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Abstract

Three auditory perceptual processes (resistance to distortion, selective listening in the form of auditory dedifferentiation, and binaural synthesis) were evaluated by five assessment techniques: (1) low pass filtered speech, (2) accelerated speech, (3) competing messages, (4) accelerated plus competing messages, and (5) binaural synthesis. Subjects were 287 kindergarten students who were divided into speech-delayed and normal speaking subsamples. Twenty-five stimulus sentences for each of the five tests were taped under carefully controlled conditions and presented on a 1 to 1 basis in a sound-treated room. The children responded to spoken sentences by pointing to one of three pictures intended to represent the word which completed the sentences. A longitudinal analysis was made of the relationship between performance on these central auditory ability measures and first- and second-grade academic achievement, IQ, phonic ability, family socioeconomic status, and spontaneous speech improvement. The Gates Primary Reading Tests, the Stanford Achievement Test (Primary I and II), the Peabody Picture Vocabulary Test, and the Templin-Darley Screening and Diagnostic Tests of Articulation were among the testing measures used. All 132 correlation coefficients obtained for academic achievement were statistically significant. Many other significant correlations were found. Tables and references are included. (CM)

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Relations Among Central Auditory Abilities, Socio-Economic Factors, Speech Delay, Phonic Abilities and Reading Achievement: A Longitudinal Study

Cooperative Research Project No. 6-8313

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and

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I. STATEMENT OF THE PROBLEM

In a recent journal article MacGinitie (1967) emphasized the importance of auditory perception in the reading process. He described some subtle factors involved in the auditory perceptual process which could affect a child's early attempts at learning to read, and he concluded that "auditory perception is one of the many factors in beginning reading that has as yet received too little programatic, detailed study by educational researchers and too little systematic consideration from teachers."

MacGinitie's efforts to bring into focus the very important role of auditory perception in the reading process are laudable, especially in view of the paucity of scientific educational research relating to auditory perception available to him. But as other educators before him who have attempted to describe the relationship between auditory perception and reading, MacGinitie's efforts fall short of presenting the total picture of the auditory perceptual process as an audiological neurophysiological entity, and how it relates to the neurophysiological process of reading.

Perhaps one reason why reading specialists have failed to come up with an adequate understanding of the auditory perceptual process involved in reading and other areas of learning is that too much emphasis has been placed on such isolated perceptual abilities as e.g., "auditory discrimination," "auditory blending," etc. and too little emphasis given to such important auditory perceptual factors e.g., "selective listening," "resistance to distortion," "auditory dedifferentiation," "binaural synthesis," "auditory vigilance," "memory," etc. Additionally, far too many educators purport to assess auditory perceptual abilities in children without the least consideration being given to such basic auditory processes e.g., peripheral hearing ability, (auditory acuity) and the intensity of the message being presented to the subject.

Moreover, MacGinitie emphasizes one very important aspect completely overlooked by educators who have assigned a minor role to auditory perception as it relates to the reading process. MacGinitie indicates that "an important possibility is that difficulties in auditory perception that contribute to reading problems may be largely left behind by the time the reading problems are studied."

The problem therefore, as it applies to the relationship of auditory perception to the reading process is twofold: (1) the assessment techniques of auditory perceptual skills must be concerned with sophisticated audiological-neurophysiological methodology based on research which has demonstrated the efficacy of these procedures with normal and pathological subjects: and (2) assessment of auditory perceptual skills must be completed with children at a very early age in their perceptual development and related to future achievement data over a period of time.

In view of the foregoing discussion, the overall purpose of the present study effort was to search for relationships between Central Auditory Abilities* of kindergarten children and later (first and second

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* The term "Central Auditory Abilities" (here designated "CAA" refers to auditory perceptual factors on the central nervous system level as opposed to peripheral hearing functions, e.g., auditory acuity. In essence, central hearing may be described as the brain's ability to interpret meaningful messages under a variety of difficult listening conditions, such as are normally encountered by the human listener.

grade) academic achievement (focusing on reading), and other factors presumed to be critically related to the learning process, e.g.,speech-articulation proficiency, phonic abilities in kindergarten, and socio-economic level of the child's family.

II. OBJECTIVES AND HYPOTHESES

In view of the stated overall purpose of the study, specific objectives are proffered in relation to research hypotheses as follows:

Objective A: to determine if speech-language delayed first-semester kindergarten children differ in central hearing ability when compared to their normal speaking peers.

Hypothesis A: Will differences exist between the means of the delayed speech group and the normal speaking group for the five measures of central auditory abilities?;

Objective B: to determine if socio-economic status of the family affects the development of CAA in kindergarten children;

Hypothesis B: Will relationships be found between five CAA measures and socio-economic standing of the family for the total sample of kindergarten children?;

Objective C: to determine if socio-economic status of the family affects the development of CAA of speech-delayed children;

Hypothesis C: Will relationships be found between five CAA measures and socio-economic standing of the families of speech-delayed children?;

Objective D: to determine if phonic abilities of second-semester kindergarten children are related to CAA development of the same children as evaluated during the first semester in kindergarten;

Hypothesis D: Will relationships exist among five CAA measures and five measures of phonic abilities for a sub-sample of kindergarten children?;

Objective E: to determine the predictive value of CAA measures obtained in kindergarten with respect to spontaneous speech improvement over a period of ten months for a sub-sample of speech-delayed kindergarten children;

Hypothesis E: Will relationships be found between the speech severity spontaneous-improvement index and the five CAA kindergarten measures for the speech-delayed sub-sample:;

Objective F: to determine the predictive value of the CAA measures (obtained for the primary sample in kindergarten) with respect to academic achievement scores of the same subjects to be obtained during the latter part of first grade and second-semester second grade;

Hypothesis F: Will relationships be found between the CAA kindergarten measures and first and second-grade achievement scores for the remainder of the original sample of 287 children?

III. RELATED RESEARCH

With respect to independent variables utilized in the present study effort, consideration was given to three important auditory perceptual processes (central hearing functions): (a) the factor of Resistance to Distortion (two forms: internal and external distortion); (b) the Process of Selective Listening (in the form of Auditory Dedifferentiation); and (c) Binaural Synthesis. These three central hearing processes were evaluated by five separate yet highly interrelated assessment techniques:

(1) Low Pass Filtered Speech (LPFS) - a form of resistance to internal distortion;

(2) Accelerated Speech (AS) - resistance to external distortion in the form of compressed speech;

(3) Competing Messages (CM) - auditory dedifferentiation as a factor in selective listening;

(4) Accelerated plus Competing Messages (AS + CM) - dual distortion in the form of resistance to external distortion and auditory dedifferentiation;

(5) Binaural Synthesis (BS) - a factor of binaural integration, fusion, and/or synthesis.

Each CAA technique will be defined as an individual auditory perceptual ability and will be discussed in relation to earlier related research and/or precedent.

Low Pass Filtered Speech -(LPFS)

LPFS is an auditory perceptual factor of resistance to internal distortion. The resistance to distortion factor in auditory perception is defined as the auditory mechanism's ability to function efficiently under conditions of distortion, either within the system itself and/or under conditions of external distortion. In the case of internal distortion there is an apparent short-circuiting within the internal central mechanism of hearing. This short circuiting may render the listener incapable of perceiving important perceptual clues, e.g. high frequency sounds.

French and Steinberg (1947) demonstrated that in high pass filtering at 1000 Hz. an articulation score of 90% was obtained (for nonsense syllables), whereas a low pass filter at the same cut-off level allowed for an articulation score of only 27%. Hirsh, Reynolds and Joseph (1954) also indicated that eliminating all frequencies by filtering below 1600 Hz. does not impair the intelligibility for words seriously. Finally, Miller and Nicely (1955) concluded that audibility is the problem for high pass systems, and confusibility being the predominant difficulty in low pass filtering.

Further use of the distorted speech signal in conjunction with the binaural summation principle has provided the field with a sensitive diagnostic procedure in the investigation of central nervous system pathology, and possibly in the assessment of central auditory-sound discrimination abilities. Bocca, Calearo, Cassinari, and Migliavacca (1955) tested patients with supratentorial cerebral tumors by utilizing a low pass filter system at about 1000 Hz. Their findings stressed that in nearly all cases observed, the articulation score for distorted speech in each ear separately was asymmetric. The scores were significantly lower in the ear contralateral to the lesion. Bocca (1955) in a separate study with normal hearing subjects, developed a procedure utilizing filtered and sub-threshold auditory stimuli to test what he termed "binaural summation". Bocca, and subsequently Calearo (1957) in a follow-up study testing subjects with lesions of the temporal lobe, provided evidence that summation ability was absent in cases where there was impairment of the cortical auditory area. Both authors concluded that their tests could be useful as instruments in the evaluation of the efficiency of the central mechanism of hearing. Flowers and Costello (1963) successfully adapted the filtered speech and binaural summation principle in a study which evaluated the central mechanism of hearing of speech delayed children in first grade. Flowers (1964, 1965), employed the LPFS technique with kindergarten and third grade school children in an effort to establish relationships between central auditory abilities, and reading achievement.

Accelerated Speech (AS)

AS is an auditory perceptual factor of resistance to distortion. A speech message may encounter external distortion in the form of poor articulation or by being accelerated abnormally by the speaker. Another approach to distorting speech is by compressing it for an effect of acceleration without altering the frequency spectrum. Fairbanks, Everitt and Jaeger (1954) were among the first to experiment with recorded compressed speech material in an effort to present the signal in less than the normal original time without altering other dimensions of the original signal. Fairbanks, Gutman and Miron (1957) presented two technical messages at various percentages of compression of the original message, and discovered that factual comprehension is significantly affected by: 1) time compression; 2) listener aptitude; and 3) message effectiveness.

Accelerated speech has been utilized in pathological conditions by Calearo and Lazzaroni (1957) who maintained that accelerated speech involved a strain on the patient's superior auditory centers thus making normal discrimination possible only when these higher auditory mechanisms were completely unimpaired. The authors further suggested that accelerated speech could become a useful approach for the evaluation of the "superior auditory function". Harris, Haines and Myers (1960) tested adult males with high frequency hearing losses and normal hearing men. A test designed to "speed-up" words as a temporal distortion simulating everyday conditions encountered by the normal hearing and hearing-defective person was utilized. The authors concluded that "a normal or near normal audiogram at 3 KC is essential for high sentence intelligibility if stress is put upon the speech signal through a speed-up". Foulke, Amster, Nolan and Bixler (1962) used a method of speech compression to accelerate the speech signal without appreciably altering the basic characteristics of the message. The authors employed this technique in an attempt to assess the listening comprehension of accelerated speech by blind students. Costello and Flowers (1964) utilized a method of accelerated speech in a study of children manifesting severe speech-language delay. Their results indicated some difficulties in the perception of rapid speech by the speech-defective children as compared with their normal speaking peers. Flowers (1964) employed the AS technique with normal and lower group third-grade reading children. Results indicated the procedure was sensitive in differentiating the two groups with respect to this particular aspect of central hearing Competing Messages (CM).

CM is an auditory perceptual factor of auditory dedifferentiation. This concept may be defined as the ability to differentiate a significant foreground stimulus from an insignificant background stimulus. Educators and clinical psychologists may refer to this function as "figure-ground" perception, whereas experimental psychologists may consider this to be selective listening. Traditionally, phonetically-balanced words or pure tones are utilized as the significant stimulus, with a white noise background. The present investigators were interested in a situation which would more readily simulate everyday auditory environmental conditions a child is likely to encounter. For this purpose, competing messages were presented.

The task of listening to two messages or two separate word stimuli at once has been investigated and workers generally agree that an increase in the amount of information presented causes a relative decline in efficiency. Cherry (1953) demonstrated that a listener can, after repeated presentations, separate out two different speech passages, recorded by the same voice on the same tape. Peters (1954) has shown that unwanted speech which is similar in content to the wanted message produces greater difficulty than does a dissimilar background. Broadbent (1954) presented pairs of messages simultaneously, requiring an answer to only one of the messages. The investigator found that spatial separation of loud speakers was of help to listeners as was stereophonic separation. Poulton (1956) found a drop in relative efficiency when two relevant messages arrived simultaneously, as compared with isolated messages or with the simultaneous arrival of relevant and irrelevant messages.

In pathological conditions, Carhart, Pollock and Lotterman (1963) tested the efficiencies of four groups of 12 subjects each, when listening to PB material presented against competing sentences, and reproduced binaurally through matched hearing aids. The groups consisted of normal hearers, patients with conductive losses, and two groups manifesting sensory-neural hearing defects. The results indicated that performance for all groups was reduced in a monaural indirect condition, and this reduction increased sharply as the intensity ratio between the primary and competing message was made more unfavorable. Flowers (1964) discovered that the CM technique was a sensitive measure by which normal and low-reading groups could be differentiated with respect to the factor of auditory dedifferentiation. He also found that the CM procedure was significantly related to reading achievement in third grade while remaining independent of IQ.

Accelerated Speech and Competing Messages (AS + CM)

The AS + CM condition is a combination of resistance to distortion and selective listening. It was felt by the investigators that an often-encountered classroom-listening situation is that of a child struggling to listen to an overzealous kindergarten teacher who enthusiastically but unwittingly accelerates her rate of speech while competing with a continuous background of noise (an irrelevant message in the form of children's random conversation). The rationale for the AS + CM condition is the same as that presented for conditions AS and CM.

Binaural Synthesis (BS)

BS is a factor of binaural integration. It can be defined as the brain's ability to synthesize or fuse a single speech message which is split into two separate frequency components. Matzker (1959) was the first experimenter to employ the binaural synthesis technique while utilizing narrow band pass filtering in an attempt to localize CNS pathology. The investigator was successful in employing a low band pass filter at 500-800 Hz. combined with a high band pass filter at 1500-2400 Hz. Subsequently, Menzel (1961) found that much less frequency information may be used for a more sensitive test. He employed a low band pass filter at 450-540 Hz. in combination with a high band pass filter at 2400-2800 Hz. Both investigators felt that the BS technique was a discrete methodology by which one portion of central hearing may be measured.

IV. PROCEDURE

A. Subjects

Subjects for the study were 287 randomly-selected first-semester kindergarten boys and girls selected from a pool of 550 kindergarten children attending school at the Grand Blanc Community Schools, Grand Blanc, Michigan. Although a random selection method was employed, subjects' characteristics were specified in accordance with the following criteria: (1) they were within an IQ range of 85-130; (2) they were required to pass a pure tone audiometric examination which indicated normal peripheral hearing bilaterally (testing 250, 500, 1000, 2000, 3000, and 4000 Hz.); (3) they were considered to be free of any observable gross organic and/or structural impairments (e.g.: cerebral palsey, cleft palate, etc.), and (4) they were considered as being free of history indicating emotional involvements of any kind, (e.g. schizophrenia, etc.)

Sub-samples for purposes of testing various associated research hypotheses were also selected at random from the primary sample of 287 subjects. In accordance with the various hypotheses to be tested, the sub-samples selected were as follows:

Objective A: the primary sample of 287 children was divided into an experimental (speech delayed) and control (normal speaking) group;

Objective B: the primary sample of 287 children was utilized in this portion of the study;

Objective C: the sub-sample of children diagnosed as the speech-delayed group (N = 133) was used for this portion of the study;

Objective D: a randomly-selected sub-sample of 120 children was selected from the primary sample for the phonic abilities portion of the study;

Objective E: the speech-delayed sub-sample (N = 133) was utilized;

Objective F: the total remaining primary samples of 235 (grade one) and 212 (grade two) children were utilized.

B. Apparatus

The experimental conditions were prepared with utmost care and control. All stimulus (test) sentences were recorded on a dual-channel tape-recorder, passed through various frequency filter systems and audiometers, and were recorded in a sound-treated, sound-proof audiologically-specified room. The experimental conditions were presented to subjects in a one-to-one relationship, on two separate days (approximately two weeks apart), in random order. The experimental conditions were presented in the central office of the Grand Blanc Community School District, in a specially adapted sound-treated room. The conditions were presented to subjects via ear-phones or via sound field as specified by individual experimental conditions. In each listening situation, the children responded to spoken sentences by pointing to one of three pictures intended to represent the word which completed the test sentences.

C. Method and Instrumentation

Condition I - Low Pass Filtered Speech (LPFS): 25 sentences were filtered at 1200 Hz. low pass and presented binaurally via ear-phones (same signal to both ears) at + 45 decibels, re: audiometric zero; subjects were instructed to listen to each sentence and to complete the sentence by pointing to one of three pictures which represented the required answer;

Condition II, Accelerated Speech (AS): 25 sentences were presented binaurally via earphones at an acceleration rate of 280 words per minute, (as per Foulke et al 1962) and at an intensity level of + 45 decibels, re: audiometric zero; the required response was the same as in condition I;

Condition III - Competing Messages (CM): 25 sentences were presented via sound field through the medium of air without earphones, while simultaneously a competing message was presented via sound field emanating from another speaker. Technically, the procedure was as follows: the sentences were recorded on tape by an adult female talker (relevant message) to be presented via speaker I as the primary auditory stimulus. A children's story was recorded on track II of the same tape by the same adult female talker; to be presented via speaker II, as the competing and/or unwanted background auditory stimulus. Both messages were presented at an intensity level of + 60 decibels, re: audiometric zero, to insure a comfortable listening intensity level. In this situation, the subject was expected to differentiate the relevant message emanating from speaker I from the unwanted message coming from speaker II. The messages were presented by matched loudspeakers located at 45 degree angles on opposite sides of the listening position; the required response was the same as specified in Condition I;

Condition IV - Accelerated Speech and Competing Messages (AS + CM): 25

sentences accelerated to 280 wpm (non-mechanical acceleration-no compression)were presented as the primary relevant message via speaker I, while the same children's story, (employed in condition III) was presented as the competing message via speaker II. Both messages were presented at the same steady state intensity level of +60 db re: audiometric zero; the required response was the same as in condition I; Condition V - Binaural Synthesis (BS): 25 sentences were presented via earphones in a stereophonic type listening situation. One portion of the frequency spectrum of the message was presented in one ear while the other portion of the frequency spectrum of the same message was simultaneously presented to the other ear. The left ear received the high frequency narrow band pass message containing frequencies from 2400 to 2880 Hz., while the right ear received the lower band pass frequencies ranging from 420 to 540 Hz. Normally, both high and low portions of the spectrum presented simultaneously fuse to provide enough information to allow for normal or near normal intelligibility of the message. The required responses were the same as specified in condition I.

Complete lists of test sentences for experimental conditions I - V may be found in Appendix A.

V. RESULTS

Relationships Among Kindergarten Central Auditory Abilities and First and Second Grade Academic Achievement: The Longitudinal Analyses

Objective (f) was to determine the predictive value of the CAA measures (obtained for the primary sample in kindergarten) with respect to reading achievement scores of the same subjects in first and second grade. Additionally, analyses involving other areas of academic achievement and learning skills (eg: social science, language factors, word study skills, etc.) were included.

The primary sample of 287 subjects was selected at random from a pool of approximately 550 first semester kindergarten children. At that time, the complete battery of five CAA measures was administered to the children. The data obtained during the kindergarten testing was retained for purposes of conducting longitudinal analyses with regard to achievement data to be collected at the end of first and second grade (during the months of May and June). The primary sample of N = 287 had dwindled to N = 235 for the first grade sample and N = 212 for the second grade sample.

Table 1 indicates sample Ns and attrition percentages over the three-year period of the study.

Table 1

Sample Size and Attrition Rate For Kindergarten, First and Second Grade Achievement Analyses

Grade and Year of Study	N	Percentage of N Loss Relative To First Year. (Initial Primary Sample
Kindergarten (First Year)	287	-
First Grade (Second Year)	235	17 %
Second Grade (Third Year)	212	25 %

Intercorrelations were obtained between total and individual CAA kindergarten scores and various first and second grade academic achievement scores. Following is a breakdown of individual achievement areas utilized in the longitudinal analyses for each grade level, indicating sub-tests used for each achievement test employed in the study:

Grade One

1. Reading Battery: Gates Primary Reading Test

   (a) Word Recognition

(b) Sentence Reading

(c) Paragraph Reading

2. Achievement Battery: Stanford Achievement Test (Primary I Battery)

(a) Word Reading

(b) Paragraph Meaning

(c) Vocabulary

(d) Spelling

(o) Word Study Skills

(f) Arithmetic

Grade Two

1. Reading Battery: Gates Advanced Primary Reading Tests

(a) Word Recognition

(b) Paragraph Reading

2. Achievement Battery: Stanford Achievement Test (Primary II Battery)

(a) Word Meaning

(b) Paragraph Meaning

(c) Science and Social Studies Concepts

(d) Spelling

(e) Word Study Skills

(f) Language

(g) Arithmetic Computation

(h) Arithmetic Concepts

For purposes of presenting the results in a more comprehensible form, correlation coefficientsfor grades one and two will be presented in five major achievement area categories:

Category I: Reading (including all Gates and Stanford Reading sub-test areas).

Category II: Overall Achievement (including the sum of all Stanford Achievement sub-tests).

Category III: Language (including Stanford Primary I Vocabulary, Spelling and Word Study Skills; and Primary II Spelling, Language and Word Study Skills).

Category IV: Science-Social Studies

Category V: Arithmetic (including Stanford Primary II Arithmetic Computation and Concepts).

Category I, Reading Achievement: Longitudinal Results

Table 2 lists correlation coefficients obtained between kindergarten CAA totals (scores of five CAA scores combined) and first and second grade Gates Reading Test and Stanford Achievement reading sub-test scores. The kindergarten-first grade analyses covered a time span of approximately eighteen months while the kindergarten-second grade correlations represent a longitudinal period of approximately thirty months. (two and one-half years.)

Table 2

Correlations Between Kindergarten Central Auditory Abilities Totals and First and Second Grade Reading Achievement Scores (First Grade N = 235; Second Grade N = 212)

Kdg. CAA Totals (five sub-tests combined)	1st Gr. Reading Test (N = 235)	r	2nd Gr. Reading Test (N = 212)	r
CAA Totals and	Gates Totals	.67	Gates Totals	.66
" " "	Gates Word Recognition	.64	Gates Word Recognition	.63
" " "	Gates Paragraph Reading	.64	Gates Paragraph Reading	.64
" " "	Gates Sentence Reading	.61		
" " "	Stanford Word Meaning	.50	Stanford Word Meaning	.59
" " "	Stanford Paragraph Meaning	.46	Stanford Paragraph Meaning	.63

(Note: All rs were significant beyond the .01 level of confidence)

A cursory examination of Table 2 will reveal that all correlations obtained were statistically significant beyond the .01 level of confidence. Furthermore, the first and second grade Gates rs did not differ much from one year to the next. On the other hand, the Stanford reading sub-test rs showed a marked increase from grade one to grade two.

Table 3 depicts correlations between individual CAA measures and first and second grade Gates Totals scores. Correlations between individual CAA and various Gates and Stanford reading sub-tests for grades one and two may be found in Appendix B 1.

Table 3

Correlations Between Individual Kindergarten Central Auditory Abilities and First and Second Grade Gates Totals
(First Grade N = 235; Second Grade N = 212)

Kdg. CAA Measure	1st Gr. Gates Totals	r	2nd Gr. Gates Totals	r
AS and	Gates Totals	.64	Gates Totals	.61
CM "	" "	.60	" "	.60
AS + CM and	" "	.53	" "	.56
BS and	" "	.55	" "	.50
LPFS and	" "	.50	" "	.51

(Note: all reported rs were significant beyond the .01 level of confidence)

Correlation coefficients in Table 3 indicate a similar strong correlational trend as was found between kindergarten CAA totals and various first and second grade achievement test results. All rs were significant beyond the .01 level. There was little difference to be found between first and second grade rs among individual CAA measures. The AS and CM measures appeared to consistently yield the highest rs.

With respect to relationships between individual kindergarten CAA measures and various first and second grade reading sub-tests, most correlations were found to be in the upper .40 and .50 levels (see Appendix B 1). Again, small differences were to be found between first and second grade rs for individual measures, with the exception of a marked increase in correlation values from first to second grade for both Stanford reading sub-tests. These marked increases appeared consistently for all individual CAA results. All reading sub-test rs were significant beyond the .01 level of confidence.

Category II, Overall Achievement: Longitudinal Results

Overall or total achievement was measured by combining all Stanford Achievement sub-test scores. Table 4 illustrates correlations obtained between various kindergarten CAA measures and first and second grade Stanford Achievement Test Totals.

Table 4

Correlations Between Various Kindergarten CAA Measures and First and Second Grade Stanford Achievement Test Totals (First Grade N = 235; Second Grade N = 212)

Kdg. CAA Measures		1st Gr. Stanford Achv. Totals		r	2nd Gr. Stanford Achv. Totals		r
CAA Totals	and	Stanford	Totals	.61	Stanford	Totals	.63
AS "	"	"	"	.60	"	"	.57
CM "	"	"	"	.57	"	"	.58
AS + CM	"	"	"	.52	"	"	.52
BS Totals	"	"	"	.51	"	"	.51
LPFS "	"	"	"	.50	"	"	.51

(Note: all reported rs were significant beyond the .01 level of confidence)

The correlational trends of little change in r values from first to second grade continue to be manifested in the present analysis where total achievement scores are concerned. Most individual CAA measures obtained relatively equal rs in the fifties (all significant beyond the .01 level). As in the previous analyses, the CAA Totals measure led all other individual CAA results with rs of .61 and .63 for grades one and two respectively.

Category III: Language

Assessment of language abilities as they related to the study effort involved the utilization of Stanford Achievement sub-tests Vocabulary (Primary I, first grade), Language (Primary II, second grade), and the Spelling and Word Study Skills sub-tests of the Primary I and II batteries. Table 5 lists correlations between kindergarten CAA totals and first and second grade language sub-test results. Complete intercorrelations between individual CAA measures and language sub-tests are represented in Appendix A 2.

Table 5

Correlations Between Kindergarten CAA Totals and First and Second Grade Language Achievement Results (First Grade N = 235; Second Grade N = 212)

Kdg. CAA Measure	1st Gr. Stanford Language Factor	r	2nd Gr. Stanford Language Factor	r
CAA Totals and	Spelling	.44	Spelling	.45
" " "			Language	.48
" " "	Vocabulary	.51		
" " "	Word Study Skills	.47	Word Study Skills	.48

(Note: all reported rs were significant beyond the .01 level of confidence)

Category IV: Science-Social Studies

Table 6 depicts correlation coefficients between kindergarten CAA measures and second grade science-social studies achievement only. The Stanford test does not include science nor social studies in its first grade Primary I Battery.

Table 6

Correlations Between Kindergarten Central Auditory Abilities and Second Grade Science-Social Studies Achievement (N = 212)

Kdg. CAA Measure	2nd Gr. Stanford Science-Social Studies	r
CAA Totals		.45
LPFS		.42
AS		.40
BS		.40
AS + CM		.36
CM		.35

(Note: all reported rs were significant beyond the .01 level of confidence)

Category V: Arithmetic

The achievement area of arithmetic was assessed by utilizing three sub-tests of the Stanford Test. In first grade, only one arithmetic sub-test was available while the Primary II battery (second grade) provided a more definitive assessment in the form of Arithmetic Computation and Arithmetic Concepts sub-tests. Table 7 shows correlations between kindergarten CAA scores and first and second-grade arithmetic achievement sub-test scores.

Table 7

Correlations Between Kindergarten Central Auditory Abilities and First and Second Grade Arithmetic Achievement (First Grade N = 235; Second Grade N - 212)

Kdg. CAA Measure		1st Gr. Arithmetic Measure	r	2nd Gr. Arithmetic Measure	r
CAA Totals	and	Arithmetic	.51	Computation	.54
CAA Totals	"			Concepts	.54
CM	"	Arithmetic	.45	Computation	.56
CM	"			Concepts	.51
AS + CM	"	Arithmetic	.50	Computation	.47
AS + CM	"			Concepts	.46
AS	"	Arithmetic	.38	Computation	.46
AS	"			Concepts	.44
BS	"	Arithmetic	.44	Computation	.39
BS	"			Concepts	.43
LPFS	"	Arithmetic	.40	Computation	.39
LPFS	"			Concepts	.40

(Note: all reported rs were significant beyond the .01 level of confidence)

Although the longitudinal findings have yielded unusually strong correlations between kindergarten CAA measures and first and second grade achievement, the question can be raised as to how much influence was exerted on the CAA results by the all-important factor of I.Q. Any measure containing pictorial and verbal materials involves receptive language function and hence verbal I.Q. must be given careful consideration. It is expected that a certain amount of common variance will be found between kindergarten CAA scores and I.Q. at the time the CAA tests were administered. Table 8 represents correlations between CAA and I.Q. scores as measured during first semester kindergarten for each primary sample (kindergarten, first and second grade). I.Q. was obtained by administering the Peabody Picture Vocabulary Test (PPVT, per Dunn).

Table 8

Correlations Between Central Auditory Abilities and I.Q. for Kindergarten, First and Second Grade Samples

Kdg. CAA Measure	Kdg. I.Q. r (N=287)	1st Gr. I.Q. r (N=235)	2nd Gr. I.Q. r (N=212)
CAA Totals	.19 *	.26 *	.20 *
FS	.19 *	.25 *	.19 *
AS	.13 ‡	.19 *	.13 ‡
CM	.19 *	.23 *	.19 *
AS + CM	.17 ‡	.21 *	.17 ‡
BS	.19 *	.22 *	.21 *

(* significant at .01 level; ‡ significant at .05 level)

As could be expected, most rs were found to be statistically significant at the .01 or .05 levels. However, the majority of CAA-I.Q. rs were in the .13 - .26 range; indicating that the common variance shared between CAA-I.Q. was far below the level shared between kindergarten CAA and first and second grade achievement scores. No statistically significant correlations were obtained between kindergarten I.Q. scores and all areas of first and second grade achievement.

With respect to reliability of the CAA kindergarten measures, reliability coefficients were obtained for individual CAA measures by employing the "split-halves" correlation method (coefficient of internal consistency). Reliability coefficients obtained for each individual kindergarten CAA measure were as follows (N = 287):

FS, r = .90

CM, r = .88

AS + CM, r = .87

AS, r = .85

BS, r = .84

Relationships Among Phonic Abilities and Central Auditory Abilities

Objective (d) was to determine if central auditory abilities of first semester kindergarten children were related to phonic abilities in these same children as measured during the second half of kindergarten (approximately seven months later).

Five measures of phonic abilities were administered in a one-to-one relationship to a sub-sample of 101 kindergarten children. Sub-sample subjects were selected at random from the primary sample of 287 children. The five phonic abilities measured were:

(1) Naming capital letters

(2) Naming lower case letters

(3) Identifying capital letters named

(4) Identifying lower case letters named

(5) Sounds capital letters make

Multiple correlation coefficients were obtained between CAA and phonic abilities measures. A complete breakdown of individual correlations may be found in Appendix B 3.

With an N of 101 (df: N-2), an r of approximately .195 need be obtained to reach statistical significance at the .05 level of confidence, and .254 for the .01 level. Of 30 correlation coefficients obtained in the present analysis (between various CAA and phonic abilities measures) 24 rs were significant at the .01 level, while of the remaining six rs, five were significant at the .05 level of confidence. Only one out of 30 coefficients failed to reach statistical significance at either the .05 or .01 levels of confidence.

The most consistently highest rs were obtained between a given measure of phonic abilities and (a) CAA totals; and (b) competing messages (CM). Highest CAA and phonic abilities rs were as follows:

CAA totals and Phonic Abilities Totals:	.46
Competing messages and Phonic Abilities Totals:	.44
CAA totals and Identifying Lower Case Letters Named:	.51
Competing Messages and Identifying Lower Case Letters Named:	.47
CAA totals and Identifying Capital Letters Named:	.48
Competing Messages and Identifying Capital Letters Named:	.44
CAA totals and Sounds Capital Letters Make	.51
Filtered Speech and Sounds Capital Letters Make	.50
Accelerated Speech and Sounds Capital Letters Make	.50
Competing Messages and Sounds Capital Letters Make	.47

It is readily apparent that the strongest relationships between various phonic abilities and central auditory abilities were found among phonic skills requiring the identification of a spoken verbal message (excluding the "phonic abilities totals" rs). The individual phonic ability most consistently obtaining the highest r with various CAA scores was the "Sounds Capital Letters Make" classification.

<u>Relationships Between Socio-Economic Standing Of The Family And Central Auditory Abilities Of Speech Delayed Children.</u>

Objective (c) was to determine if socio-economic status of the family effects the development of central auditory abilities in speech-delayed kindergarten children.

Socio-economic status of families within the delayed-speech classification (children with articulation problems were considered as being delayed in their speech development) was determined by obtaining the father's job classification from school files and then assigning a numerical index as presented by Hatt and North (1947 - "Jobs and Occupations: A Popular Evaluation"). Speech defect severity was assessed by administering the Templin-Darley Screening and Diagnostic Tests of Articulation (1960) on an individual basis by a qualified speech therapist.

Correlations were obtained between the jobs and occupations index of the father and CAA scores. The speech delayed sub-sample consisted of 110 subjects (of the total primary sample of 287 children). With an N of 110 (df: N-2), it was necessary to obtain an r of approximately .18 to reach a significance level of .05, and an r of approximately .24 for the .01 level.

Table 9

Correlations Between Socio-Economic Status and Central Auditory Abilities for the Delayed Speech Sub-Sample (N=110)

Socio-Economic Status of Family and CAA totals		.22 ‡
	Low Pass Filtered Speech	.11
	Accelerated Speech	.28 *
	Competing Messages	.20 ‡
	Accelerated Speech + CM	.19 ‡
	Binaural Synthesis	.20 ‡

(* : r is significant at .01 level; ‡ : r is significant at .05 level)

As can be seen in Table 9, five of the six correlations obtained reached statistical significance at the .05 or .01 levels of confidence.

Comparatively speaking, the rs were considerably lower than those obtained between various CAA measures and learning factors on a longitudinal basis (including achievement test scores and phonic abilities scores over a period of time). The findings do however, indicate that significant relationships existed between socio-economic status of the family and central auditory abilities in speech delayed children.

Another correlation coefficient of importance was obtained between family socio-economic status and speech-articulation proficiency at the beginning of kindergarten. An r of .06 was obtained, indicating that no significant influence was exerted on speech development by socio-economic status of the families of speech delayed children.

Relationships Between Socio-Economic Standing Of The Family And Central Auditory Abilities Of First Semester Kindergarten Children

Objective (b) was to determine if socio-economic status of the family affects the development of central auditory abilities of kindergarten children.

Socio-economic status of the family was ascertained in the same manner as was accomplished with the speech delayed sub-sample. (utilizing the Hatt and North method) Correlations were obtained accordingly between the father's occupation index and CAA scores. The total kindergarten sample for this particular analysis consisted of 232 children.

All correlations were significant at the .01 level of confidence for all CAA measures, indicating that the development of central auditory abilities in kindergarten children is significantly influenced by the socio-economic standing of the family as assessed by the father's occupation. Table 10 depicts rs for individual CAA measures.

Table 10

Correlations Between Socio-Economic Status and Central Auditory Abilities for the Primary Kindergarten Sample (N = 232)

Socio-Economic Status of the Family and CAA Totals		.29 *
	Low Pass Filtered Speech	.22 *
	Accelerated Speech	.27 *
	Competing Messages	.18 *
	Accelerated Speech + CM	.19 *
	Binaural Synthesis	.27 *

(* significant at .01 level)

Additional correlations worthy of mention at this time are those obtained between socio-economic status of the family and (1) IQ, and (2) receptive vocabulary level as measured by the Peabody Picture Vocabulary Test. An r of .30 was obtained between fathers' occupation index and IQ for the total kindergarten sample (N = 232), while an r of .34 was recorded for the Peabody measure.

The Relationship Between Kindergarten Central Auditory Abilities And Spontaneous Speech Improvement

Objective (e) was to determine the predictive value of central hearing measures (CAA) obtained in kindergarten with respect to spontaneous speech improvement in speech impaired children over a period of ten months.

A sub-sample of 86 speech impaired first semester kindergarten children was obtained from the total primary sample of 287 children. Children were classified as manifesting speech defects when one or more phonemes were either distorted, omitted and/or substituted. Articulatory errors were judged by the project director who at the time of the speech and hearing assessment, held advanced clinical certification in Speech Pathology with the American Speech and Hearing Association. Severity of the articulation defect was determined by use of the Templin-Darley Screening and Diagnostic Tests of Articulation (T-D) 64 item screening device.

Following the assignment of a severity rating based on the T-D test, the pre-test scores were retained for further analyses following a ten month period of time, during which no speech therapeutic techniques were introduced to this group of children. The speech handicapped children participated in a conventional kindergarten school program during the ensuing ten months, thus allowing for the natural development of speech-articulation proficiency. At the end of the ten-month kindergarten period, the sub-sample subjects were re-tested (post-test) on the T-D for purposes of determining the rate of spontaneous improvement in articulation proficiency or what was subsequently labeled "Spontaneous Speech Improvement Index" (SSII). SSII was arrived at by subtracting T-D pre-test scores from T-D post-test scores.

The final statistical procedure for determining the predictive value of central auditory abilities with respect to spontaneous speech improvement in kindergarten children was accomplished by correlating the SSII of each subject with his kindergarten CAA scores. A visual inspection of Table 11 indicates that the SSII correlated negatively with all CAA measures, and that none of the negative rs reached statistical significance. It was concluded that CAA measures obtained on the kindergarten level are not predictive in nature when considering spontaneous speech improvement.

Table 11

Correlations Between Spontaneous Speech Improvement and Kindergarten Central Auditory Abilities (N = 86)

Spontaneous Speech Improvement Index and	CAA Totals	-.15
	Low Pass Filtered Speech	-.16
	Accelerated Speech	-.08
	Competing Messages	-.16
	Accelerated + CM	-.12
	Binaural Synthesis	-.18

(Note: none of the reported rs reached statistical significance)

It might be of interest to note that the SSII correlated negatively with first grade Stanford Achievement totals (r: -.13) and Gates Reading Totals (r: -.07); however, neither of the coefficients reached statistical significance.

Central Auditory Abilities of Speech Delayed Kindergarten Children

Objective (a) was to determine if speech delayed kindergarten children differed in central hearing ability when compared with their normal speaking peers.

Speech-articulation analyses were performed on 281 children at the time they were being tested on the CAA battery during the first semester in kindergarten. Of the total group participating in the speech analyses, 134 children were judged as manifesting some form of articulatory error, and were assigned to the speech defective experimental group. The experimental group was compared on CAA scores with a control group of 149 normal speaking peers.

A simple one-way analysis of variance was conducted on the scores to determine if statistically significant differences existed between the means of the experimental and control groups for CAA Totals scores and individual CAA results. Complete analyses of variance summary tables for individual CAA measures are presented in Appendix C. Means and standard deviations for individual and total CAA measures are presented in Table 12.

Table 12

Means and Standard Deviations of Experimental and Control Groups for Kindergarten Central Auditory Abilities Scores

(Speech Delayed Group N = 134; Normal Speaking Group N = 149)

Kdg. CAA Measure	Speech Delayed Group Mean	Normal Speaking Group Mean	Speech Delayed Standard Deviation	Normal Speaking Standard Deviation
CAA Totals	86.57	96.26	24.93	24.95
FS	15.98	19.07	4.69	3.72
AS	18.60	21.37	5.17	3.09
CM	17.90	20.63	5.99	3.84
AS + CM	16.92	20.23	5.79	3.98
BS	18.06	22.33	4.99	16.15

A study of Appendix C shows that F ratios obtained for each CAA measure were significant beyond the .01 level of confidence (df = 1,281), in favor of the normal speaking group. These analyses indicate that speech delayed kindergarten children are inferior to their normal speaking peers on all measures of central hearing ability. A comparison of mean IQ for both groups also indicated a significant difference between means in favor of the normal speaking children. The F ratio was significant at the .05 level of confidence (see Appendix C 7).

VI. CONCLUSIONS AND IMPLICATIONS

Perhaps the most significant findings emerging from the present study effort are those related to the longitudinal analyses which involved the relationship of kindergarten Central Auditory Abilities and first and second grade school achievement. Teachers and administrators have long suspected that auditory perceptual skills such as phonics were intimately related to at least one area of achievement, reading, but not much consideration had been given to the role of hearing and listening when evaluating learning abilities in other achievement areas. Findings of the present longitudinal analyses strongly indicate that auditory perceptual abilities occupy a major role in the child's early attempts at learning in all categories of school achievement. Furthermore, the strong correlation coefficients obtained between individual kindergarten CAA measures and various first and second grade achievement scores, indicate that a diversity of auditory perceptual factors need to be taken into account when considering the academic development of the early elementary school child.

Among the most interesting findings of the longitudinal portion of the study are the consistently strong correlations obtained between kindergarten CAA measures and various areas of academic achievement when comparing grade one with grade two results. Ordinarily, one might expect lower correlations as the time factor increases, however, in the majority of cases, the correlations differed by only a point or two. (e.g. Kdg. CAA Totals and 1st grade Gates Totals $r = .67$; and 2nd grade $r = .66$; Kdg. CAA Totals and 1st grade Stanford Totals $r = .61$; 2nd grade $r = .63$). In most cases, the correlations improved a point or two from first to second grade. Only in the area of the Stanford Achievement reading sub-tests were sizeable changes in rs noted from grade one to grade two. Increases in correlations in these areas ranged from four to twenty-three points from first to second grade results (e.g. Kdg. LPFS and Stanford Paragraph Meaning 1st grade r = .36, 2nd grade r = .59; Kdg. AS and Stanford Word Reading 1st grade r = .44, 2nd grade r = .52).

Since most of the correlations between kindergarten CAA measures and first and second grade achievement scores were found to be in the .50 to .67 range, and the lowest achievement rs ranging from high thirties to high forties (all 132 correlation coefficients obtained in the longitudinal analyses were statistically significant beyond the .01 level of confidence), it may be safe to infer that Central Auditory Abilities in kindergarten children are significantly related to future academic success. Furthermore, the strength of the correlations indicate that assessment of central auditory abilities in kindergarten and possibly pre-school levels is imperative if educators are interested in obtaining valid information pertaining to the child's pre-academic learning capability, especially when considering one aspect of the receptive language function.

It should be emphasized that according to the findings of the present study, the receptive language function - in the form of auditory perceptual ability and/or capacity - plays an integral and highly important role in a young child's ability to learn in all areas of academic endeavor. In addition to various reading skills, consistently strong correlations were obtained in the academic areas of Spelling, Language, Word Study Skills, Arithmetic (computation and concepts), and Vocabulary.

In addition to the strong indication of the need for early identification programs with regard to auditory perceptual disability, the present findings coupled with an earlier study (Flowers 1964) indicate that a Central Auditory Abilities test battery may be successfully utilized in the identification of auditory perceptual deficit in older school children already classified as manifesting various kinds and degrees of learning disability. Once these disabilities are identified, specific training procedures should be developed utilizing a remedial approach.

At this point in the discussion of the longitudinal findings, it should be emphasized that sophisticated auditory perceptual test instruments and diagnostic batteries are near worthless from a practical standpoint, if sound school training and rehabilitation programs are not planned and utilized.

One of the gratifying aspects of the present study findings lies in the fact that highly diverse but closely interrelated individual central auditory abilities correlated strongly with a variety of achievement factors. These findings indicate that several complex auditory perceptual functions exist in young children, and that current educational emphases on just one auditory perceptual skill ("auditory discrimination"), must be supplemented with a total consideration of several prominent auditory factors, all of which contribute substantially to the young child's development of total language capability. Training procedures will now need to be concentrated on such highly differentiated central auditory abilities, e.g. selective listening; internal and external resistance to distortion; auditory dedifferentiation, auditory memory; auditory vigilance, etc. Special attention will need to be given to the development and use of special technology in training programs, such as giving emphases to high frequency perceptual clues in a given auditory message (see Costello and Flowers 1967, A Language Enrichment Program for Young Children Through Development of Auditory Perceptual Abilities.) Special consideration will need to be given to the development of these auditory perceptual skills within the framework of a totally integrated language system, with emphases on the auditory perceptual aspect of the receptive language function.

As could be expected, the phonic abilities aspect of the study lends credence to the major longitudinal findings. Correlations between kindergarten CAA measures and various phonic abilities were not as strong as those obtained in the achievement section of the study, however, the vast majority of rs were statistically significant (24 out of 30 correlations were significant beyond the .01 level). Again, as could be anticipated, the strongest relationships were found among phonic skills requiring the identification of a spoken verbal message.

The suspicion that early development of auditory perception in the young child is influenced by socio-economic status of the child's family appears to be well-founded. Although the highest correlation between socio-economic status of the family and various kindergarten CAA measures reached a mere .29, all correlations involving individual CAA scores and socio-economic status were found to be statistically significant beyond the .01 level.

These findings have serious implications for educators who are responsible for programs involving lower income, economically and culturally disadvantaged school populations. It is well-accepted that disadvantaged children are inferior in all aspects of language development, therefore, it is conceivable that early identification and intervention programs, (e.g. Head Start programs) utilizing an auditory perceptual approach could be instrumental in affecting positive changes in language development patterns of this group of needy school children. It may be correctly assumed that early language enrichment more adequately prepares the disadvantaged child for the rigors of formal academic training.

Along these same lines, statistically significant correlations were obtained between kindergarten CAA measures and socio-economic class of the family for a sub-sample of kindergarten children identified as being delayed in their speech-articulation development. In this case five out of six CAA correlations reached statistical significance, although four rs were significant only at the .05 level. It is interesting to note that while CAA were significantly related to socio-economic status of speech-delayed kindergarten children, no statistically significant correlations were obtained between socio-economic status and speech-articulation proficiency of this group of children.

When kindergarten speech-delayed children were compared with a group of normal speaking peers on central hearing tasks, the speech-delayed group was inferior to the normal talkers. Differences in the means of the experimental and control groups were found to be statistically significant beyond the .01 level of confidence for individual and total CAA scores. However, non-significant correlations were obtained between kindergarten CAA measures and spontaneous speech improvement over a period of ten months in kindergarten.

VII. SUMMARY

The most salient features of the findings of the present study may be summarized as follows:

A. Central Auditory Abilities (auditory perceptual factors) of kindergarten children were significantly related to all areas of first and second grade academic achievement.

B. Several diverse rather than one or two specific auditory perceptual factors (e.g. resistance to internal and external distortion, auditory dedifferention, binaural synthesis, etc.), were significantly related to early elementary academic success.

C. Early development of central hearing ability as measured in kindergarten significantly influenced development of the receptive language function and hence subsequent ability to learn in school.

D. Central Auditory Abilities as measured in kindergarten may be utilized for purposes of group prediction with respect to first and second grade achievement in the areas of reading, spelling, vocabulary, word study skills, arithmetic, language, and science and social studies concepts.

E. Reliability coefficients of the total CAA battery and individual central auditory abilities measures in kindergarten ranged between .84 to .90.

F. Correlation coefficients between kindergarten CAA and first and second grade achievement varied little from grade one to grade two. In the majority of cases, correlations improved slightly on the second grade level.

G. Strongest correlations were obtained between kindergarten CAA (total score for the five-test battery) and first and second grade Gates Reading Totals (totals of all Gates sub-tests), and Stanford Achievement Totals (totals of all Stanford sub-tests). Correlations ranged from .61 to .67.

H. The strength of relationships between kindergarten central auditory abilities and later academic achievement indicates that measurement of auditory perceptual capacity at kindergarten and/or pre-school levels is imperative in any assessment program designed to obtain information regarding a child's pre-academic learning capability.

I. The study findings coupled with a previous related study indicate that the CAA battery could be utilized in identifying auditory perceptual deficit in older school children already classified as manifesting learning disabilities.

J. Educators should plan to provide programs in auditory perceptual training within the framework of a program of total language development based on CAA test results administered at kindergarten and pre-school levels.

K. Research efforts should proceed in refining the experimental CAA battery with emphases on investigation of new techniques in the assessment of auditory perceptual capacity.

L. Some effort should be made in attempting to utilize the CAA battery in the assessment of perceptual-learning capacity of educable mentally handicapped children.

M. First semester kindergarten central hearing ability is significantly related to end of kindergarten knowledge of phonics.

N. Early development of auditory perceptual capacity is significantly influenced by the socio-economic status of the family.

O. The influence of family socio-economic status on the development of central auditory abilities supports the contention of educators that economically disadvantaged children are inferior in overall language development, especially when considering auditory perception as a receptive language function. Early identification and training programs in the area of auditory perception should be planned for these children.

P. Statistically significant correlations were obtained between CAA and socio-economic status for a sub-sample of speech delayed kindergarten children.

Q. No significant relationship was found between socio-economic status and speech-articulation proficiency for the speech delayed kindergarten sub-sample.

R. Speech delayed children in kindergarten were found to be inferior to a group of normal speaking peers on all central hearing tasks.

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APPENDIX A 1
Flowers-Costello Test of Central Auditory Abilities
Low-Pass Filtered Speech Sentences

1. Mother hangs the clothes with /clothes pins.
2. The cowboy rides a /horse.
3. Mother wears this when she cooks. /apron.
4. At night, this shines in the sky. /star.
5. Father smokes a /pipe.
6. The girl poured the juice from the /pitcher.
7. An animal with a long trunk is an /elephant.
8. I carry water in the /bucket.
9. When it gets hot, we turn on the /fan.
10. At the Circus, I saw a /clown.
11. Mother puts on the baby's diapers with a /pin.
12. The woodsman cut the tree down with the /saw.
13. An animal that growls is a /tiger.
14. Mother wears this on her head. /hat.
15. The artist paints with /brushes and palette.
16. We use these to see with. /eyes.
17. The boy spins the /top.
18. Mother cleans the house with a /mop.
19. The girl took the picture with a /camera.
20. The cowboy uses a /gun.
21. In autumn, this falls off the trees. /leaf.
22. This lives in the ocean. /fish.
23. Mother irons the clothes on an /ironing board.
24. Father wears this around his neck. /tie.
25. At Christmas, we eat /turkey.

APPENDIX A 2

Flowers-Costello Test of Central Auditory Abilities

Accelerated Speech Sentences

1. A large animal in a circus is an /elephant.
2. When we dress, we put a shoe on our /foot.
3. An animal that barks loud is a /dog.
4. A soldier must always salute the /flag.
5. We must be careful when we cut paper with /scissors.
6. When we eat dinner, we sit on a /chair.
7. We read a book with our /eyes.
8. For dessert we had a delicious piece of /cake.
9. After dinner, father likes to smoke a /pipe.
10. In spring, leaves begin to grow on a /tree.
11. Mother takes baby for a ride in a /buggy.
12. Bugs Bunny, the rabbit, likes to eat /carrots.
13. Father paints the house with a /brush.
14. Santa Claus comes into a house through a /fireplace.
15. During war, a soldier drives a /tank.
16. Out west, cowboys ride on a /horse.
17. When we send a letter, we put it in a /mailbox.
18. All dogs like to chew on a /bone.
19. Every morning, father drives to work in a /car.
20. Baseball players hit the ball with a /bat.
21. The carpenter hit the nail with a /hammer.
22. Some Indians shoot with a bow and /arrow.
23. Mother drinks her coffee from a /cup.
24. On a farm, the farmer milks a /cow.
25. At the zoo, the monkey ate a /banana.

APPENDIX A 3
Flowers-Costello Test of Central Auditory Abilities
Competing Messages Sentences

1. A fireman wears a /firehat.
2. The boy blows the /horn.
3. Mother cooks on a /stove.
4. On Halloween, we carved a /pumpkin.
5. The mailman brings us a /letter.
6. A horse lives in a /barn.
7. We ride over the snow on a /sled.
8. The baby sleeps in a /crib.
9. For my birthday, Mother baked a /cake.
10. The little boy rides his /bicycle.
11. My father wears a /hat.
12. A hunter carries a /gun.
13. A squirrel eats an /acorn.
14. The King wears a /crown.
15. We use a net to catch a /butterfly.
16. Mother puts my clothes in the /dresser.
17. When we are in school, we sit at /desks.
18. To make music, we blow a /horn.
19. Mother sews the clothes with a /needle and thread.
20. I carry water in a /bucket.
21. To build a house, the carpenter uses a /hammer.
22. When we go to a zoo, we see the /elephant.
23. A rabbit eats a /carrot.
24. The teacher rings the /bell.
25. F ther drives to work in the /car.

APPENDIX A 4
Flowers-Costello Test of Central Auditory Abilities
Accelerated and Competing Sentences

1. The fish swims in a /fish bowl.
2. A bird lays its eggs in a /nest.
3. Mother cooks dinner on a /stove.
4. The barber cuts hair with /scissors.
5. The baby sleeps in a /crib.
6. The farmer keeps his animals in the /barn.
7. At night, this shines in the sky. /moon.
8. The man paints with a /brush.
9. A toy that spins is a /top.
10. The dog lives in the /dog house.
11. We lock the door with a /key.
12. The baby plays with /blocks.
13. You can play music with a /horn.
14. Mother wears this around her neck. /necklace.
15. An Indian lives in a /teepee.
16. We dig sand with a /shovel.
17. The man wears this on his wrist. /wristwatch.
18. Leaves grow on a /tree.
19. We put letters in the /mailbox.
20. The man who makes us laugh is the /clown.
21. We drink water from a /glass.
22. We eat soup with a /spoon.
23. A man flies in an /airplane.
24. Mother keeps food in the /refrigerator.
25. Mother sews with /needle and thread.

APPENDIX A 5

Flowers-Costello Test of Central Auditory Abilities
Binaural Synthesis Sentences

1. When it rains, we use the /umbrella.
2. At the birthday party, I wore a /hat.
3. An animal who lives in the zoo is the /elephant.
4. A bird lives in a /nest.
5. The man who brings presents at Christmas is /Santa Claus.
6. To keep our hands warm, we wear /mittens.
7. I cut paper with /scissors.
8. A bird that lives in a tree is the /owl.
9. Mother waters the flowers with a /watering can.
10. The fisherman caught the /fish.
11. A monkey eats the /banana.
12. When it gets dark, we turn on the /lamp.
13. To open the door, we put the key in the /lock.
14. The horse pulls the /wagon.
15. In the winter, we make a /snowman.
16. At the beach, I dig with my /shovel.
17. A hunter uses a /gun.
18. Mother hen has a little /chick.
19. The fireman put out the /fire.
20. My dog lives in a /dog house.
21. Mother wears this on her finger. /ring.
22. The Indian lives in a /teepee.
23. I like to drink a /soda.
24. The musician blows the /horn.
25. Something that goes "quack" is the /duck.

Appendix B 1

Correlation Coefficients Between Individual Kindergarten Central Auditory Abilities and Various First and Second Grade Gates and Stanford Reading Sub-Tests

(First Grade N = 235; Second Grade N = 212)

Kdg. CAA Measure		Reading Sub-Test	1st grade r	2nd grade r
AS (Accelerated Speech)	and	Gates Word Recognition	.58	.59
AS	"	Gates Sentence Reading	.57	N.A.
AS	"	Gates Paragraph Reading	.57	.55
AS	"	Stanford Word Reading	.44	.52
AS	"	Stanford Paragraph Meaning	.42	.54
CM (Competing Messages)	and	Gates Word Recognition	.55	.56
CM	"	Gates Sentence Reading	.50	N.A.
CM	"	Gates Paragraph Reading	.55	.58
CM	"	Stanford Word Reading	.42	.53
CM	"	Stanford Paragraph Meaning	.40	.57
AS + CM (Accelerated + Competing)	and	Gates Word Recognition	.50	.53
AS + CM	"	Gates Sentence Reading	.45	N.A.
AS + CM	"	Gates Paragraph Reading	.50	.53
AS + CM	"	Stanford Word Reading	.37	.45
AS + CM	"	Stanford Paragraph Meaning	.38	.50

Appendix B 1 (continued)

Kdg. CAA Measure		Reading Sub-Test	1st grade r	2nd grade r
BS (Binaural Synthesis)	and	Gates Word Recognition	.50	.47
BS	"	Gates Sentence Reading	.48	N.A.
BS	"	Gates Paragraph Reading	.52	.51
BS	"	Stanford Word Reading	.38	.42
BS	"	Stanford Paragraph Meaning	.38	.49
LPFS (Low Pass Filtered Speech)	and	Gates Word Recognition	.46	.51
LPFS	"	Gates Sentence Reading	.45	N.A.
LPFS	"	Gates Paragraph Reading	.48	.48
LPFS	"	Stanford Word Reading	.37	.48
LPFS	"	Stanford Paragraph Meaning	.36	.59

(Note: all reported rs were significant beyond the .01 level of confidence)

Appendix B 2

Correlation Coefficients Between Individual Kindergarten Central Auditory Abilities and First and Second Grade Language-Achievement Results

(First Grade N = 235; Second Grade N = 212)

Kdg. CAA Measures	1st Gr. Stanford Language Factor	r	2nd Gr. Stanford Language Factor	r
AS (Accelerated Speech)	Spelling	.44	Spelling	.41
AS			Language	.42
AS	Vocabulary	.45		
AS	Word Study Skills	.42	Word Study Skills	.42
CM (Competing Messages)	Spelling	.41	Spelling	.43
CM			Language	.43
CM	Vocabulary	.48		
CM	Word Study Skills	.44	Word Study Skills	.44
BS (Binaural Synthesis)	Spelling	.34	Spelling	.34
BS			Language	.37
BS	Vocabulary	.42		
BS	Word Study Skills	.39	Word Study Skills	.38
AS + CM (Accelerated + Competing)	Spelling	.37	Spelling	.36
AS + CM			Language	.41
AS + CM	Vocabulary	.44		
AS + CM	Word Study Skills	.40	Word Study Skills	.40

(Note: all reported rs were significant beyond the .01 level of confidence)

Appendix B 3

Correlation Coefficients Between Central Auditory

Abilities and Phonic Abilities

(N = 101)

CAA Totals and	Phonic Abilities Totals	.46 *
"	Naming Capital Letters	.32 *
"	Naming Lower Case Letters	.35 *
"	Identifying Lower Case Letters Named	.51 *
"	Identifying Capital Letters Named	.48 *
"	Sounds Capital Letters Make	.51 *
Low Pass Filtered Speech and	Phonic Abilities Totals	.33 *
"	Naming Capital Letters	.22 ‡
"	Naming Lower Case Letters	.20 ‡
"	Identifying Lower Case Letters Named	.51 *
"	Identifying Capital Letters Named	.48 *
"	Sounds Capital Letters Make	.50 *
Accelerated Speech and	Phonic Abilities Totals	.40 *
"	Naming Capital Letters	.28 *
"	Naming Lower Case Letters	.29 *
"	Identifying Lower Case Letters Named	.40 *
"	Identifying Capital Letters Named	.42 *
"	Sounds Capital Letters Make	.50 *

Appendix B 3 (continued)

Competing Messages and	Phonic Abilities Totals	.44 *
"	Naming Capital Letters	.31 *
"	Naming Lower Case Letters	.35 *
"	Identifying Lower Case Letters Named	.47 *
"	Identifying Capital Letters Named	.44 *
"	Sounds Capital Letters Make	.47 *
Accelerated Speech + Competing Messages and	Phonic Abilities Totals	.33 *
"	Naming Capital Letters	.20 ‡
"	Naming Lower Case Letters	.25 ‡
"	Identifying Lower Case Letters Named	.42 *
"	Identifying Capital Letters Named	.35 *
"	Sounds Capital Letters Make	.38 *
Binaural Synthesis and	Phonic Abilities Totals	.28 *
"	Naming Capital Letters	.15
"	Naming Lower Case Letters	.23 ‡
"	Identifying Lower Case Letters Named	.36 *
"	Identifying Capital Letters Named	.29 *
"	Sounds Capital Letters Make	.28 *

(* Significant at the .01 level; ‡ significant at the .05 level)

Appendix C 1

Analysis of Variance Summary Table

CAA Totals

Source of Variation	df	SS	MS	F	p
Between	1	6621.50	6621.50	10.57	.01
Within	281	176001.30	626.33		
Total	282	182622.80			

Appendix C 2

Analysis of Variance Summary Table

Low Pass Filtered Speech

Source of Variation	df	SS	MS	F	p
Between	1	673.41	673.41	37.76	.01
Within	281	5010.26	17.83		
Total	282	5683.67			

Appendix C 3

Analysis of Variance Summary Table

Accelerated Speech

Source of Variation	df	SS	MS	F	p
Between	1	542.16	542.16	30.36	.01
Within	281	5016.94	17.85		
Total	282	5559.10			

Appendix C 4

Analysis of Variance Summary Table

Competing Messages

Source of Variation	df	SS	MS	F	p
Between	1	527.59	527.59	21.17	.01
Within	281	7002.17	24.91		
Total	282	7529.76			

Appendix C 5

Analysis of Variance Summary Table

Accelerated + Competing Messages

Source of Variation	df	SS	MS	F	p
Between	1	772.74	772.74	31.70	.01
Within	281	6848.04	24.37		
Total	282	7620.78			

Appendix C 6

Analysis of Variance Summary Table

Binaural Synthesis

Source of Variation	df	SS	MS	F	p
Between	1	1281.35	1281.35	8.52	.01
Within	281	42223.29	150.26		
Total	282	43504.64			

Appendix C 7

Analysis of Variance Summary Table

IQ

Source of Variation	df	SS	MS	F	p
Between	1	4199.60	4199.60	5.26	.05
Within	279	222514.40	797.54		
Total	280	226714.00			

FINAL SUMMARY

RELATIONS AMONG CENTRAL AUDITORY ABILITIES, SOCIO-ECONOMIC FACTORS, SPEECH DELAY, PHONIC ABILITIES AND READING ACHIEVEMENT: A LONGITUDINAL STUDY

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Cooperative Research Project No. 6-8313
Duration: June 1, 1966 to August 31, 1967

BACKGROUND

One of the more pressing problems facing educators today is the lack of adequate assessment techniques with respect to early identification of potential learning disability in young children. Recent research and program development emphases on visual-motor perceptual problems have provided educators with limited diagnostic tools for the assessment of pre-learning factors in young children. However, the all important receptive language factor of auditory perception has been given very little scientific research attention, especially when considering the relationship of early auditory perceptual development to later academic achievement.

Most research efforts dealing with auditory perception have been confined to study efforts which have attempted to relate one isolated auditory perceptual factor ("auditory discrimination") to the academic area of reading. Such significant auditory perceptual factors, e.g., "selective listening," "resistance to internal and external distortion," "binaural synthesis", "binaural summation," "auditory dedifferentiation," etc., have been completely ignored by educational researchers. Additionally, educators have compounded the assessment problem by overlooking such important audiological considerations, e.g., the child's peripheral hearing capacity (auditory acuity); the relationship of the intensity level of verbal test materials to the child's acuity level; and the physical environmental controls deemed so critical in the assessment of the auditory perceptual function.

Finally, MacGinitie (1967) appears to have focused attention on one of the most critical problems faced by educators who are concerned with learning problems in young children, when he observed that "an important possibility is that difficulties in auditory perception that contribute to reading problems may be largely left behind by the time the reading problems are studied."

In view of the foregoing discussion of the background of the present study effort, the problem as it applies to the relationship of auditory perceptual development to later academic achievement is twofold:

(1) assessment techniques of auditory perceptual skills must be concerned with sophisticated, scientific, well-controlled audiological-neurophysiological methodology, based on research precedent and experience which has demonstrated the efficacy of these procedures with normal and pathological subjects; and

(2) assessment of auditory perceptual skills must be completed with children at a very early age in their perceptual development and related to future achievement data over a period of time.

Once discrete auditory perceptual evaluation has been effected, training procedures designed to counteract the identified deficiencies could be included in the pre-school, kindergarten, and early elementary school curriculum.

OBJECTIVES

The overall purpose of the present study effort was to search for relationships between Central Auditory Abilities ("CAA"; auditory perceptual factors) of kindergarten children and later academic achievement (focusing on reading) in first and second grade. Additional relationships were investigated between kindergarten CAA and other factors presumed to be critically related to the learning process, e.g., speech-articulation proficiency, phonic abilities, and socio-economic level of the child's family.

Specific research objectives were as follows:

1. To determine the predictive value of kindergarten CAA measures with respect to academic achievement scores during the latter part of first grade and second-semester second grade.

2. To determine if phonic abilities of second-semester kindergarten children are related to early CAA development.

3. To determine if socio-economic status of the family affects the development of CAA in kindergarten children.

4. To determine if speech-language delayed first-semester kindergarten children differ in central hearing ability when compared with normal speaking peers.

5. To determine if socio-economic status of the family affects the development of CAA of speech-delayed kindergarten children.

6. To determine the predictive value of CAA measures with respect to spontaneous speech improvement over a period of ten months for a sub-sample of speech-delayed kindergarten children.

PROCEDURE

A. Subjects

Subjects for the study were 287 randomly selected first-semester kindergarten boys and girls selected from a pool of 550 kindergarten children attending school at the Grand Blanc Community Schools, Grand Blanc, Michigan. Although a random selection method was employed, subjects' characteristics were specified in accordance with the following criteria: (1) they were within an IQ range of 85 - 130; (2) they were required to pass a pure tone audiometric examination which indicated normal peripheral hearing bilaterally (testing 250, 500, 1000, 2000, 3000, and 4000 Hz.); (3) they were considered to be free of any observable gross organic and/or structural impairments (e.g., cerebral palsey, cleft palate; etc.), and (4) they were considered as being free of history indicating emotional involvements of any kind, (e.g., schizophrenia, etc.). Sub-samples for purposes of testing various associated research hypotheses were also selected at random from the primary sample of 287 subjects

B. Techniques Employed

Condition 1 - Low Pass Filtered Speech (LPFS; an auditory perceptual factor of resistance to internal distortion): 25 sentences were filtered at 1200 Hz. low pass and presented binaurally via earphones (same signal to both ears) at + 45 decibels, re: audiometric zero; subjects were instructed to listen to each sentence and to complete the sentence by pointing to one of three pictures which represented the required answer; no verbal response was required..

Condition 2 - Accelerated Speech (AS; an auditory perceptual factor of resistance to external distortion): 25 sentences were presented binaurally via earphones at an acceleration rate of 280 words per minute, (compressed as per Foulke et al 1962) and at an intensity level of + 45 decibels, re: audiometric zero; the required response was the same as in condition 1.

Condition 3 - Competing Messages (CM; an auditory perceptual factor of selective listening in the form of auditory dedifferentiation): 25 sentences were presented via sound field through the medium of air without earphones, while simultaneously a competing message was presented via sound field emanating from another speaker. Technically, the procedure was as follows: the sentences were recorded on tape by an adult female talker (relevant message) to be presented via speaker I as the primary auditory stimulus. A children's story was recorded on track II of the same tape by the same adult female talker, to be presented via speaker II, as the competing and/or unwanted background auditory stimulus. Both messages were presented at an intensity level of + 60 decibels, re: audiometric zero, to insure a comfortable listening intensity level. In this situation, the subject was expected to differentiate the relevant message emanating from speaker I from the unwanted message coming from speaker II. The messages were presented by matched loud speakers located at 45 degree angles on opposite sides of the listening position; the required response was the same as specified in Condition I.

Condition 4 - Accelerated Speech and Competing Messages (AS - CM; an auditory perceptual factor of dual distortion): 25 sentences accelerated to 280 wpm (non-mechanical acceleration - no compression) were presented as the primary relevant message via speaker I, while the same children's story, (employed in Condition 3) was presented as the competing message via speaker II. Both messages were presented at the same steady state intensity level of + 60 db re: audiometric zero; the required response was the same as in Condition I.

Condition 5 - Binaural Synthesis (BS; an auditory perceptual factor of binaural synthesis and/or binaural integration): 25 sentences were presented via earphones in a stereophonic-type listening situation. One portion of the frequency spectrum of the message was presented in one ear while the other portion of the frequency spectrum of the same message was simultaneously presented to the other ear. The left ear received the high frequency narrow band pass message containing frequencies from 2400 to 2880 Hz., while the right ear received the lower band pass frequencies ranging from 420 to 540 Hz. Normally, both high and low portions of the spectrum presented simultaneously fuse to provide enough information to allow for normal or near normal intelligibility of the message. The required responses were the same as specified in Condition 1.

C. Statistical Analyses

Most of the major research hypotheses were tested by obtaining intercorrelations between independent and dependent variables (Pearson Product-Moment correlation coefficients). The research hypothesis dealing with the comparison of speech delayed vs. normal speaking kindergarteners on CAA was tested by employing a simple, one-way analysis of variance technique.

RESULTS

1. Correlations between kindergarten CAA Totals (sum of five CAA sub-test scores) and first and second grade reading achievement scores (Gates and Stanford sub-tests) ranged from .46 to .67; the majority of correlations being in the .61 to .67 range.

2. The longitudinal achievement analyses involved 132 correlation coefficients. All 132 correlations obtained were significant beyond the .01 level of confidence.

3. Correlation values showed little change from first to second grade results, except on Stanford reading sub-tests where changes showed marked improvement in rs in favor of second grade.

4. Correlations between individual kindergarten CAA and first and second grade Gates Totals (sum of three sub-tests) ranged from .50 to .64. The AS and CM measures consistently yielded the highest rs.

5. Intercorrelations between individual CAA measures and various first and second grade reading sub-tests yielded rs ranging between .40 to .50. Again, little differences were to be found between first and second grade rs, except for the marked increase in r values from first to second grade for both Stanford reading sub-tests.

6. Correlations between kindergarten CAA measures and first and second grade Stanford Achievement Totals (overall achievement, sum of all Stanford sub-tests) ranged from .50 to .63. The highest r was obtained between kindergarten CAA Totals and second grade Stanford Achievement Totals (r = 63). Little change in first to second grade rs was in evidence.

7. Correlations between kindergarten CAA Totals and first and second grade language-achievement results were predominently in the upper forties.

8. Correlations between kindergarten CAA and second grade science-social studies achievement ranged from .35 to .46. The highest was obtained between kindergarten CAA totals and second grade science-social studies results (r = .46).

9. Correlations between kindergarten CAA and first and second grade arithmetic achievement results ranged from .38 to .56.

10. Reliability coefficients for five kindergarten CAA measures ranged from .84 to .90.

11. Correlations between kindergarten CAA measures and later kindergarten phonic abilities ranged between .34 and .48. Of 30 rs obtained, 24 rs were significant beyond the .01 level, while of the remaining six rs, five were significant beyond the .05 level.

12. Correlations between socio-economic status of the family and CAA for a delayed speech group of kindergarten children ranged from .11 to .28. Four out of six rs were significant at the .05 level while one r reached significance at the .01 level. For the total primary sample of kindergarteners (N = 232), correlations ranged from .18 to .29; all rs reached statistical significance beyond the .01 level.

13. Correlations between CAA and spontaneous speech improvement at the end of kindergarten (over a ten-month period) were all negative, none of the rs reaching significance at the .05 level of confidence.

14. Kindergarten speech-delayed children were found to be inferior to their normal speaking peers on all CAA tasks. Differences in means between the two groups for all CAA tasks were significant beyond the .01 level of confidence.

CONCLUSIONS

The most salient features of the findings of the present study may be summarized as follows:

1. Central Auditory Abilities (auditory perceptual factors) of kindergarten children were significantly related to all areas of first and second grade academic achievement.

2. Several diverse rather than one or two specific auditory perceptual factors (e.g., resistance to internal and external distortion, auditory dedifferentiation, binaural synthesis, etc.), were significantly related to early elementary academic success.

3. Early development of central hearing ability as measured in kindergarten significantly influenced development of the receptive language function and hence subsequent ability to learn in school.

4. Central Auditory Abilities as measured in kindergarten may be utilized for purposes of group prediction with respect to first and second-grade achievement in the areas of reading, spelling, vocabulary, word study skills, arithmetic, language, and science and social studies concepts.

5. Reliability coefficients of the total CAA battery and individual central auditory abilities measures in kindergarten ranged between .84 to .90.

6. Correlation coefficients between kindergarten CAA and first and second-grade achievement varied little from grade one to grade two. In the majority of cases, correlations improved slightly on the second grade level.

7. Strongest correlations were obtained between kindergarten CAA (total score for the five-test battery) and first and second grade Gates Reading Totals (totals of all Gates sub-tests), and Stanford Achievement Totals (totals of all Stanford sub-tests). Correlations ranged from .61 to .67.

8. The strength of relationships between kindergarten central auditory abilities and later academic achievement indicates that measurement of auditory perceptual capacity at kindergarten and/or pre-school levels is imperative in any assessment program designed to obtain information regarding a child's pre-academic learning capability.

9. The study findings coupled with a previous related study indicate that the CAA battery could be utilized in identifying auditory perceptual deficit in older school children already classified as manifesting learning disabilities.

10. Educators should plan to provide programs in auditory perceptual training within the framework of a program of total language development based on CAA test results administered at kindergarten and pre-school levels.

11. Research efforts should proceed in refining the experimental CAA battery with emphases on investigation of new techniques in the assessment of auditory perceptual capacity.

12. Some effort should be made in attempting to utilize the CAA battery in the assessment of perceptual-learning capacity of educable mentally handicapped children.

13. First semester kindergarten central hearing ability is significantly related to end of kindergarten knowledge of phonics.

14. Early development of auditory perceptual capacity is significantly influenced by the socio-economic status of the family.

15. The influence of family socio-economic status on the development of central auditory abilities supports the contention of educators that economically disadvantaged children are inferior in overall language development, especially when considering auditory perception as a receptive language function. Early identification and training programs in the area of auditory perception should be planned for these children.

16. Statistically significant correlations were obtained between CAA and socio-economic status for a sub-sample of speech-delayed kindergarten children.

17. No significant relationship was found between socio-economic status and speech-articulation proficiency for the speech-delayed kindergarten sub-sample.

18. Speech-delayed children in kindergarten were found to be inferior to a group of normal speaking peers on all central hearing tasks.

BIBLIOGRAPHY

There are 28 references listed in the final report.