intell.* (%)	Phoneme Intell. (%)
Level II				
1	3-11	48	52	52
2	5-4	20	20	45
3	5-8	20	9	25
5	5-10	16	22	69
$\bar{x}$	5-0	25	25.8	42.3
SD	-	15.8	18.4	11.9
Range	3-11∿5-10	16∿48	9∿52	25∿69
Level III				
4	5-8	92	61	69
7	6-10	36	70	71
8	8-3	40	22	61
10	8-11	40	52	69
$\bar{x}$	7-5	52	51.2	67.5
SD	-	26.7	20.8	4.4
Range	5-8∿8-11	36∿92	22∿70	61∿71
Level IV				
6	6-9	100	100	94
9	6-10	92	100	99
11	9-9	88	100	98
12	9-10	92	100	96
13	11-9	80	91	90
14	12-9	56	91	93
$\bar{x}$	9-7	84.7	97	95
SD	-	15.5	4.6	3.3
Range	6-9∿12-9	56∿100	91∿100	93∿99

*As judged by a panel.

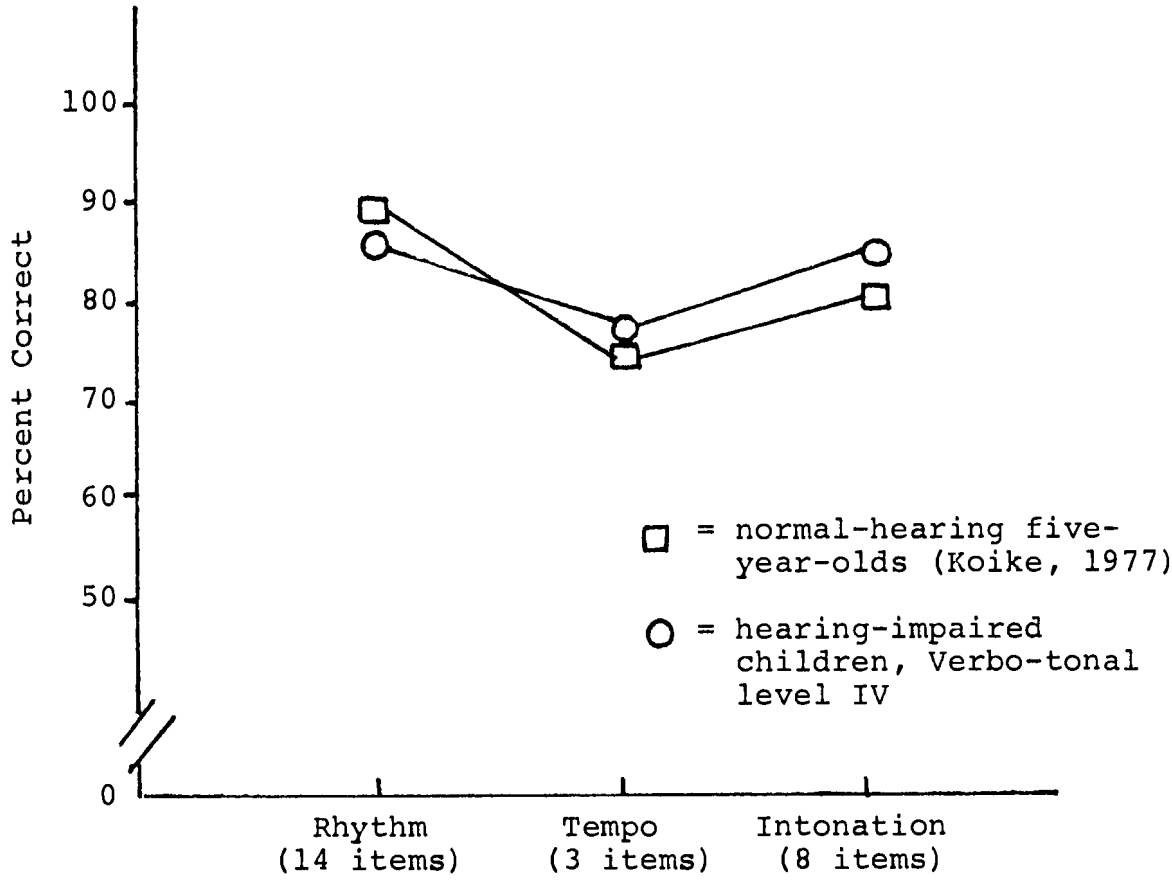


Figure 3. The mean percent correct for the rhythm, tempo and intonation subtests.

N = number of test items in each part.

For example, the test items with two syllables had a mean score of 50 percent correct; three syllables had 38 percent correct; four syllables had 33 percent correct; six syllables had 28 percent correct; and, nine syllables had 14 percent correct. (See Appendix E.) For these hearing-impaired children, the difficulty of the test items may be related to auditory memory span. Koike (1977) reported a similar trend in the responses of normal-hearing three-year-olds.

For children who produced greater than five syllables, the difficulty did not increase as the number of syllables increased, with the exception of item 17 that had nine syllables with a quick tempo. (See Appendix F.) Normal-hearing five-year-olds showed similar results (Koike, 1977).

Tempo. As the tempo quickened, the test items were more difficult. However, Subject 3 successfully imitated six syllables (item 16), but did not produce three syllables (item 15) correctly. Subject 12 produced six and nine syllables (items 16 and 17), but missed three syllables (item 15). For some children a fewer number of syllables with a slow tempo may be more difficult than a greater number of syllables with a quick tempo.

Rhythm pattern. For the rhythm section, the hearing-impaired children had poorer scores for four syllables with a regular tempo (item 7, 29 percent), for six syllables and

a quick tempo (item 11, 29 percent) and for three syllables with a regular tempo (item 3, 43 percent). Normal-hearing three-year-olds also scored low on items 7 (50 percent) and 11 (20 percent), but scored higher (70 percent) on item 3 (Koike, 1977). Items 7 and 11 may be more difficult rhythm patterns that develop later in both normal-hearing and hearing-impaired children.

The hearing-impaired children had the highest score on item 1 (86 percent). This is the stress pattern for the word "mama" which may make it easier for the children.

Pause. Half of the subjects did not include a pause or responded before the stimulus item was completed. Normal-hearing three-year-olds performed in a similar manner (Koike, 1977). However, McGarr (1976) reported that deaf children were more successful in producing pauses than stress or rising intonation while reading sentences. The speech patterns while reading sentences may be different than for imitating rhythm and intonation patterns.

Intonation pattern. The hearing-impaired children scored the highest on a gradual falling pattern (item 22, 100 percent). Normal-hearing three-year-olds scored 100 percent and five-year-olds scored 90 percent on this falling pattern. A gradual rising intonation pattern (item 23) was more difficult for the hearing-impaired children. Fast

rising (item 19) was more difficult than fast falling (item 18). The performance of normal-hearing three-year-olds was similar (Koike, 1977).

Fast falling to rising (item 20) and fast rising to falling (item 21) patterns were similar in difficulty. A gradual rising to falling pattern (item 25) was easier for the children than a gradual falling to rising intonation pattern (item 24). The performance of normal-hearing children was similar (Koike, 1977).

Word Intelligibility, Phoneme Intelligibility and TRIP Scores

The TRIP scores and word intelligibility scores were significantly correlated, as were word intelligibility and phoneme intelligibility. The latter finding was also reported by Smith (1975).

Phoneme intelligibility is not the only factor affecting word intelligibility. Subjects 4 and 8 had similar phoneme intelligibility; however, the word intelligibility score of Subject 4 was 39 percent higher than the score of Subject 8. In addition, the confidence rating for the judges was better for Subject 4 (3.0) than for Subject 8 (2.3). Subject 8 had five words that had no segmental errors, but were judged unintelligible. On the TRIP, Subject 8 scored 52 percent lower than Subject 4.

Subjects 1 and 5 also had similar phoneme intelligibility scores; however, the word intelligibility score of Subject 1

was 30 percent better than Subject 5. In addition, the confidence rating for Subject 1 (2.5) was better than for Subject 5 (1.2). On the TRIP, Subject 1 scored 32 percent better than Subject 5.

For these two examples, it appears that the ability to imitate suprasegmental patterns is closely related to word intelligibility scores, especially when phoneme intelligibility is similar. There may also be a relationship between the ability to imitate suprasegmental patterns and the intelligibility of phrases or sentences.

CHAPTER IV

DISCUSSION

The purpose of this study was to evaluate the supra-segmental patterns of hearing-impaired children who were trained with the Verbo-tonal method. The TRIP score was compared to the child's age, hearing level, intelligence quotient, language age, and word intelligibility.

The TRIP scores were not significantly related to the ages, hearing levels or intelligence quotients. This suggests that the suprasegmental skills of hearing-impaired children are not related to these factors.

The correlation between the TRIP scores and the language ages was significant. Suprasegmentals may be important in language development (Kaplan, 1969; Engel, 1973).

The TRIP scores were also significantly correlated with word intelligibility. A comparison of individual subjects indicated that phoneme intelligibility is not the only factor that affects word intelligibility. This supports the suggestion that suprasegmentals affect the intelligibility of hearing-impaired children (Asp, 1973; Smith, 1975; Ling, 1976).

The TRIP was useful for measuring the ability of children between four and thirteen years of age to imitate

rhythm and intonation patterns. These children were ranked between levels II and IV in Verbo-tonal training. However, the examiner was not successful in testing children in level I (two to four years of age). Koike (1977) was able to administer the TRIP to normal-hearing three-year-olds. The test procedures may need to be modified for hearing-impaired children under four years of age. Rapport and method of presentation appear to be important in evoking responses from these children.

Even for a child who responds to the testing procedures, an examiner familiar with the child's abilities may be needed to measure the "best" performance. After the data for this study were obtained, two of the children (Subjects 2 and 5) who were considered difficult to test were retested by a Verbo-tonal clinician. The retest scores of the children were higher than their original scores. For some of the children, the best performance may not have been measured during the first test administration.

The TRIP appears to be a useful tool for clinical evaluation of suprasegmental skills. It provides both an overall measure of suprasegmental skills and three subtests for rhythm, tempo and intonation. The results reported by Koike (1977) and Shadden et al. (1977) suggest that the TRIP could be standardized on children of different age levels. The TRIP can be reliably scored by an examiner as it is

administered. Thus, the TRIP could be used for an initial assessment of suprasegmental skills as well as a measure of progress in a program.

The TRIP also appears to be a useful tool for future research. It could be used to investigate the relationship between the imitation of suprasegmental patterns and their production in spontaneous speech. It could also be used to compare the suprasegmental skills of hearing-impaired children trained in the Verbo-tonal method and those of hearing-impaired children who have learned speech through other methods. Imitation ability on the TRIP could also be compared with suprasegmental abilities during the reading of sentences.

The conclusions which can be made from this study about the relationship between suprasegmental and segmental production are limited. Intelligibility samples from oral sentence reading or picture description were impractical in this study because some subjects were too young and had limited language skills. Unfortunately, word intelligibility testing is limited because some of the prosodic features of connected speech are absent on one-word utterances. However, a comparison of individual responses suggests that, even on one-word responses, suprasegmentals affect intelligibility. Further research is needed to clarify the interaction between suprasegmental skills and the speech intelligibility of hearing-impaired children.

BIBLIOGRAPHY

BIBLIOGRAPHY

American National Standards Institute. Specifications for Audiometers. ANSI S3.6-1969. New York: American National Standards Institute (1969).

Asp, C. W. The effectiveness of low-frequency amplification and filtered speech testing for preschool deaf children. Final Report for B.E.H. Project No. 522113. U.S. Department of Health, Education and Welfare. Washington, D.C.: U.S. Government Printing Office (1973).

Asp, C. W. Measurement of aural speech perception and oral speech production of the hearing-impaired. In S. Singh (Ed.), Measurement Procedures in Speech, Hearing and Language. Baltimore: University Park Press (1975).

Bartoshuk, A. K. Human neonatal cardiac responses to sound: A power function. Psychon. Science, 1, 151-152 (1964).

Berry, M. Language Disorders of Children: Bases and Diagnoses. New York: Appleton-Century-Crofts (1969).

Berry, M. and Eisenson, Jr. Speech Disorders. New York: Appleton-Century-Crofts (1956).

Braine, M. D. S. The ontogeny of English phrase structure: The first phrase. Language, 39, 1-13 (1963).

Bridger, W. H. Sensory habituation and discrimination in the human neonate. Am. J. of Psychiat., 117, 991-996 (1961).

Buhler, C. and Hetzer, H. (1928). Das erste verstandnis fur asudruck im ersten lebensjahr. Z. Psych., 197, cited in M. Lewis, Infant Speech: A Study of the Beginnings of Language. London: Routledge and Kegan Paul (1951).

Carroll, J. B. The Study of Language. Boston: Harvard University Press (1953).

Crystal, D. Prosodic Systems and Intonation in English. Cambridge: University Press (1969).

Dale, P. Language Development: Structure and Function. New York: Holt, Rinehart and Winston (1976).

Deese, J. Psycholinguistics. Boston: Allyn and Bacon (1970).

Eguchi, S. and Hirsh, I. Development of speech sounds in children. Acta Otolaryng., Supple. 257, Uppsala, Sweden (1969).

Eisenson, J., Auer, J. J., and Irwin, J. V. The Psychology of Communication. New York: Appleton-Century-Crofts (1963).

Engel, W. The development from sound to phoneme in child language. In C. A. Ferguson and D. I. Slobin (Eds.), Studies of Child Language Development. New York: Holt, Rinehart and Winston (1973).

Faircloth, S. and Faircloth, M. Phonetic Science: A Program of Instruction. Englewood Cliffs, N.J.: Prentice-Hall (1973).

French, N. R. and Steinberg, J. C. Factors governing the intelligibility of speech sounds. J. Acoust. Soc. Am., 19, 90-119 (1947).

Goës, A. The Stress System of English. Stockholm: K. L. Beckmans Tryckeri AB (1974).

Goldman, R. and Fristoe, M. Goldman-Fristoe Test of Articulation. Circle Pines, Minn.: American Guidance Service (1972).

Hood, R. and Dixon, R. Physical characteristics of speech rhythm of deaf and normal-hearing speakers. J. Comm. Dis., 2, 20-28 (1969).

Hoops, R. Speech Science: Acoustics in Speech. Springfield, Ill.: Charles C. Thomas (1969).

Hopper, R. and Naremore, R. Children's Speech: A Practical Introduction to Communication Development. Evanston, Ill.: Harper and Row (1973).

Hornby, P. A. and Hass, W. A. Use of constrastive stress by preschool children. J. Speech Hearing Res., 13, 395-399 (1970).

Hudgins, C. Speech breathing and speech intelligibility. Volta Rev., 48, 642-644 (1946).

Hudgins, C. and Numbers, F. An investigation of the intelligibility of the speech of the deaf. Genet. Psychol. Monogr., 25, 289-392 (1942).

John, J. and Howarth, J. The effect of time distortions on the intelligibility of deaf children's speech. Lang. Speech, 8, 127-134 (1965).

Kaplan, E. L. The role of intonation in the acquisition of language. Doctoral Dissertation, Cornell University, Ithaca (1969).

Koike, K. A test of rhythm and intonation patterns for young, normal-hearing children. Unpublished Master's Thesis, The University of Tennessee, Knoxville (1977).

Kressin, L. A perceptual analysis of intonation patterns and selected segmental features in normal two-three year old children. Unpublished Master's Thesis, The University of Tennessee, Knoxville (1976).

Lehiste, I. Suprasegmentals. Cambridge: M.I.T. Press (1970).

Lenneberg, E. The natural history of language. In F. Smith and G. Miller (Eds.), The Genesis of Language: A Psycholinguistic Approach. Cambridge, Mass.: M.I.T. Press (1966).

Lenneberg, E. Biological Foundations of Language. New York: John Wiley and Sons (1967).

Lewis, M. Infant Speech: A Study of the Beginnings of Language. London: Routledge and Kegan Paul (1951).

Lewis, M. Language, Thought and Personality in Infancy and Childhood. London: S. G. Harrap (1963).

Lieberman, P. Intonation, Perception and Language. Cambridge, Mass.: M.I.T. Press (1967).

Ling, D. Speech and the Hearing-Impaired Child: Theory and Practice. Washington, D.C.: Alexander Graham Bell Association (1976).

Löwenfeld, B. (1927). Reaktionen der säuglinge auf klänge and geräusche, cited in M. Lewis, Infant Speech: A Study of the Beginnings of Language. London: Routledge and Kegan Paul (1951).

McElroy, C. W. Speech and Language Development of the Preschool Child. Springfield, Ill.: Charles C. Thomas (1972).

McGarr, N. The production and reception of prosodic features. Paper presented at the annual meeting of the A. G. Bell Association, Boston, Mass. (1976).

Menyuk, P. and Bernholtz, N. Prosodic features and children's language production. Quarterly Progress Report of the Research Laboratory of Electronics. Cambridge, Mass.: M.I.T. Press, 93, 216-219 (1969).

Minifie, F. D., Hixon, T. J., and Williams, F., (Eds.). Normal Aspects of Speech, Hearing and Language. Englewood Cliffs, N.J.: Prentice-Hall (1973).

Morse, P. A. The discrimination of speech and nonspeech stimuli in early infancy. J. of Exper. Child Psych., 14, 477-492 (1972).

Moskowitz, A. I. The two-year-old stage in the acquisition of English phonology. Language, 46, 426-441 (1970).

Netsell, R. Speech physiology. In F. D. Minifie, T. Hixon and F. Williams (Eds.), Normal Aspects of Speech, Hearing and Language. Englewood Cliffs, N.J.: Prentice-Hall, 211-233 (1973).

Peterson, G. E. and Shoup, J. E. The elements of an acoustic phonetic theory. J. Speech Hearing Res., 9, 5-99 (1966).

Schafer, P. (1922). Beobachtungen und versuche an einem kinde, cited in M. Lewis, Infant Speech: A Study of the Beginnings of Language. London: Routledge and Kegan Paul (1951).

Shadden, B., Asp, C., Tonkovich, J., and Mason, D. Imitation of suprasegmental patterns by five-year-old children with adequate and inadequate articulation. Unpublished study. The University of Tennessee, Knoxville (1977).

Shelton, D. Acoustic and perceptual analyses of segmental and suprasegmental features in verbal responses of four-year-old children with adequate or inadequate articulatory development. Doctoral Dissertation, The University of Tennessee, Knoxville (1976).

Smith, C. Residual hearing and speech production in deaf children. J. Speech Hearing Res., 18, 795-811 (1975).

Stark, R. E. and Levitt, H. Prosodic feature reception and production in deaf children. Jour. Acous. Soc. Amer., 55 (A) (1974).

Stratton, W. Intonation feedback for the deaf through a tactile display. Volta Rev., 76, 26-35 (1974).

Tonkova-Yampol'skaya, R. Development of speech intonation in infants during the first two years of life. In C. Ferguson and D. Slobin, Studies of Child Language Development. New York: Holt, Rinehart and Winston (1973).

Tonkovich, J., Asp, C., Shadden, B., and Mason, D. Imitation of suprasegmental patterns by apraxic and normal adult speakers. Unpublished study. The University of Tennessee, Knoxville (1977).

Vetter, H. J. Language Behavior and Communication: An Introduction. Itasca, Ill.: F. E. Peacock (1969).

Wasz-Hockert, O., Partanen, T. J., Vuorenkoske, V., Michelsson, K., and Valanne, E. The identification of some specific meanings in infant vocalization. Experentia, 20, 154 (1964).

Werner, H. and Kaplan, E. The acquisition of word meanings: A developmental study. Society for Research in Child Development Monographs, 15, Ser. No. 51 (1950).

Wertheimer, M. Psychomotor coordination of auditory and visual space at birth. Science, 134, 1692 (1961).

Winitz, H. Articulatory Acquisition and Behavior. New York: Appleton-Century-Crofts (1969).

Wolff, P. H. The natural history of crying and other vocalizations in early infancy. In B. M. Foss (Ed.), Determinants of Infant Behavior, IV, London: Metheum (1966).

Wood, N. E. Delayed Speech and Language Development. Englewood Cliffs, N.J.: Prentice-Hall (1964).

Zimmerman, I., Steiner, V., and Evatt, R. Preschool Language Scale. Columbus, Ohio: Charles E. Merrill (1969).

APPENDIXES

APPENDIX A

DEFINITION OF TERMS

Duration	The perceived length of a sound, sound-group, utterance or silence (Crystal, 1969).
Intonation	The perception of changes in the fundamental frequency of vocal fold vibration during speech production (Netsell, 1973).
Pause	When there is no vibration of the vocal folds or no air emerging from the glottis (Hoops, 1969).
Pitch	The psychological response to the physical stimulus of frequency (Hoops, 1969).
Rhythm	The perception of the time program applied to the phonetic events (Netsell, 1973).
Stress	The relative degree of syllable-pulse energy given to a syllable in a unit (Goës, 1974).
Suprasegmentals	Suprasegmentals consist of three main features: (1) quantity features that are perceived as duration; (2) tonal features that are perceived as pitch changes; and, (3) stress features that are perceived as a change in loudness. These features' domain extends over more than one segment (Lehiste, 1970).
Syllable	The phonological unit which consists of one vowel nucleus, or its combination with a consonant or clusters of consonants (Faircloth and Faircloth, 1973).
Tempo	The speed of utterance or speech rate (Crystal, 1969).

APPENDIX B

REVIEW OF LITERATURE

Speech is characterized by segmental phonemes and suprasegmental patterns (McElroy, 1972; Tonkova-Yampol'skaya, 1973). Segmental phonemes are the articulatory aspects of speech generally referred to as vowels, semivowels and consonants (Vetter, 1969). Suprasegmentals are tonal, quantity and stress features that extend over more than one segment (Lehiste, 1970). Perceptually, suprasegmentals are changes in pitch, duration, loudness and stress (Carroll, 1953; Lehiste, 1970). The acoustic correlates of these features are fundamental frequency, duration, intensity and amplitude (Peterson, 1966; Lieberman, 1967, Netsell, 1973).

The perception and production of suprasegmental patterns occurs early in speech and language development (Lewis, 1951; Kaplan, 1969; Engel, 1973). The parameters of intonation, duration and stress appear to contribute to the linguistic meaning of an utterance (Vetter, 1969; Crystal, 1969; Minifie, 1973); and, suprasegmental production affects the intelligibility of speech (Hudgins, 1946; French and Steinberg, 1947; Braine, 1963; Moskowitz, 1970).

The review will be divided into three sections: (1) the development of suprasegmental speech patterns in normal-hearing children; (2) the development of suprasegmental

speech patterns in hearing-impaired children; and, (3) the measurement of suprasegmental speech patterns.

Suprasegmental Development of Normal-Hearing Children

Birth to six months of age. As early as ten minutes after birth, newborns exhibit rudimentary directional auditory localization (Wertheimer, 1961). One to five day old babies can discriminate between two pure-tones with different pitches, and their heart rates vary with the stimulus intensity (Bridger, 1961; Bartoshuk, 1964). Infants 40 to 50 days of age can discriminate the acoustic cues for intonation (Morse, 1972). At four months of age, children respond positively to a pleasant sound and negatively to an unpleasant sound (Löwenfeld, 1927). Within the first two weeks of life, children begin to respond to the human voice; and, at three months of age, they respond positively to a friendly voice and negatively to an angry voice (Buhler and Hetzer, 1928).

The first means of verbal communication for infants is the cry, which, from birth to three weeks, is the same in response to all stimuli (Berry and Eisenson, 1956). By three weeks of age, the cry is differentiated into at least three types: hunger, pain and pleasure (Wasz-Hockert et al., (1964). Each cry is rhythmical, occurring in a pattern of cry, rest, inspiration and rest (Wolff, 1966). It is characterized by a rising and falling frequency contour

(Dale, 1976); and, has a distinct intonation pattern (Tonkova-Yampol'skaya, 1973).

At one to two months of age, children produce noncrying utterances which indicate comfort or discomfort (Goës, 1974). These vocalization, or "cooing," are back, rounded vowel sounds repeated with variations in pitch and loudness (Berry and Eisenson, 1956; McElroy, 1972); and, they have an intonational contour different from the cry (Lenneberg, 1967).

Between three and six months of age, children's noncry vocalizations are "babbling," or the random repetitions of sounds and syllables with variations in pitch, stress and rhythm (Berry and Eisenson, 1956; Dale, 1976). Four to six month old children also imitate the intonational pattern of interjection in the speech of others.

Six months to one year of age. At seven months of age, children use a "requesting intonation" with patterns of fundamental frequency and intensity similar to those exhibited in an emotional request by adults (Tonkova-Yampol'skaya, 1973). Between four and eight months of age, infants can discriminate between normal falling and rising intonation contours (Kaplan, 1969). At ten months of age, an "insistent intonation" occurs in the vocalizations of children; it is similar to the intonation of persuasion and insistent command in the speech of adults (Tonkova-Yampol'skaya, 1973). Nine to twelve month old infants'

understanding of adult utterances is based on pitch, stress and intonation cues rather than the phonetic forms or linguistic meaning (Schafer, 1922; Lewis, 1963).

One to two years of age. At the end of the first year, the suprasegmental pattern becomes secondary in importance to the phonetic pattern (Lewis, 1951). Children produce one word utterances at about one year of age (Lenneberg, 1967; Dale, 1976). These "holophrases" serve the function of sentences (Werner and Kaplan, 1950; Hopper and Naremore, 1973). Declarative, interrogative and emphatic intonational contours are varied to express different ideas (Menyuk and Bernholtz, 1969).

Two to three years of age. At about two years of age, children produce two and three word sentences (Deese, 1970). Children use identical sentences with different intonational patterns to indicate different linguistic meanings (Wood, 1964). Between 2.2 to 2.4 years of age, children use rising intonation in yes/no questions (Berry, 1969). Three-year-old children make less than 3 percent errors in the imitation of simple rising and falling intonation (Kressin, 1976).

Three to five years of age. Three to five-year-old children are still developing suprasegmental features. When compared with older subjects, maximal variance occurs in the fundamental frequencies and formant frequencies of three-

year-olds (Eguchi and Hirsh, 1969). At four years of age, children learn to use contrastive stress to draw attention to the subject of a sentence (Hornby and Hass, 1970). Five-year-old children imitate suprasegmental patterns significantly better than three-year-old children, suggesting that the younger group is still acquiring some suprasegmental features (Koike, 1977).

It has not been determined at what age development of suprasegmental patterns plateaus. However, there is evidence to suggest that a delay in the development of suprasegmental features may influence the development of segmental features. The speech of four-year-old children with adequate articulation skills has greater intensity, longer duration, and greater range of fundamental frequency and intensity than that of four-year-old children with inadequate articulation skills (Shelton, 1976).

Suprasegmental Patterns of Hearing-Impaired Children

The development of suprasegmental speech patterns in hearing-impaired children begins to differ from that of normal-hearing children at six to nine months of age (Eisenson, Auer and Irwin, 1963). The hearing-impaired children repeat certain types of noise, while normal-hearing children go through a wide range of different babbling sounds (Lenneberg, 1966).

Several studies have examined the suprasegmental patterns in the speech of school-aged children and adults who are hearing-impaired. The speech of the hearing-impaired shows less variation of fundamental frequency and intensity than the speech of persons with normal hearing (Hood and Dixon, 1969); it is characterized by abnormal rhythm patterns, intonation patterns and duration of the speech sounds (Hudgins and Numbers, 1942; John and Howarth, 1965; Stratton, 1974). These characteristics are common even among hearing-impaired children who have been taught to produce segmental phonemes correctly. Suprasegmental patterns may need to be developed before teaching segmental phonemes in order that the speech of the hearing-impaired may sound more like that of persons with normal-hearing (Asp, 1973; Ling, 1976).

Tests of Suprasegmental Patterns

As mentioned earlier, the Prosodic Feature Test is a test of suprasegmental patterns (Stark and Levitt, 1974). It consists of two, three and five syllable sentences with three gross prosodic contrasts: final rising intonation, stress and pausal juncture. This test has been used with eleven-year-old profoundly deaf children who were able to read the sentences.

Koike (1977) developed the Test of Rhythm and Intonation Patterns (TRIP) which measures fourteen rhythm patterns, three tempo patterns and eight intonation patterns. He used

the test to detect a significant difference between three and five-year-old normal-hearing children. In addition, there was a significant correlation between the suprasegmental scores and receptive language scores for three-year-olds, but not for the five-year-olds.

Shadden et al. (1977) used the TRIP to test five-year-old children with adequate articulation skills and five-year-old children with inadequate articulation skills. Although there were no significant statistical differences between the two groups, the mean score for the group with adequate articulation was higher than the mean score for the group with inadequate articulation. Shadden et al. postulated that a difference between the groups may have been obscured by the enrollment in therapy of the inadequate articulation group.

Tonkovich et al. (1977) measured the performance of normal and apraxic adult speakers on the TRIP. The apraxic speakers performed significantly poorer and had a wider range of variability than the normal speakers.

Although the TRIP has not been standardized, the studies by Koike (1977), Shadden et al. (1977) and Tonkovich et al. (1977) indicate that this test is sensitive and repeatable. This makes it appropriate for analyzing the suprasegmental patterns of hearing-impaired children.

APPENDIX C

WORDS USED FOR INTELLIGIBILITY TEST

1. house
2. telephone
3. cup
4. gun
5. knife
6. window
7. wagon
8. chicken
9. zipper
10. scissors
11. duck
12. vacuum
13. matches
14. lamp
15. shovel
16. car
17. rabbit
18. fishing
19. church
20. feather
21. pencils
22. carrot
23. bathtub

APPENDIX D

TABLE 6

PERCENT AGREEMENT BETWEEN THE EXAMINER AND THE PANEL FOR THE JUDGMENT OF THE SUBJECTS' RESPONSES TO THE TEST ITEMS ON THE TRIP

Subjects	Agreement Between Examiner and Panel (Percent)
1	96
2	80
3	88
4	92
5	92
6	100
7	76
8	92
9	92
10	88
11	96
12	92
13	80
14	92
$\bar{x}$	90
SD	6.8
Range	76∿100

APPENDIX E

TABLE 7

PERCENT CORRECT FOR EACH TEST ITEM FOR SUBJECTS WHO COULD PRODUCE FIVE OR FEWER SYLLABLES

Test Items	Number of Syllables	Percent Correct
1.	2	71
2.	2	43
3.	3	29
4.	3	71
5.	3	29
6.	4	57
7.	4	14
8.	4	57
9.	4	14
10.	4	29
11.	6	14
12.	6	14
13.	3	29
14.	3	14
15.	3	57
16.	6	57
17.	9	14
18.	1	71
19.	1	43
20.	2	29
21.	2	14
22.	2	100
23.	2	43
24.	4	14
25.	4	43

APPENDIX F

TABLE 8

PERCENT CORRECT FOR EACH TEST ITEM FOR SUBJECTS WHO COULD PRODUCE GREATER THAN FIVE SYLLABLES

Test Items	Number of Syllables	Percent Correct
1.	2	100
2.	2	71
3.	3	57
4.	3	86
5.	3	71
6.	4	100
7.	4	43
8.	4	86
9.	4	86
10.	4	100
11.	6	43
12.	6	86
13.	3	86
14.	3	86
15.	3	86
16.	6	100
17.	9	29
18.	1	71
19.	1	71
20.	2	57
21.	2	86
22.	2	100
23.	2	86
24.	4	71
25.	4	100

VITA

Diane Leigh Williams was born in Birmingham, Alabama on June 9, 1954. She attended elementary school in Bessemer, Alabama and was graduated from Hueytown High School in June, 1972. The following September she entered Auburn University. In June, 1976 she received a Bachelor of Science degree in Education with a major in Speech Pathology. In the fall of 1976 she began study toward a Master of Arts degree in Speech Pathology. She received this degree in March, 1978.