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Influence of speech sample size on opportunities of sound segments in connected speech samples produced by phonologically disordered children

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INFLUENCE OF SPEECH SAMPLE SIZE ON OPPORTUNITIES OF SOUND SEGMENTS IN CONNECTED SPEECH SAMPLES PRODUCED BY PHONOLOGICALLY DISORDERED CHILDREN

by

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ABSTRACT

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The purpose of the present study was to determine characteristics of various-sized connected speech samples for articulation assessment. The present investigation studied the time, number of intelligible words, and the number of different speech sound segment occurrences for various-sized speech samples. Sixteen children, ages 5;0 through 8;10, with phonological disorders, served as subjects in the present study. A 30-minute conversational speech sample was obtained from each subject and transcribed orthographically. Sample sizes of 25, 50, 100, 150, and 200 different words were chosen from the orthographic transcription. The number of speech sound segments (single consonants and consonant clusters) were determined in three word positions for each sample size. The results of the statistical analyses revealed that significant differences existed between 25-, 50-, 100-, 150-, and 200-word sample sizes for the following variables: total speech sound segments, single consonants, and consonant clusters. That is, the number of new speech sound segments in different word positions increased significantly with each successive sample size. Thus, the 200-word sample size, which took an average of ten minutes to obtain, may not provide sufficient data regarding all sound segments in all positions for a thorough phonological assessment. Future research studies should include sample sizes larger than 200 different words to establish the most representative connected speech sample size, considering an economical use of evaluation time, for various client populations.

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CHAPTER I

INTRODUCTION

The results of an articulation assessment should accurately describe the phonological system an individual uses in speaking. Speech-language pathologists assess articulation performance to determine whether or not an individual has an articulation disorder, and if so, to obtain information to assist in remediation decisions. Among other procedures, an articulation assessment battery typically includes a formal single-word articulation test and a connected speech sample. Connected speech sampling has been recommended as the best means for obtaining a representative sample of an individual's speech (Faircloth and Faircloth, 1970; Ingram, 1976; Bernthal and Bankson, 1981). In addition, the assessment of speech sound productions in spontaneous connected discourse is essential because the ultimate objective of articulation remediation is the acceptable production of speech sounds in conversational speech. Although investigators frequently recommend using a connected speech sample as part of the articulation assessment battery (Darley & Spriestersbach, 1978; Shriberg & Kwiatkowski, 1980; Bernthal & Bankson, 1981), information regarding the desired characteristics of such samples is lacking. If spontaneous speech samples are to be used as an effective clinical tool, several characteristics of speech samples require further investigation. Some of these characteristics are: 1) the number of opportunities for different phonemes to occur in various-sized speech samples, and 2) the average amount of time required to obtain various-sized connected speech samples. If a connected speech sample is used for making clinical decisions it is necessary to know if the speech corpus provides a representative sample of English phonemes. The clinician needs to know the number of opportunities for phoneme occurrences in various-sized speech samples so that he/she knows if the sample supplies an adequate data base for making clinical decisions. Speech-language pathologists must make maximum use of their time in clinical and public-school settings. Information regarding the time required to obtain a representative sample of a child's connected speech productions would promote more efficient use of speech-evaluation time. The purpose of the present study was to investigate these characteristics of various-sized speech samples.

Importance of Connected Speech Samples In Articulation Assessment

Articulation proficiency should be determined by evaluating an individual's most typical speech productions. Bernthal and Bankson (1981) stated that articulation testing usually is used to: 1. describe the phonetic proficiency of an individual; 2. screen for possible articulation disorders; 3. determine if his/her speech sound system is sufficiently deviant to merit intervention; 4. determine the direction, form, and frequency of a remediation program; 5. predict and make prognostic statements and 6. observe changes due to instruction, to maturation, or other factors in an individual's phonetic proficiency. Typically, an articulation assessment battery is administered to provide a representative data base on which to make these decisions. The battery usually includes a formal articulation inventory using a single-word picture-naming or imitation test, and a sample of connected speech. Although single-word articulation tests are usually administered to elicit desired phonemes in given positions and phonetic contexts in a limited time period (Darley & Spriestersbach, 1978), spontaneous connected speech has been recommended as the most representative of an individual's habitual articulation productions (Faircloth &

Faircloth, 1970; Ingram, 1976; Bernthal & Bankson, 1981). Because individuals communicate in part through connected speech, assessment of articulation proficiency in connected discourse should be included both for the initial evaluation and for measurement of speech sound acquisition during remediation.

Results from research indicate that an individual's articulation skills may vary depending upon the speech task used in assessment. Investigators reported differences in articulation performance when using single-word versus connected speech tasks (Faircloth & Faircloth, 1970; Dubois & Bernthal, 1978; Johnson , Winney, & Pederson, 1980). All of these investigators found a significantly greater number of articulation errors when analyzing connected speech sampling than when analyzing isolated single-word responses. Based on their results, Faircloth and Faircloth (1970) suggested that analysis of connected speech describes a person's habitual articulatory behavior more adequately than does single-word testing. Johnson et al. (1980) recommended basing clinical decisions regarding diagnosis and remediation planning on representative connected speech samples.

Although consistency of phoneme production and the influence of coarticulation are not the main focus of the present study, they are important elements to consider in articulation assessment using connected speech samples. An individual's articulation in connected speech is influenced by coarticulation, or the changes in sound production caused by the surrounding phonemes. While single-word speech sound inventories provide an efficient and relatively easy method for obtaining a sample of phoneme productions, the number of phonetic contexts sampled is often limited (Bernthal & Bankson, 1981). Connected speech samples can also provide more opportunities for the occurrence of some target phonemes than can single-word tests. Ingram (1976) stated that acquisition of sounds is gradual and correct usage of the sound will vary, even within the same words. Therefore, testing a sound once in one word may not reflect the child's real ability. In summary, the results of the previously mentioned studies indicate that connected speech samples provide important information about a person's typical speaking performance and should be part of the articulation assessment battery.

Limited Information Available Regarding Adequacy of Speech Samples

Although the importance of using connected speech samples in articulation assessment has been established, guidelines for obtaining a representative sample are lacking. Some investigators (Darley & Spriestersbach, 1978; Johnson et al., 1980; Bernthal & Bankson, 1981) have recommended using a connected speech sample without specifying the number of words or amount of time necessary to obtain a representative sample. Furthermore, investigators have not suggested which type of criterion may be best for sample sizes—a certain number of words or a certain period of time. In addition, the issue of what constitutes a representative speech sample has not been adequately addressed (Faircloth & Faircloth, 1970; Darley & Spriestersbach, 1978; Dubois & Bernthal, 1978; Emerick & Hatten, 1979; Johnson et al., 1980; Bernthal & Bankson, 1981). More information is needed to determine the number of expected occurrences for different phonemes from various-sized speech samples for phonologically disordered children.

Although some recommendations exist in the literatue suggesting the appropriate size of speech sample to use in articulation assessment, the bases for these recommendations were often not provided (Faircloth & Dickerson, 1977; Michel, 1978; Shriberg & Kwiatkowski, 1980; Weiss, Lillywhite, & Gordon, 1980; Ingram, 1981). Speech-language pathologists need to know how the recommended sample size was determined and what information they can expect to obtain in that sample size. For example, Ingram (1981) made the "arbitrary assumption that any sound used by the child should at least occur once in any random selection of twenty-five phonetic forms or lexical types" (p.26). This estimate appears to be in conflict with data reported by Mader (1954), Roberts (1965), and Mines, Hanson, and Shoup (1978). For example, comparative percentages of occurrence for different consonants showed wide variation. Certain phonemes such as /θ, ʃ, j, dʒ, hw, tʃ, ʒ / appeared less than 1% of the time in 10-minute conversational samples of children in grades one, two, and three (Mader, 1954). Although the frequency of occurrence for phonemes is known for 10-minute samples, the frequency of occurrence for phonemes for smaller sample sizes has not been reported. In addition, the mean number of words and the variance were not reported for the children's 10-minute conversational samples.

Other suggestions for speech sample size apparently lack substantiating data. Faircloth and Dickerson (1977) suggested that approximately three to five minutes of recorded conversation usually provide "sufficient data" for conversational speech analysis; but again, no empirical bases for this recommendation were provided. Weiss et al. (1980) suggested that five minutes of conversational speech is "usually sufficient" for articulation assessment of older clients. However, they did not report the number of words or which phonemes in which word positions could be anticipated to occur in a 5-minute sample. Michel (1978) suggested that at least two minutes of conversation from the client are needed (excluding the examiner's conversation) for articulation assessment in connected speech, but he did not provide the bases for this recommendation. What is not known is whether a 5-minute sample would provide more clinically relevant information for assessment than would a 2-minute sample or if either sample size would provide sufficient information about a child's production of all phonemes in multiple contexts.

Other investigators recommended sample sizes varying from 50 to 225 intelligible words as "representative" for a phonological process analysis. For example, Crary and Schafer (1981) studied the influence of sample size on assessment of spontaneous speech using phonological process analyses. Their 50-, 100-, and 150-word sample sizes included only one phonetic production of a particular word unless subsequent productions of that word were different. Their results indicated that the 50-word conversational samples were just as descriptive as 100- or 150-word samples in producing the actual and potential occurrences of individual phonological processes. They cautioned that their results could not be generalized to other sampling formats or other types of phonological analyses. Further, they stressed the need for additional research using spontaneous speech samples. Shriberg and Kwiatkowski (1980) suggested that a conversational speech sample of approximately 225 intelligible words will yield approximately 90 different words for natural process analyses. That is, 40% of a 225-word sample can be used for analysis. However, they did not report the bases for this suggestion, nor did they provide information about the number of specific phonemes in which word positions could be expected to occur in that sample size. Faircloth and Dickerson (1977) reported that "research has shown that segments of approximately 60 words reveal information comparable to a larger sample for subjects with moderate articulation problems. Segments of approximately 90 words are more appropriate for subjects with severe articulation disorders" (p.1). They did not report the data from their research upon which they based their recommendations, or if the sample sizes consisted of different or total words. In addition, they did not report what specific "information" would be revealed in a sample 60 words, or why a 90-word sample is more appropriate for subjects with severe articulation disorders. Shriberg and Kwiatkowski (1982) published a table which provided information regarding the proportional occurrence of consonants in connected speech samples. While information was provided about consonant singletons, data were not reported about consonant clusters, or regarding the proportional occurrences of sounds in different word or syllable positions. In addition, while Shriberg and Kwiatkowski provided the proportional occurrence of consonants in speech samples, they did not report the number of specified sounds and in which word positions these sounds occurred in given amounts of time.

Given the varying suggestions for the number of minutes or the number of words required for a speech sample raises questions about the accuracy and validity of information obtained from these samples. Several investigators acknowledged the difficulty in obtaining a spontaneous speech corpus that contains a representative sample of English phonemes, especially from children (Bernthal & Bankson, 1981; Ingram, 1981). However, the investigators cited previously have not provided information regarding the number of potential occurrences of different speech-sound segments (consonants and consonant clusters) for a given sample size.

<u>Time-Cost Efficiency Considerations</u>

Speech- language pathologists need to consider the amount of time required for an assessment and need to determine the cost-efficiency of that method: That is, how much useful information is obtained in specified time periods. A comprehensive nation-wide sampling of public school clinicians reported that children with functional articulation disorders constituted 81% of their average current caseload (Darley & Spriestersbach, 1978). Therefore, testing procedures for articulation assessment must be effective and economical. If spontaneous speech samples are to be used as an effective and efficient clinical tool, clinicians must know the sample size which provides the most representative information about a child's phonological proficiency in the least amount of time. Articulation assessment could be approached more efficiently with knowledge regarding the amount of time required to obtain a certain number of words in connected speech. Furthermore, clinicians would benefit from knowing which sound segments in which positions could be anticipated to occur in a given number of words.

Purpose of the Present Study

Spontaneous speech sampling is typically used in articulation assessment as part of a battery. Several characteristics of connected speech samples warrant further investigation before the effectiveness and efficiency of the clinical tool can be determined. The present investigation studied the number of opportunities for different speech sound segments to occur in various-sized speech samples. The investigator also determined the average amount of time required to obtain different speech sample sizes. Specific research questions were:

1. Is there a significant difference in the number of different speech sound segments (consonants and consonant clusters) which occurred in the glossed transcriptions of connected speech samples containing 25, 50, 100, 150, and 200 different words?

2. What is the average amount of time required to obtain connected speech samples containing 25, 50, 100, 150, and 200 different words?

CHAPTER II

METHOD

Subjects

Sixteen children, 12 males and 4 females, ranging in age from 5;0 through 8;10, served as subjects in the present study. All subjects met the following criteria for inclusion in this investigation:

1. Identified by a licensed speech-language pathologist as having a phonological disorder. This was determined by consistent misarticulation of two or more phonemes in spontaneous speech.

2. Exhibited no overt evidence of anatomical, physiological or neurological abnormalities as determined through parent and teacher report.

3. Demonstrated normal hearing bilaterally as evidenced by passing an audiometric screening test at 20-dB HL at 1000 and 2000 Hz, and 25-dB HL at 4000 Hz [re: ANSI, 1969 (R1973)].

4. Resided in an English-speaking home.

5. Evidenced no significant language delays as determined by observation of a licensed speech-language pathologist. In addition, each subject performed within one standard deviation of the mean score for his/her age level on the Peabody Picture Vocabulary Test - Revised (Dunn & Dunn, 1981), administered within six months prior to data collection for this study.

Appendix A contains specific information concerning the subjects.

Procedures

Speech Sampling Procedures

Connected speech samples were recorded in a single session by the investigator. All subjects were instructed as to the nature of their task (Appendix B). The recording session took place in a speech therapy room in elementary school buildings in Corvallis and Stevensville, Montana. Each test room was equipped with a table, chairs, and stimulus materials. Only the clinician and the subject were present in the room during the recording session. Recording took place on the weekends so that ambient noise would not interfere with the recording. The speech samples were recorded on 60-minute cassette tapes (FUJI-FL) using an audio cassette recorder (Centrex KD-12) and a high quality microphone (Sony F500S). The recorder was placed on soft material to minimize transfer of table noise to the recorder, with the microphone placed in a stand approximately 15 to 20 inches from the child's mouth. Each session lasted for 30 minutes which was determined to be an adequate amount of time for obtaining an average of 1000 intelligible words (Shriberg & Kwiatkowski, 1980). Thirty minutes was also considered to be a reasonable amount of time in which to collect a speech and language sample for an evaluation.

A standard set of procedures was used in collecting speech samples from all subjects in order to provide consistency across subjects. First the investigator engaged the subject in conversation about topics such as pets, hobbies, movies, and sports, following suggestions from Darley and Spriestersbach (1978) and Bernthal and Bankson (1981) for obtaining a speech sample. The investigator kept her questions and comments to a minimum. Following a 5- to 10-minute period of conversation, or if conversation waned earlier, the investigator presented each subject with a set of pictures involving words containing infrequently occurring phonemes such as /ʃ, tʃ, dʒ, θ/. The infrequently occurring sounds were chosen from data provided by

Mader (1954). Subjects were then requested to tell a story about the pictures using complete sentences. The same set of pictures and instructions (contained in Appendix C) were presented to each subject in order to provide the same opportunity for occurrence of phonemes across subjects.

If a 30-minute speech sample had not yet been obtained, the subjects were asked to tell stories from other pictures and books. Materials and procedures were chosen which would appeal to both sexes and various age groups. Throughout the session the investigator asked open-ended questions; e.g., What happened?, What next?, Tell me more., rather than questions requiring yes-no or one-word answers (Miller, 1981). In addition, the investigator frequently repeated verbatim what the child intended to say. This task, called "glossing," is critical for subsequent transcription from an audio tape (Shriberg & Kwiatkowski, 1980).

Glossed Transcription

The subjects' utterances were "glossed," or written orthographically, according to the child's target word, rather than phonetically as it was actually produced. The number of opportunities for each segment to occur was based on the "gloss" transcription for each subject. The following procedures for glossing were adapted from Shriberg and Kwiatkowski (1980):

1. Utterances were entered exactly the way the child intended to say them. If the child said, for example, /hɪm doʊd/ it was entered "him goed" rather than the correct "he went". Adherence to this was important for determining the possibilities for phoneme occurrences.

2. All casual speech forms were glossed the way a child would normally say them in conversational speech; for example, "n" (and); "ya" (yes); "m" (them).

3. All catenatives were glossed as they occur in casual or fast speech; for example, "gonna" (going to); "hafta" (have to); "wanna" (want to).

4. Unintelligible words and words which the transcriber was unsure of were marked by an "X" in the transcription and excluded from the analysis. Disfluencies, partial words, noises, songs, and made-up words were also excluded from the transcription.

5. All the words in language formulation attempts, where the child may have produced an incomplete sentence, were included; e.g., "I got a, I'm getting a horse."

6. All the words in word formulation attempts, where the child may have repeated or changed a word, were included. Parentheses were placed around the word repetition or formulation before the target word, e.g., "(I, me) I went", "(She) She said."

Sample Sizes

Qualified words were chosen from the orthographic gloss of the connected speech samples to make up the sample sizes of 25, 50, 100, 150, and 200 different words. The sample size of 25 words was chosen because of Ingram's (1981) estimation that each sound in a child's inventory should occur once in a random sample of 25 lexical types. Shriberg and Kwiatkowski (1980) and Faircloth and Dickerson (1977) recommended sizes of approximately 100 words for use in analysis. The 200 word sample was chosen to determine what information a sample twice the size of that previously recommended would provide. Other sample sizes of 50 and 150 words were used to provide interim points between 25, 100, and 200 words. Each successive sample size included the words from the previous sample. The following procedures were used to determine the sample sizes of 25, 50, 100, 150, and 200 qualified words:

1. The first 15 utterances in the sample were excluded from the analysis. Byrne (1978) suggested dropping the first 15 sentences because a child may take a few minutes to "warm up." Thus, elimination of the early responses may result in a more accurate measure of his/her linguistic performance.

2. Word formulation attempts which were placed in parentheses were excluded from the analysis. Only the target word was included, e.g., "(I, me) I went."

3. Only the first occurrence of a lexical type (vocabulary word) was included for analysis, in accordance with Shriberg and Kwiatkowski's (1980) suggestions. They stated that the token procedure, using all intelligible words would bias the results since repetitions of particular lexical items can occur frequently in a sample.

Additional criteria for qualified words counted in the sample sizes are listed in Appendix D.

Data Obtained

The orthographic transcriptions of the subjects' words were used to determine the number of occurrences of different speech sound segments for the various-sized speech samples. Speech sound segments (single consonants and consonant clusters) were chosen for investigation because they are typically the phonemes misarticulated in children's speech (Powers, 1971). Specific single consonants and consonant clusters (blends of two or more consonants) analyzed in the present study are listed in Appendix E.

Consonants and consonant clusters were identified in the initial (prevocalic), ambisyllabic (intervocalic), and final (postvocalic) positions of words in the sample sizes. Ingram's (1981, p.57) definitions for speech segment positions and guidelines for determination of syllable boundaries were used in the analysis:

1. Initial (or Prevocalic) Consonant(s): A consonant or consonant cluster that appears: 1) at the beginning of a word, e.g., /p/ in "pig," "pencil"; or 2) after a syllable boundary, e.g., /m/ in "to/mato" and /t/ in "bath/tub."

2. Ambisyllabic (or Intervocalic) Consonant(s): A consonant or consonant cluster that occurs between two vowels or syllabic segments and functions both to end one syllable and to begin the next, e.g., /p/ in "paper," /nd/ in "candle," and /ns/ in "pencil."

3. Final (or Postvocalic) Consonant(s): A consonant or consonant cluster that occurs after a vowel: 1) at the end of a word, e.g., /g/ in "pig," /b/ in "bath/tub"; or 2) before a syllable boundary, e.g., /θ/ in "bath/tub."

Guidelines for determination of syllable boundaries and specific phonetic transcription procedures used to determine speech segments in the present study are listed in Appendix F and G respectively.

Measurements

The following measurements were determined for each subject from the sample sizes of 25, 50, 100, 150, and 200 words:

1. The number of different sound segments (target consonants and consonant clusters) in each of the three positions for each sample size.

2. The time (in total number of seconds) required to obtain the number of qualified words for each sample size.

3. The number of intelligible words necessary to obtain the number of qualified words for each sample size.

CHAPTER III

RESULTS

The present study investigated some characteristics of connected speech samples. The main question was to determine whether a significant difference for the number of occurrences of different sound segments was present between sample sizes of 25, 50, 100, 150, and 200 different words. In addition, the amount of time and the number of intelligible words and syllables per sample size were obtained. Statistical and distributional methods were used to analyze the data. The statistical methods used were the Analysis of Variance (ANOVA) and the Pearson Product-Moment Correlation Method (Pearson-r). The results of the reliability measures are presented first and are then followed by the results of the statistical and distributional analyses.

Reliability

Both interjudge and intrajudge reliability coefficients were obtained by determining the percentage of point-by-point agreement for the number of speech sound segments scored for each sample size. Interjudge reliability was established by determining the percentage of agreement of the investigator's results with the results independently obtained by two speech-language graduate students for two different samples. The samples were randomly selected utilizing a random numbers table. The two judges were trained to 95% agreement on a 50-word sample size prior to conducting reliability measures. (Appendix H contains additional information regarding the training sessions.) Interobserver reliability ranged from 90% to 98% with an average agreement of 94% for determining the occurrences of speech sound segments in the various sample sizes. In addition, the investigator provided intraobserver reliability by repeated measures on two randomly selected samples which were scored at least three weeks apart. Intrajudge reliability ranged from 94% to 98% with an average agreement of 96% for speech sound segments in the various sample sizes. In addition, interjudge and intrajudge reliability was established within six words for the number of intelligible words necessary to obtain each sample size for two subjects each. Intrajudge reliability was established within two seconds for the time measure for all sample sizes of the two samples.

Experimental Results

Four variables—total sound segments, single consonants, consonant clusters, and time—were each analyzed by sample size (25, 50, 100, 150, and 200 words) in a one-way by five-way Analysis of Variance (ANOVA), with repeated measures on the last factor. The ANOVA's were executed using a computer program developed by Ullrich and Pitz (1981), with significance established at the .05 level. As shown in Table 1, significant differences were obtained by sample size for all the variables considered (total speech sound segments, single consonants, consonant clusters, and time).

Tukey Honestly Significant Difference (HSD) Tests (Kirk, 1968) were employed as the a posteriori procedure. Results of the Tukey HSD tests are summarized in Table 2. The results indicated that, with one exception, all sample sizes were significantly different from each other for all four variables. The only nonsignificant difference was between the 25- and 50-word samples for the time variable. The number of different speech sound segments, single consonants, and consonant clusters accounted for in the three word positions increased significantly with each larger sample size. The results indicated that each time measurement also increased significantly with each larger

TABLE 1

ANOVA SUMMARY TABLE FOR SAMPLE SIZE EFFECTS

Analysis of variance results for speech sample size (25, 50, 100, 150, and 200 words) by 16 subjects for four different variables (total speech sound segments, consonant clusters, single consonants, and time). Significance was established at the .05 level.

SOURCE	SUMS OF SQUARES	MEAN SQUARE	DF	F-RATIO	PROB.
TOTAL SPEECH SOUND SEGMENTS					
Sample Size	30246.1	7561.52	4	829.227	0.00000
Error	547.126	9.1188	60		
CONSONANT CLUSTERS					
Sample Size	6203.67	1150.92	4	371.737	0.00000
Error	250.32	4.17	60		
SINGLE CONSONANTS					
Sample Size	9192.30	2298.08	4	665.146	0.00000
Error	207.30	3.45	60		
TIME (NUMBER OF SECONDS)					
Sample Size	0.347	868004.00	4	192.652	0.00000
Error	270334.00	4505.56	60		

TABLE 2

TUKEY ANALYSIS RESULTS

Tukey Honestly Significant Difference (HSD) test results between sample sizes (25, 50, 100, 50, and 200 words) for four different variables (total speech sound segments, consonant clusters, single consonants, and time). The numbers under each column of the four variables represent the differences between the means for the two adjacent sample sizes. An asterisk (*) denotes significance at the .05 level.

SAMPLE SIZES	TOTAL SOUND SEGMENTS	CONSONANT CLUSTERS	SINGLE CONSONANTS	TIME (SECONDS)
25	--	--	--	--
50	12.94*	4.44*	8.50*	45.81
100	18.44*	7.56*	10.88*	127.31*
150	11.81*	6.19*	5.63*	179.38*
200	10.06*	6.00*	4.06*	212.13*
CRITICAL DIFFERENCE	3.00	2.03	1.85	66.79

sample size except for the difference between the 25- and the 50-word sample sizes.

The distributional findings of the investigation are presented in Table 3 and in Appendices I and J. The means and standard deviations for the total speech sound segments, single consonants, and consonant clusters are provided in Table 3 and are plotted in Figure 1. The plotting of the means of the total speech sound segments resulted in a rising slope from the 25- to 100-word sample sizes. From the 100- to the 200-word sample sizes there was a slight decrease in the slope, indicating that the means became smaller with each succesive sample size after the 100-word sample. Whether or not this demonstrates the beginning of a true plateau effect could not be determined from the present data. The plotting of the single consonants also showed the same pattern, indicating that the mean number of new consonants in the different positions decreased slightly from the 100- to the 200-word sample sizes. The slope for the means of the consonant clusters appeared to continually rise, indicating that approximately the same number of new clusters appeared with each successive sample size.

TABLE 3

MEANS AND STANDARD DEVIATIONS

	TOTAL SPEECH SOUND SEGMENTS		TIME SECONDS		TIME MINUTES	
SAMPLE SIZE	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION
25	26.88	2.80	31.31	9.50	31.31	9.50
50	39.81	4.09	77.13	23.13	1:17.13	23.13
100	58.25	4.52	204.44	52.51	3:24.44	52.51
150	70.06	4.01	383.81	104.78	6:23.81	1:44.78
200	80.13	4.19	595.94	163.24	9:55.94	2:43.24

	SINGLE CONSONANTS		CONSONANT CLUSTERS	
SAMPLE SIZE	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION
25	21.56	2.56	5.31	1.74
50	30.06	2.52	9.75	2.62
100	40.94	2.91	17.31	3.40
150	46.56	2.56	23.50	3.65
200	50.63	2.60	29.50	3.86

	INTELLIGIBLE WORDS		SYLLABLES	
SAMPLE SIZE	MEAN	STANDARD DEVIATION	MEAN	STANDARD DEVIATION
25	33.56	6.19	30.63	2.45
50	80.94	18.17	60.50	3.03
100	203.94	30.10	124.13	4.60
150	363.50	48.80	192.06	5.09
200	527.38	66.93	265.19	7.64

FIGURE 1

MEANS AND STANDARD DEVIATIONS

FOR SPEECH SOUND SEGMENTS, SINGLE CONSONANTS, AND CONSONANT CLUSTERS ACROSS SAMPLE SIZES

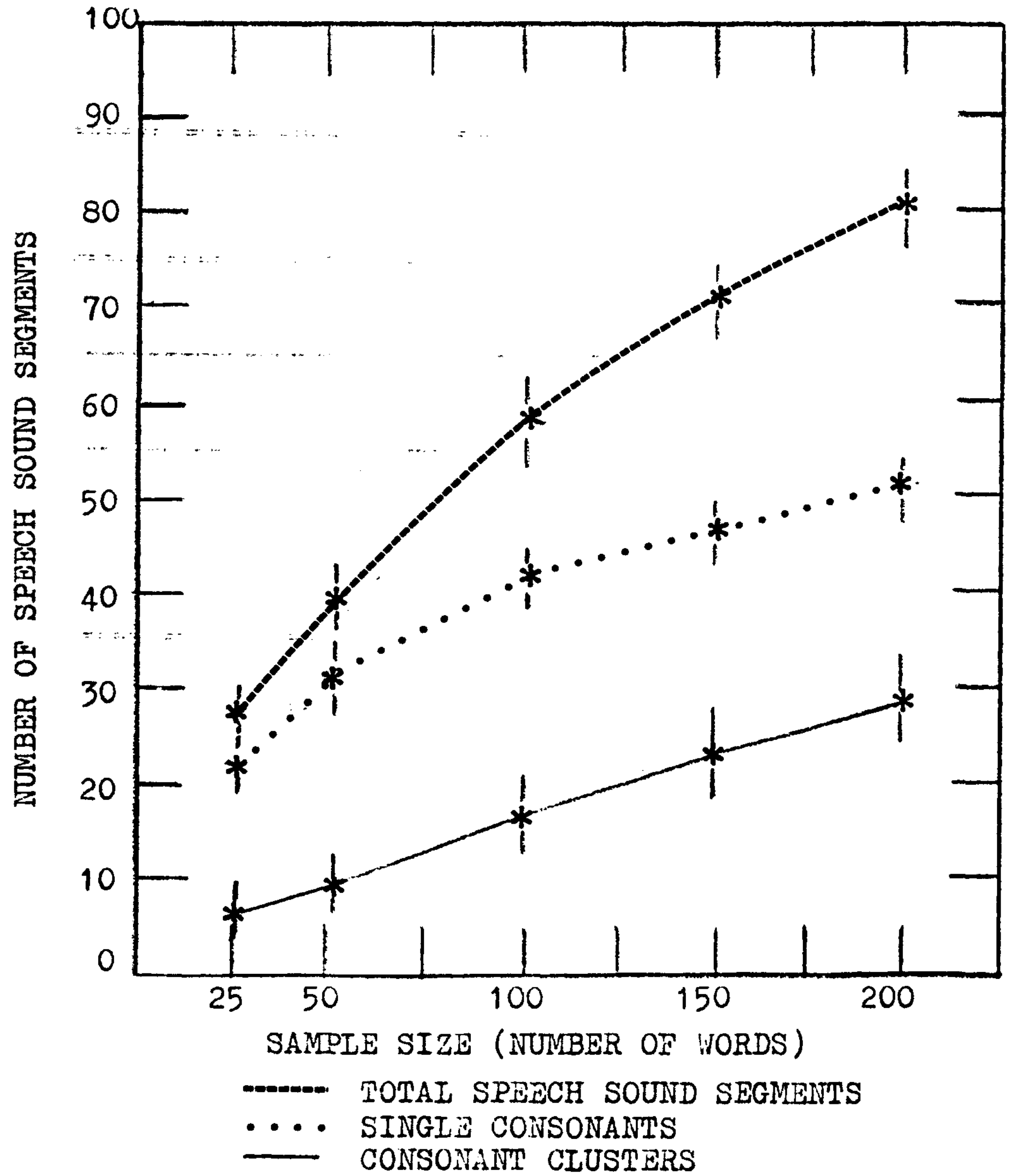


Table 3 also contains the means and standard deviations for the time, intelligible words, and syllables for each sample size. Approximately 1/2 minute was needed to obtain 25 different words, 1-1/2 minutes for 50 words, 3-1/2 minutes for 100 words, 6-1/2 minutes for 150 words, and 10 minutes for the 200-word sample size. Because different words were used to make up sample sizes, more time, as well as more intelligible words, were necessary to obtain each successive sample size. In addition, the number of syllables increased slightly with each successive sample size, which may have been due to the more common monosyllabic words occurring in the earlier samples.

Appendix I contains a table of the total number of different speech sound segments in each of the three word positions which occurred in the sample sizes for the 16 subjects. As would be expected, some speech sound segments occurred more frequently in some positions than others. Typically, some sound segments occurred more frequently in the initial or final positions than the ambisyllabic position. Furthermore, the number of some single consonants which occurred in the ambisyllabic position increased in the larger sample sizes which contained more multi-syllabic words. Additional consonant clusters appeared which were not included in the target cluster list. These clusters are listed in Appendix J.

The Pearson Product Moment Correlation Method (Pearson-r) (Coladarci & Coladarci, 1981) was used to analyze the relationship of the mean for the sample size of 200 with each of the means of the smaller sample sizes, for the total sound segments measurement. The confidence level was established at .05. The correlation analysis was used with the underlying assumption that the sample size of 200 different words would be more than enough to provide a representative sample of the phonemes in a child's inventory. The statistical analyses did not support this assumption, since the Tukey test results indicated that significantly more new sound segments in the three positions occurred in each increasing sample size from 25 to 200 words. The 200-word sample size provided the most representative sampling of phonemes out of the sample sizes used in the present study, but perhaps not the most representative of a child's complete inventory of phonemes since no ceiling effect was obtained. However, the results of the Pearson-r correlation appeared to provide some useful information which are presented in Table 4. The correlation coefficients were plotted and are located in Figure 2. A perfect correlation would be indicated by

TABLE 4

CORRELATION RESULTS

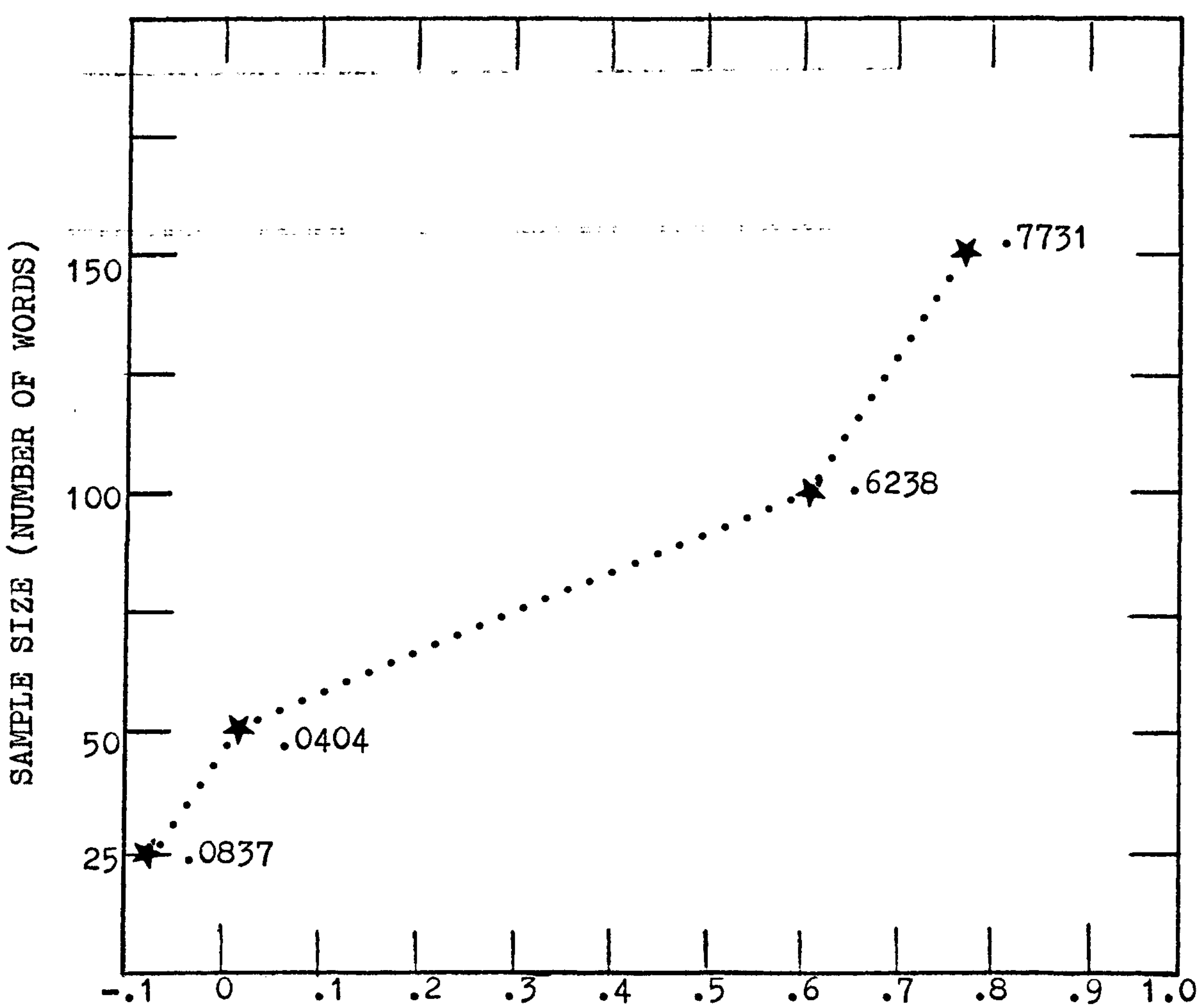
Corrlation coefficients for sample sizes of 25, 50, 100, and 150 correlated with the sample size of 200 different words for the variable, total speech sound segments. Significance was established at the .05 confidence level.

SAMPLE SIZES	CORRELATION COEFFICIENT BY 200 WORDS	SIGNIFICANCE LEVEL
25	-0.0837	.379
50	0.0404	.441
100	0.6238	.005
150	0.7731	.000

FIGURE 2

CORRELATION COEFFICIENTS

FOR SAMPLE SIZES OF 25, 50, 100, AND 150 WORDS
WITH 200 WORDS FOR THE TOTAL SPEECH SOUND SEGMENTS



CORRELATION COEFFICIENTS

1.0. The 25-word and the 50-word sample sizes obtained correlation coefficients of -.0837 (p=.379) and .0404 (p=.441) respectively, which indicated little relationship to the 200-word sample size. That is, the sounds which occurred in the 25- and 50-word sample sizes were similar only by chance to the sounds which occurred in the 200-word sample size. The 100-word sample size obtained a low correlation of .6238 (p=.005). Although the 150-word sample size was most closely correlated, only a moderate correlation of .7731 (p=.000) was obtained. Correlation coefficient classifications were determined according to Edwards' (1946, p.100) classifications with ranges of .46-.63 as low and .64-.77 as moderate.

CHAPTER IV

DISCUSSION

The results of the present study revealed that significant differences existed between 25-, 50-, 100-, 150-, and 200-word sample sizes for the potential occurrences of the following variables: total speech sound segments (consonants and clusters), single consonants, and consonant clusters. Furthermore, the sample size of 200 different words was not sufficiently large for determining the most representative speech sample for the subjects of this study, aged 5 through 8 years. Suggestions from previous investigators for an appropriate speech sample size were in conflict with the findings of the present study. The following discussion will concentrate on three topics: 1) Comparison of the present results to those previously reported; 2) Clinical implications; and 3) Suggestions for future research.

<u>Comparison of the Results to Other Studies</u>

This section will describe differences of the present results from previous findings and discuss possible explanations for those differences. Previous investigators suggested various sample sizes ranging from 25 to 100 words or samples obtained in approximately 5 minutes (Faircloth & Dickerson, 1977; Michel, 1978; Shriberg & Kwiatkowski, 1980; Weiss et al., 1980; Ingram, 1981). The results of the present study suggest that the smaller sample sizes may not provide adequate information about a child's productions of all phonemes in the different word positions. However, caution must be taken when directly comparing the results of the present study to previous research, since an adequate data base was not usually provided to support the recommendations from other studies.

Investigators such as Faircloth and Dickerson (1977), Shriberg and Kwiatkowski (1980), Crary and Schafer (1981), and Ingram, (1981) suggested that connected speech samples smaller than 200 words (specifically 25 to approximately 100 words) should be sufficient for speech analysis. The results from the present study indicated that some consonants and clusters may not appear in all possible positions (particularly the ambisyllabic position) unless larger sample sizes are obtained. That is, significantly more new sound segments occurred in different word positions with each larger sample size investigated. In fact, there was no correlation of the 25- and 50- word sample sizes with the 200-word sample size and only a low to moderate correlation of the 100- and 150-word size samples with the 200-word size. These findings suggest that speech sample sizes of 100 words or less do not provide an adequate sample of a child's phonological system.

The results of the present study also conflict with Crary and Schafer's (1981) findings that a 50-word sample was as descriptive as the 100-word and 150-word sample sizes for the phonological process analyses. Crary and Schafer were evaluating potential and actual phonological process occurrences, rather than target phoneme occurrences, which may account for the discrepant findings. However, information about phoneme occurrences is still necessary to determine which phonemes are affected by a process and to determine the consistency of a process occurrence across phonemes. Therefore, a 50-word speech sample is not adequate for phonological process analyses when considering consistency of a process.

In addition to speech sample sizes of a specified number of words, recommendations were suggested for a specific amount of time. Faircloth and Dickerson (1977), Michel (1978), and Weiss et al., (1980) recommended two to five minutes for a conversational speech sample for speech analysis. The means for the time variable (Table 4) indicated that a 5-minute conversational speech sample provided between 100 and 150 different words. The statistical analysis results from the present study revealed that significantly more new sounds occurred in each successive sample size up to 200 words. That is, some sounds in some positions do not occur in a 5-minute sample, especially less frequently occurring sound segments and sounds in the ambisyllabic word positions. Thus, a speech sample size of five minutes or less may not provide sufficient data for all phonemes for phonological assessment.

In summary, previously recommended sample sizes of 100 words and conversational speech samples of five minutes do not appear to provide an adequate data base from which to make a thorough phonological analysis. Furthermore, the assumption that the 200-word sample size would be sufficient to provide a representative sample of a child's phonetic inventory was not validated. The 200-word sample size was chosen for the present study because it was twice the size of previously recommended samples (Faircloth & Dickerson, 1977; Shriberg & Kwiatkowski, 1980). However, the results indicated that significantly more new sound segments in different word positions occurred in each successive sample size up to 200 words. The plotting of the means for each sample size (Figure 1) revealed that there was only a slight decrease in the slope as the sample size increased. Therefore, even 200 words may not be sufficient for an adequate speech sample size.

Previous recommendations for sample sizes were often provided without specific data and information regarding the methodology of these studies. However, possible explanations for the differences in the results between the previous studies and the results of the present study exist. First, the present study investigated phoneme occurrences in the initial, ambisyllabic, and final positions of words. Other studies may have counted a phoneme when it occurred once in any word position. Larger sample sizes are necessary to obtain phonemes in all word and syllable positions. The present results revealed a trend for more multisyllabic words to appear in the larger sample sizes, which allowed more opportunities for phonemes in the ambisyllabic position. Articulation assessment should include evaluation of phonemes in various word or syllable positions as a child's productions may vary during phoneme acquisition across the different postions (Ingram, 1981).

Secondly, specific clusters as well as single consonants were analyzed for potential occurrences in the present study. Clusters can be classified in a variety of ways. Clusters were classified as a unit in the present study. Other investigators may have classified each segment separately or they may have omitted clusters (Faircloth & Dickerson, 1977; Shriberg & Kwiatkowski, 1982). Thus, the method used in classification of clusters can influence the number of different sound segments identified in a specified sample size. Speech-language pathologists need to assess the production of clusters since clusters are among the most frequently misarticulated sounds in children's speech (Powers, 1971; Weiss et al., 1980).

Third, other studies may have included subjects of different age levels or with different language skills, which could affect speech productions. An attempt was made in the present study to control for age and language ability by including subjects between 5;0 and 8;11 without language disorders. Older children and children with normal language skills (such as those in the present investigation) may provide increasingly different sound segments with the larger sample sizes as they continue to produce more varied language and vocabulary. Leonard, Schwartz, Chapman, Rowan, Prelock, Terrell, Weiss, and Messick (1982) reported that language-impaired children, as well as normal children, were more likely to produce words containing sounds already in their repertoires rather than words whose sounds were absent from their phonologies. Thus, preschool children or those identified as severely phonologically disordered, such as some of the subjects in the Shriberg and Kwiatkowski (1982) research projects, may have demonstrated limited language output because of a limited sound system. All their available phonemes would then be elicited in a smaller number of words. Therefore, increasing the sample size would not necessarily allow for more new sound segments as the limits of their phonological system had already been reached. In contrast, in the present study more new sound segments occurred in larger sample sizes as the school-age children continued to produce more words with different phonemes in different positions.

Although several factors have been suggested as possible reasons for the present results to differ from previous research, direct comparison is difficult due to lack of reported data of those earlier studies. However, the results of the present study indicate that a larger sample size than those previously suggested is necessary to provide a sufficient data base for phonological assessment for phonologically disordered school-age children.

Clinical Implications

The most important outcome of the present investigation is that previously recommended connected speech sample sizes of 100 words or less do not provide sufficient data for school-age children for a thorough phonological assessment of consonants and clusters in all word positions. In fact, the results reveal that even the sample size of 200 different words, the largest size used in this investigation, do not provide an adequate representation of all English sound segments. The finding that significantly more new sound segments occurred in each successive sample size suggests that speech-language pathologists should be cautious when using sample sizes of less than 200 words, especially if they are using a total word count rather than different word types to make up the sample sizes. If sample sizes smaller than 200 words are used, some sound segments will not have the opportunity to occur in all positions.

One factor which may influence a child's phonological productions in a speech sample is the presentation of stimulus materials. Pictures appeared to be useful in eliciting phoneme occurrences of the infrequently occurring sounds, such as /ʃ, tʃ, dʒ, θ/ in the present study. These phonemes appeared more often in the larger sample sizes of 150 and 200 words, an increase which coincided with the presentation of the stimulus pictures containing these sounds to most of the children.

Future Research

Several characteristics of connected speech samples warrant further investigation. As previously discussed, sample sizes larger than 200 different words should be included in future research studies. The results of the present study indicated that significantly more new speech sounds occurred in each successively larger sample size from 25 to 200 words. Therefore, future investigation should include larger sample sizes to determine in which sample size the number of new phonemes will plateau. The amount of additional time to reach this sample size should also be considered in order to determine the most representative speech sample with an economical use of time.

Future studies should establish data on phoneme occurrences in specified sample sizes for persons with normal as well as disordered phonological systems. Comparisons could then be determined for the number of potential phoneme occurrences in connected speech samples for persons with and without phonological disorders. As previously discussed, future studies are warranted to further investigate the effects of different language abilities upon phonological productions in connected speech samples.

In addition, research should address the issue of using the word versus the syllable unit in measuring sample sizes. Children with higher language skills may use more multisyllabic words, thus allowing more opportunities for phoneme occurrences. Therefore, using words as the unit to make up sample sizes may not provide equivalent bases for comparison. Although the PPVT-R was administered to rule out language disordered children from the present study, there was no control for different expressive language skills. Future research studies should include sample sizes composed of syllables in order to determine whether the syllable or word unit is the most appropriate measure for speech sample sizes.

Finally, several other factors may influence a child's productions in conversational speech samples, including age, language skills, and severity of phonological involvement. Although the influence of age and language levels were not analyzed in this study, these variables should be considerations in future studies of connected speech samples. Older children and children with normal to above-normal language skills may provide a high vocabulary output which could allow for obtaining a sample size of different words in less time. For example, the oldest child and the child with the highest receptive vocabulary score (PPVT-R) took the least amount of time (less than 7 minutes) to obtain the 200-word sample size. However, the three children who took the longest time (over 13 minutes) to obtain the 200-word sample evidenced a range of phonological and linguistic skills. For example, two of those three children were the youngest and the most severely phonologically involved. However, the third child achieved one of the highest vocabulary test scores. These findings indicate that several factors may interact to affect the number of words and phonemes produced in a specified time period. Further investigation is warranted to explore the effects of these variables upon phonological productions in connected speech samples.

Conclusion

The present investigation established information about the number of different sound segment occurrences in different word positions and the time necessary to obtain various-sized speech samples from phonologically disordered school-age children. The results indicated that the number of new speech sound segments (consonants and clusters) significantly increased with each sample size from 25 to 50, 100, 150, and 200 different words. An average of approximately 10 minutes was necessary to obtain the largest sample size of 200 different words. Previous investigators recommended sample sizes that were too limited in terms of time (less than 10 minutes) and number of words (less than 200 words) to provide an adequate data base for a thorough phonological assessment. The present results emphasized the need for establishing data about sound segment occurrences in sample sizes larger than 200 words. Speech-language pathologists must be aware that all the sound segments may not have had the opportunity to occur in all positions in samples smaller than 200 words or samples obtained in less than 10 minutes. Future research should address the issue of establishing the most representative connected speech sample size, considering an economical use of time, for various client populations.

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APPENDIX A

DESCRIPTIVE INFORMATION OF SUBJECTS

SUBJECT NUMBER	SEX	AGE	PPVT-R STD. SCORE	PHONEMES MISARTICULATED
1	M	5-5	105	/l, r, s, z, ʃ, tʃ, dʒ, f, v, θ, ð/
2	M	6-10	101	/s, z, ʃ, θ, ð/
3	M	6-0	97	/r, s, z, tʃ, dʒ, θ, ð/
4	M	5-11	106	/s, z, tʃ, θ, ð/
5	M	5-10	86	/l, r, j, θ, ð/
6	M	8-10	99	/s, z, ʃ, θ/
7	M	6-3	105	/l, r, ʃ, tʃ, θ, ð/
8	F	5-0	96	/r, j, s, z, ʃ, tʃ, ʒ, dʒ, v, θ, ð/
9	M	6-5	97	/r, ʃ, tʃ, ʒ, dʒ, θ, ð/
10	M	7-3	107	/r, θ, ð/
11	F	6-11	125	/s, z/
12	M	7-1	103	/r, s, z/
13	F	7-0	98	/s, z, tʃ, ð/
14	F	6-0	118	/s, z, ʃ, tʃ, dʒ/
15	M	6-5	115	/l, r, dʒ, θ, ð/
16	M	5-11	105	/l, r, s, ʃ, dʒ, v, θ, ð/

APPENDIX B

INSTRUCTIONAL SET

Initial instructions:

"We will be talking together today for about half an hour. I need to record our conversation and you can listen to yourself at the end of our session, if you would like. I want you to tell me as much as you can about what I ask you. I will be repeating what you say so that I can be sure I get it right on the recorder."

Topics of discussion were presented in the following order:

1. Plans for the weekend.

2. Pets and animals and how the child took care of them.

3. Hobbies, sports or clubs.

4. Favorite television shows and movies.

5. Directions to their home.

6. How to make a favorite food.

Subjects were then instructed to tell a story, using complete and long sentences, when presented with the stimulus materials.

APPENDIX C

STIMULUS MATERIALS USED IN GATHERING SPEECH SAMPLES

Selected materials from each group were presented in the following order. Pictures were chosen according to the child's age level and interest.

1. Goldman-Lynch Sounds Development Kit (AGS).

   Posters # 1, 2, 6, 16, 21, 22.

2. Self Told Tales (General Learning Corporation).

   Picture story books # 19, 20, 27, 35, 43.

3. What's Wrong Here? (Teaching Resources).

   Level I Pictures # 1, 2, 3, 4, 5, 6.

   Level II Pictures # 8, 12.

APPENDIX D

CRITERIA FOR QUALIFIED WORDS

The following rules were used to determine which words from the orthographic gloss were included in the sample sizes of 25, 50, 100, 150, and 200 words.

1. Exclude the first fifteen utterances, defined as one or a string of spoken syllables bounded by pauses (Shriberg & Kwiatkowski, 1980).

2. Include only the first occurrence of a lexical type. If two words sound the same, use the lexical meaning and spelling to determine a word's eligibility; e.g., (there, they're), (it's, its), and (two, to) are different word types. Count each as a separate word.

3. Include proper nouns and brand names, such as "Corvallis, Joan, Star Wars, Frisbee."

4. Include grammatically incorrect words; e.g., "ain't, brang, goodest."

5. Include words which are acceptable speech forms and acceptable slang terms; e.g., "yup, gonna, cause, kindof, gramma."

6. Count compound words with one meaning as one word, such as, "schoolyard, T.V., O.K., T-shirt, Four-H, upside down."

7. If a child uses letters as a referent or to spell something, the letter's name is counted as a word; e.g., "l," "m."

8. Exclude interjections, such as, "um, uh huh."

9. Exclude word repetitions and word formulations which are enclosed in parentheses in the orthographic gloss. Only the target word is included; e.g., "(I) I saw it." "(May, may) can we go?"

10. Include all the words in language formulation, such as, "and we got, we had a horse." "I went home, no, I went to the store."

APPENDIX E

SPEECH SOUND SEGMENTS EXAMINED IN THIS INVESTIGATION

Speech sound segments were adapted by Shriberg and Kent (1982) from data reported by Mader (1954) for the consonants, and from data reported by Roberts (1956) for the clusters.

	SINGLE CONSONANTS	CONSONANT CLUSTERS: WORD INITIAL	CONSONANT CLUSTERS: WORD FINAL
1.	n	pr	nt
2.	t	fr	st
3.	d	st	nd
4.	r	pl	rz
5.	s	tr	nts
6.	ð	gr	rd
7.	l	kl	ld
8.	w (includes /ʍ/)	kw	rn
9.	m	gl	kt
10.	k	sk	ŋk
11.	z	θr	nz
12.	h	br	zd
13.	b	kr	rt
14.	p	sp	ks
15.	g	fj	ts
16.	v	dr	vd
17.	f	str	rk
18.	ŋ	bl	lz
19.	θ	sm	mz
20.	ʃ	sl	rs
21.	j	fl	rst
22.	dʒ	sw	pt
23.	tʃ	tw	kst
24.	ʒ	bj	rm
25.			dz

APPENDIX F

GUIDELINES FOR DETERMINATION OF SYLLABLE BOUNDARIES

Syllable boundaries were determined in order to locate the initial, final, and ambisyllabic sound segments. Multisyllabic words in the sample sizes were divided into syllables according to the following rules suggested by Ingram (1981, p.58).

1. Place a syllable boundary after an unstressed syllable preceding a stressed syllable, e.g., "banana"="ba/nana"; "telephone"="tele/phone."

2. Place a boundary between consonants or between a vowel and a consonant if both syllables carry stress, that is, if the word is a compound, e.g., "sunset"="sun/set" as opposed to "pencil"="pencil," or "drive-in"="drive/in" as opposed to "driving"="driving."

3. Place a syllable boundary between consonants that occur between syllabic segments if those consonants cannot occur as permissable word final clusters in English, e.g., "napkin"="nap/kin," "chimney"="chim/ney" because /pk/ and /mn/ are not permissable final clusters.

   Note: all nasal and stop sequences are considered permissable final clusters even though some never occur, e.g., /mb/, /ng/.

4. All other consonants between vowels are considered ambisyllabic (or intervocalic).

In the present study, the Random House Dictionary (1968) was consulted to determine the stressed syllables for any words where the stress was in question by the judge. The first pronunciation following the entry word was used for stress identification. Both primary and secondary stress marks were considered to mark stressed syllables.

APPENDIX G

PROCEDURES FOR DETERMINATION OF SOUND SEGMENTS FROM THE ORTHOGRAPHIC TRANSCRIPTION

1. Sound segment occurrences were identified in the initial, final, and ambisyllabic positions of the words in each sample size. Ingram's (1981) definitions for word positions were used:

   Initial (or prevocalic) consonant(s): a consonant or consonant cluster that appears before a vowel: 1) at the beginning of a word, e.g., /p/ in "pig," "pencil"; or 2) after a syllable boundary, e.g., /m/ in "to/mato" and /t/ in "bath/tub."

   Final (or postvocalic) consonant(s): a consonant or consonant cluster that occurs after a vowel: 1) at the end of a word, e.g., /g/ in "pig," /b/ in "bath/tub"; or 2) before a syllable boundary, e.g., /θ/ in "bath/tub."

   Ambisyllabic (intervocalic) consonant(s): a consonant or consonant cluster that occurs between two vowels or syllabic segments and functions both to end one syllable and to begin the next, e.g., /p/ in "paper," /nd/ in "candle," and /ns/ in "pencil."

2. "A Pronouncing Dictionary of American English" (Kenyon & Knott, 1953) was consulted if the phonetic transcription of a word was in doubt by a judge.

3. There was no initial position for phonemes /ŋ/ and /ʒ/, and no final position for phonemes /w, j, h, r/.

4. Letters used as referents, such as "l" and "n," were transcribed as they were pronounced.

5. Transcription of /r, ɝ, ɚ/ was determined as follows:

a) "er" was always considered as vocalic /ɝ/ or /ɚ/. Examples: "bird" /bɝd/; "girl" /gɝl/; "further" /fɝðɚ/.

b) Any final "r" was considered a dipthong /ɚ/ (McKay, 1978). Examples: "car" /kɑɚ/; "fair" /fɛɚ/.

c) Any other vowel + "r" combination besides /ɝ/ and /ɚ/ were transcribed as a vowel + "r." Examples: "farm" /fɑrm/; "sort" /sɔrt/; "mirror" /mirɚ/.

APPENDIX H

JUDGES′ TRAINING SESSION

The investigator met with the two judges for three training sessions to orient the judges to the procedures. Both judges obtained reliability of 95% minimum agreement with the investigator for a practice 50-word list. The training sessions included:

1. Description of the purpose of the study and the judges′ roles in establishing reliability.

2. Explanation of the experimental measurements.

3. Oral and written presentation of the procedures and rules for obtaining the measurements:

   a) Counting out the qualified words for the sample sizes of 25, 50, 100, 150, and 200 different words.

   b) Dividing multisyllabic words and identifying syllable boundaries.

   c) Identifying and charting speech sound segments in the three word positions.

   d) Tabulating the numbers of different consonants, consonant clusters, and total speech sound segments for each sample size.

   e) Determining the number of syllables in the sample sizes.

   f) Determining the number of intelligible words necessary to obtain the number of qualified words for the sample sizes.

4. Practicing the procedures on different transcriptions for identifying the sound segments of a 50-word list each session.

5. Discussion of specific difficulties the investigator experienced while obtaining the measurements, to facilitate the process for the judges.

APPENDIX I-1

TOTALS FOR SPEECH SOUND SEGMENTS SINGLE CONSONANTS

This table contains the totals from the raw data for all 16 subjects for each sound segment in each of the three positions. The sound segments are listed in decreasing order of frequency. Appendix I-1 contains consonants and Appendix I-2 contains consonant clusters. Each successive sample size includes only the new (rather than cumulative) sound segments which occurred in that sample size.

SOUND SEGMENT	POSITION	SAMPLE SIZES 25	50	100	150	200	TOTAL
/t/	I	29	18	43	57	42	189
	A	9	7	16	19	21	72
	F	40	47	91	63	69	310
							571
/n/	I	14	11	34	27	25	111
	A	9	8	11	11	12	51
	F	29	32	56	63	59	239
							401
/k/	I	17	26	48	48	65	204
	A	1	6	6	14	22	49
	F	6	12	33	43	27	121
							374
/m/	I	21	21	34	31	49	156
	A	6	0	8	8	7	29
	F	21	25	35	37	32	150
							335

/l/	I	7	13	27	40	30	117
	A	4	0	12	10	13	39
	F	11	11	53	46	42	163
							319
/d/	I	27	13	40	27	28	135
	A	8	3	9	12	14	46
	F	15	11	32	27	46	131
							312
/b/	I	21	18	65	72	64	240
	A	1	4	11	9	9	34
	F	0	2	4	1	3	10
							284
/s/	I	16	23	46	39	34	158
	A	0	1	3	4	9	17
	F	10	9	23	26	24	92
							267
/z/	I	0	0	2	2	5	9
	A	0	3	7	6	23	23
	F	20	28	48	56	65	217
							249
/w/	I	35	44	58	58	50	245
	A	0	0	0	1	1	2
	F	-	-	-	-	-	-
							247
/h/	I	31	35	53	50	52	221
	A	0	0	0	0	0	0
	F	-	-	-	-	-	-
							221

/p/	I	9	11	24	39	49	132
	A	1	0	4	6	11	22
	F	7	4	9	13	13	46
							200
/g/	I	17	21	44	31	24	137
	A	0	2	2	5	3	12
	F	4	1	6	10	12	33
							182
/ŋ/	I	-	-	-	-	-	-
	A	0	0	0	0	3	3
	F	8	10	18	42	97	175
							178
/ð/	I	29	23	38	24	23	137
	A	2	4	8	7	4	25
	F	0	0	0	0	0	0
							162
/r/	I	13	11	19	24	47	114
	A	4	0	3	15	18	40
	F	-	-	-	-	-	-
							154
/f/	I	9	17	26	23	35	110
	A	0	0	1	2	4	7
	F	2	2	9	8	12	33
							150
/v/	I	2	0	2	7	3	14
	A	1	5	16	12	15	49
	F	14	11	21	11	6	63
							126

/ʃ/	I	1	4	8	22	31	66
	A	0	0	1	7	12	20
	F	0	0	5	7	9	21
							107
/θ/	I	4	1	9	19	14	47
	A	0	1	3	0	1	5
	F	1	3	10	18	11	43
							95
/tʃ/	I	4	3	10	9	18	44
	A	0	0	1	1	2	4
	F	3	1	8	6	13	31
							79
/j/	I	11	10	20	17	8	66
	A	0	0	0	1	0	1
	F	-	-	-	-	-	-
							67
/dʒ/	I	3	5	12	12	18	50
	A	0	0	3	1	1	5
	F	1	0	0	2	5	8
							63
/ʒ/	I	-	-	-	-	-	-
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							0

APPENDIX I-2

TOTALS FOR SPEECH SOUND SEGMENTS
CONSONANT CLUSTERS

SOUND SEGMENT	POSITION	25	50	100	150	200	TOTAL
		SAMPLE SIZES					
/st/	I	0	2	13	9	7	31
	A	3	3	3	4	7	20
	F	3	9	21	17	7	57
							108
/nt/	I	0	0	0	0	0	0
	A	1	1	5	3	7	17
	F	12	7	22	18	18	77
							94
/ts/	I	0	0	0	0	0	0
	A	0	0	1	0	0	1
	F	9	10	22	12	13	66
							67
/nd/	I	0	0	0	0	0	0
	A	1	1	2	3	7	14
	F	17	6	10	12	5	50
							64
/br/	I	2	3	6	21	15	47
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							47
/nz/	I	0	0	0	0	0	0
	A	0	0	0	0	0	0
	F	3	7	11	9	8	38
							38

/pl/	I	6	3	8	5	15	37
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							37
/ks/	I	0	0	0	0	0	0
	A	0	0	1	1	1	3
	F	3	1	7	12	8	31
							34
/tr/	I	2	2	8	8	8	28
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							28
/gr/	I	3	3	5	9	8	28
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							28
/ŋk/	I	0	0	0	0	0	0
	A	0	0	1	4	4	9
	F	4	2	2	3	8	19
							28
/ld/	I	0	0	0	0	0	0
	A	1	0	2	1	2	6
	F	0	1	5	5	5	16
							22
/rz/	I	0	0	0	0	0	0
	A	0	0	0	0	0	0
	F	0	1	4	8	8	21
							21

/fr/	I	1	4	6	4	5	20
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							20
/mz/	I	0	0	0	0	0	0
	A	0	0	0	0	0	0
	F	1	7	8	1	3	20
							20
/dr/	I	0	2	3	7	6	18
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							18
/sk/	I	0	2	7	5	2	16
	A	0	0	1	0	0	1
	F	0	0	0	0	0	0
							17
/rd/	I	0	0	0	0	0	0
	A	1	0	0	0	0	1
	F	2	2	3	3	6	16
							17
/lz/	I	0	0	0	0	0	0
	A	0	0	0	0	0	0
	F	3	3	4	1	5	16
							16
/pr/	I	0	0	3	4	8	15
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							15

/bl/	I	2	2	5	3	3	15
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							15
/str/	I	1	0	3	3	7	14
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							14
/θr/	I	3	0	2	5	4	14
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							14
/dz/	I	0	0	0	0	0	0
	A	0	0	0	0	0	0
	F	3	2	0	2	6	13
							13
/rt/	I	0	0	0	0	0	0
	A	1	2	0	1	2	6
	F	0	0	2	1	4	7
							13
/rs/	I	0	0	0	0	0	0
	A	1	1	1	0	1	4
	F	2	3	1	1	2	9
							13
/kr/	I	0	0	4	4	2	10
	A	0	0	4	4	0	8
	F	0	0	0	0	0	0
							18

/kl/	I	2	1	1	1	5	10
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							10
/pt/	I	0	0	0	0	0	0
	A	0	0	0	0	0	0
	F	0	1	4	2	2	9
							9
/nts/	A	0	0	0	0	0	0
	A	0	1	0	0	0	1
	F	0	0	3	3	2	8
							9
/fl/	I	0	0	1	1	7	9
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							9
/zd/	I	0	0	0	0	0	0
	A	0	0	0	0	2	2
	F	1	0	1	2	3	7
							9
/sp/	I	0	1	2	3	2	8
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							8
/kt/	I	0	0	0	0	0	0
	A	1	0	0	1	0	2
	F	0	0	2	1	1	4
							6

/sw/	I	1	0	0	2	1	4
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							4
/sl/	I	0	0	1	1	2	4
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							4
/kw/	I	0	1	0	0	2	3
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							3
/gl/	I	0	0	0	2	1	3
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							3
/kst/	I	0	0	0	0	0	0
	A	0	0	0	0	0	0
	F	0	0	0	2	1	3
							3
/rm/	I	0	0	0	0	0	0
	A	0	0	0	0	1	1
	F	0	1	0	1	0	2
							3
/vd/	I	0	0	0	0	0	0
	A	0	0	0	0	0	0
	F	0	0	1	2	0	3
							3

/rk/	I	0	0	0	0	0	0
	A	0	0	0	0	1	1
	F	0	0	1	0	1	2
							3
/rn/	I	0	0	0	0	0	0
	A	0	1	0	0	1	2
	F	0	0	0	0	1	1
							3
/sm/	I	0	0	0	2	0	2
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							2
/tw/	I	0	0	1	0	0	1
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							1
/bj/	I	0	0	0	1	0	1
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							1
/fj/	I	1	0	0	0	0	1
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							1
/rst/	I	0	0	0	0	0	0
	A	0	0	0	0	0	0
	F	0	0	0	0	0	0
							0

APPENDIX J

ADDITIONAL CONSONANT CLUSTERS

Total number of non-target consonant clusters (in addition to those listed in Appendix I-2) for all 16 subjects for all sample sizes. The clusters are listed in decreasing order from most to least in number of occurrences for each position.

ADDITIONAL CONSONANT CLUSTERS

POSITION	mb	mp	ps	gz	ndʒ	ft	lk	ŋz	skr
I	0	0	0	0	0	0	0	0	6
A	11	5	0	0	6	4	0	0	0
F	0	6	10	9	1	2	6	6	0
TOTAL	11	11	10	9	7	6	6	6	6

POSITION	vz	ls	md	ntʃ	ŋg	lt	mpt	ns	sn
I	0	0	0	0	0	0	0	0	3
A	0	2	0	1	4	2	0	2	0
F	5	2	4	3	0	1	3	1	0
TOTAL	5	4	4	4	4	3	3	3	3

POSITION	lp	lf	mps	rθ	rts	rʃ	spr	fθ	ksθ
I	0	0	0	0	0	0	2	0	0
A	1	0	0	0	0	0	0	0	0
F	1	2	2	2	2	2	0	1	1
TOTAL	2	2	2	2	2	2	2	1	1

POSITION	kj	lv	ldz	ltz	lm	lsk	lps	nj	nʃ
I	1	0	0	0	0	0	0	1	0
A	0	1	0	0	1	1	0	0	1
F	0	0	1	1	0	0	1	0	0
TOTAL	1	1	1	1	1	1	1	1	1

	ŋks	rks	rl	rdʒ	rnt	rtʃ	skw	ʃt	
I	0	0	0	0	0	0	1	0	
A	0	0	1	1	0	0	0	0	
F	1	1	0	0	1	1	0	1	
TOTAL	1	1	1	1	1	1	1	1	