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Auditory perception: and its implications for the development of language

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AUDITORY PERCEPTION:

AND

ITS IMPLICATIONS

FOR THE

DEVELOPMENT OF LANGUAGE

by

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CHAPTER I

INTRODUCTION

Speech is the end-product of the most complex system operative in the human central nervous system. Impaired speech production is the final common denominator symptom of disorders in this system, and is rarely the cause of associated disabilities in language function. Correction of speech sound production, while esthetically desirable, is frequently irrelevant to the basic, frequently complex, matter presenting the problem.[1]

Language should be viewed as a system: a complex symbol system neurologically represented and the most efficient symbol system available to living organisms. It is a temporally patterned, hierarchical, organized system which allows generalization, transfer of information, long and short term storage, and reliable retrieval.[2] Various models have been constructed for the language system, mostly based on modifications of stimulus-response and reinforcement theory, but none with any

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[1] J. M. Wepman, L. V. Jones, R. D. Bock and D. Van Pelt, "Studies in Aphasia: Background and Theoretical Formulations," Journal of Speech and Hearing Disorders, XXV (November, 1960), 323-332.

[2] D. E. Broadbent, Perception and Communication (Pergamon, 1958), pp. 36-45.

clarity regarding the neuro-anatomical or neuro-chemical structures responsible.[3,4,5]

The manifest expression of the symbol system, language as we know it is in itself complex, consisting of (a) sounds (phonemes), the science and study of which is an elaborate and technical one (phonetics); (b) forms (phoneme-sequences, morphemes), the linguistic study of which is called morphology; and (c) constructions (grammar, syntax), to which most of the linguists' attention is being given currently. From an auditory standpoint, speech involves what we usually call (a) auditory discrimination, (b) sequencing skills, and (c) the knowledge of the rules and patterns of language.[6]

This complex system is acquired, in its essentials, by the age of two or three years. Parallel processes of audition and cognition occur in the infant. The infant acquires schemata of the object world through increasingly sophisticated discrimination, increasing motor activity, synthesis of percepts, increasing self-perception and differentiation, and acquisition of percepts of time, space, and sequential-spacial arrangements. All of this occurs without signs. Simultaneously the infant babbles, coos, makes phonemic approximations; is reinforced, imitates and probably functions in something like the operant model constructed by Skinner. At first the vocalizations principally reinforced

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[3] B. F. Skinner, Verbal Behavior (New York: Appleton-Century-Crofts, 1957).

[4] C. E. Osgood, M. S. Miron, Approaches to the Study of Aphasia (Urbana: University of Illinois Press, 1963).

[5] Wepman, loc. cit.

[6] Sister Mary Arthur Carrow, "The Development of Auditory Comprehension of Language Structure in Children," Journal of Speech and Hearing Disorders, III, No. 2 (May, 1968), 100.

are cries and demands, but gradually more finely discriminated phonemes are also reinforced. For a while the infant's prelinguistic vocal behavior is largely in an action matrix.

By nine to twelve months "meaning," the reliable attachment of an auditory "sign" (percept) to an "object-action-state" develops. Labelling proceeds at a rapid rate. By two years the symbol system is arranged in reliable contingent schemas, the rules of which we know as grammar. By five to six years of age the child has a thorough working knowledge of his language at all levels of the symbol-system described. This is not to say his cognitive capabilities are fully established, only that the tools for using the linguistic code are.[7]

Most of this systematic imprinting has been by means of auditory percepts as the basic building blocks; now an auditory message must be reconstructed from the printed text in order for the child to read. The child must be made aware of the linguistic code, learn its structures didactically; but we must remember that the imprint, the storage and retrieval system, the constancy of the percepts learned are already reliably present.

In both clinical and educational settings, the child with an intellectual deficiency which is restricted to either verbal or to non-verbal abilities is a relatively infrequent but nonetheless troubling occurrence. The so-called "perceptually handicapped" child who has difficulties with visually presented stimuli has been the subject of

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[7]R. Brown and U. Bellugi, "Three Processes in the Child's Acquisition of Syntax," ed. E. H. Lenueberg, New Directions in the Study of Language (M.I.T. Press, 1963), pp. 131-61.

considerable discussions and study.[8,9,10] The child with a deficiency in verbal performance (the "language deficient" child), on the other hand, has been little studied and is little understood.[11] The etiologies of his problem are essentially unexplored, though neurological deficit, emotional disorder, and environmental deprivation are all possibilities. Even the stability of the problem through time is uncertain, though it seems to be generally assumed that it is a relatively permanent phenomenon. The consistency of the pattern of language deficit, with implications for its very nature, is again unknown. Perhaps there is no general pattern but only a series of highly test-specific difficulties. On the other hand, an organized pattern may exist and may take one of several forms. The deficit may be limited to the auditory perception area. The problem may be related more to the sensory modality through which incoming stimuli are received than to the verbal nature or level of abstraction of the tasks presented. Consequences for social adjustment and educational achievement are, again, unknown.

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[8] A. A. Strauss and Laura E. Lehtinen, Psychopathology and Education of the Brain Injured Child (New York: Grune and Stratton, 1947).

[9] A. A. Strauss and N. C. Kephart, Psychopathology and Education of the Brain Injured Child (New York: Grune and Stratton, 1955).

[10] W. M. Cruickshank, Frances Bentzen, F. H. Ratzeburg, and Marian Tannhauser, A Teaching Method for Brain-Injured and Hyperactive Children (Syracuse: Syracuse University Press, 1961).

[11] Jean Holroyd and F. Wright, "Neurological Implications of WISC Verbal-Performance Discrepancies in a Psychiatric Setting," Journal of Psychology, XXIX (1965), 206-12.

Statement of Purpose

The purpose of this paper was to present an overview of some of the most significant research in auditory perception, to describe new measures which have been developed, and to indicate some implications for language development. The studies included both basic and applied research, although in general very little application had been made to educational problems.

CHAPTER II

RESEARCH

Auditory perception involves focus, attention, tracking, sorting, scanning, comparing, retrieving, and sequencing of spoken messages at the moment of utterance. The variables dealt with in this paper were: (1) selective listening to the message, (2) tracking of the message through time, (3) discrimination of speech sounds and syllables, (4) auditory memory span, and (5) auditory sequencing.

Selective Listening

Selective listening plays a crucial role in learning, and in recent years both psychologists and speech scientists have investigated some of its characteristics. No listening can take place without there first being focus on and attention to the speech signal (sound utterance). Exactly what mechanisms of attention and neurophysiology are involved is not known.

Research relevant to attention has been largely concerned with the ability of the individual to pay attention to and comprehend two messages presented simultaneously; or to listen to two competing messages but pay attention to only one.

Interest in this problem arose in recent years because of the necessity for efficiency of control systems, such as those for regulating air traffic at airports. Broadbent points out, "A major cause of failure in these systems is that the human operator has too much information to handle simultaneously, or that he reacts to an unimportant signal when he should be dealing with an important one."[1] The capacity for transmitting information is defined as "the number of equally probable messages of which one can be sent in a specified time."[2] In education, competing messages are often an integral part of the learning situation, with the intended spoken message being subject to distraction from noise, music, and other speech. Broadbent notes:

> One of the earliest findings, and one that agrees with everyday experience, is that it is harder to understand two messages arriving simultaneously than two messages arriving one after the other. One might be tempted to explain this as a purely physical interference between the two stimuli; for example, the louder passages of one message might drown out the softer passages of the other and vice versa, rendering them both unintelligible. Actually the matter is not so simple. By recording the messages on tape and playing them for different subjects instructed to respond in different ways, the intelligibility is shown to depend on psychological factors. Specifically, either message becomes understandable if the listener is instructed to ignore the other. But the two messages together cannot both be understood, even though the necessary information is available to the ear.[3]

A number of experiments have demonstrated conditions which make comprehension easier. Some of these conditions are (1) having the two voices very different in physical characteristics, as in a man's and a woman's voice; (2) spatial separation of the two voices; (3) if one message has no importance for the listener and does not have to be answered; and (4) if each message is drawn from a small range of possibilities.

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[1] D. E. Broadbent, "Attention and the Perception of Speech," Scientific America (1962), p. 143.

[2] Ibid.

[3] Ibid.

> When the listener is thoroughly familiar with a situation, so that he knows to within a small number of alternatives what each message will be, he can comprehend two simultaneous messages. But when one or both messages are drawn from a large number of possibilities, the filter in the brain lets only one message come through.[4]

Cherry conducted a number of experiments on the recognition of speech with one and two ears. In one group of tests, two different spoken messages were presented to the subject simultaneously, using both ears. The subjects were presented with two mixed speeches recorded on tape and asked to repeat one of them word by word or phrase by phrase. Subjects reported great difficulty in accomplishing the task but were able to separate the messages with almost no errors.

When the same experiment was performed using messages constructed from one hundred fifty cliches strung together, however, the task of separating the two messages became almost impossible. In this second group of tests, one spoken message was fed to the right ear of the subjects and a different message to the left ear. The subjects were able to repeat without error one of the messages concurrently while listening. It was found, however, that they often had little idea of what the message was all about and were often unable to tell whether the rejected message was in English or in some other language. They were aware of changes of voice from male to female but could not recall detailed aspects of the rejected message.[5]

One way of conceptualizing the problem of attending to one message in the presence of another distracting one is to consider it an auditory

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[4] _Ibid._, p. 146.

[5] E. C. Cherry, "Some Experiments on the Recognition of Speech with One and Two Ears," _Journal of the Acoustical Society of America_, XXV (1953), 975-79.

figure-ground-perceptual task. Lerea did a study to examine the inference that auditory figure-ground perceptual disturbances are generally evident among brain-injured individuals. He presented brain injured subjects and familial mental retardates with syllable utterances and two noise backgrounds (connected speech and white noise). The findings were inconclusive, and he concluded that "the impaired responses of the brain-injured should not be categorically assigned to a perceptual handicap without first ruling out other interacting forces that may be responsible for the inferior behavior."[6] He also suggested that the complexity of the figure and the type and intensity of the background auditory signals make a difference in the amount of interference experienced by the listener.[7]

Maccoby and Konrad conducted a series of studies of selective listening, considered as one aspect of skill in auditory perception. In 1966, they reported a study comparing age levels--Kindergarten through fourth grade--with respect to the effects of three variables on the accuracy of selective listening: practice, binaural versus dichotic presentation of stimulus words, and number of syllables in stimulus words. Their interest was in whether there are age trends in the ability to select one auditory message when two are simultaneously present.

The subjects listened to twenty-three pairs of words spoken simultaneously by two speakers, with mono-syllables and multi-syllables alternated in the list. All subjects listened twice; in one run, they were instructed to repeat the words spoken by the male voice and in the other,

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[6]L. Lerea, "An Investigation of Auditory Figure-Ground Perception," Journal of Genetic Psychology, XCVIII (1961), 237.

[7]*Ibid.*, pp. 229-37.

the words spoken by the female voice. In the binaural condition, the voices of both speakers came to both ears. In the dichotic condition the voices were separated, the male voices coming to one ear and the female voice to the other. Within each pair of words, the words were matched for number of syllables, and the two voices were equated for loudness on the basis of judgments by adult judges.

The study showed that skill in selective listening, under the conditions of the experiment, does increase with age from kindergarten through fourth grade. Performance on mono-syllabic words tended to level off between grades two and four, while performance on multi-syllabic words continued to increase through grade four. The authors suggest that "older children's superior performance in selective listening arises at least in part from their greater familiarity with the redundancies in the material to be selected."[8]

Their later studies confirmed the fact that selective listening improves with age, from kindergarten through grade six, when the task is to give an accurate report of one of two simultaneous verbal messages. The performance of the sixth-graders was between forty and fifty per cent better than that of the kindergartners, the magnitude of the improvement being determined partly by the difficulty of the stimulus materials.

In this set of studies, the messages consisted either of single words varying in familiarity or of two-word phrases varying in sequential probability. The authors found,

> The improvement with age is greater for high sequentially probable phrases than it is for low-probability phrases. We interpret this to mean that one factor underlying the improvement in selective

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[8]Eleanor E. Maccoby and K. W. Konrad, "Age Trends in Selective Listening," Journal of Exceptional Psychology, III (1966), 121.

listening between ages five and eleven is an increasing familiarity with the probabilities of the language, permitting older children to fill in partially heard material more easily on the basis of their knowledge of what words would be likely to occur in a given linguistic setting.[9]

Taking a somewhat different approach to studying the variables, Manning and Hedrick investigated the phenomenon of competing messages. These studies are of particular interest because they form the basis of a set of auditory perceptual training lessons field-tested in regular classrooms, which will be discussed here.

Manning studied the intelligibility of competing messages with young adults, using variations in relative intensity and message similarity. Although he was interested in developing a good competing message test that could be used for analyzing cases of auditory perceptual disability, the primary purpose of the study was to assess more adequately the effective distraction upon the performance of listeners with normal hearing.

Manning obtained selective data on the effect of contrasting and matching unwanted messages on message intelligibility. He used two male speakers, each speaking the identical carrier phrase but uttering different final mono-syllabic words. Messages were tape-recorded and presented binaurally. He varied the competing messages in two ways: by varying the signal-to-noise ratios from +5 to -5 decibels, and by varying the phonetic similarity of the unwanted to the wanted messages. Examples of phonetically similar pairs of words are: match-shack, chalk-palm, veil-bake, and tease-neat; phonetically different pairs were: food-burn, zeal-rob, light-hair, and mean-judge.

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[9]Ibid., "The Effect of Preparatory Set on Selective Listening: Developmental Trends," Society for Research in Child Development, No. 112 (1967).

Manning found that the intelligibility of competing messages was dependent upon both the phonetic structure and intensity of the unwanted competing message:

> For the sample studies, it may be reported that in both matched and contrasting message conditions, intelligibility was increasingly disturbed as the unwanted message surpassed the wanted message in intensity. However, the discrimination functions for the two conditions were significantly different. For conditions where the competing messages were phonetically matched, a consistent linear increase in mean error scores was noted with each increase of the irrelevant message. When the messages were phonetically contrasted, intelligibility was consistently better. However, each increase in the unwanted message produced a relatively greater increase in mean errors than was the case for matched messages.[10]

Hedrick conducted a developmental study of the ability of children from pre-school through third grade to respond to competing messages varied in intensity and content. The mean chronological ages ranged from five years to nine years. Male and female voices provided contrast for the signal (the wanted-message) and the distraction (unwanted-message). Messages were varied systematically in intensity and in content. Three signal-distraction relationships were used: +5, 0 and -5. Responses were made by pointing to pictures on a card. The content of the unwanted messages also carried in three ways: both the signal word and the distraction word were found on the response card; the distraction word was not on the response card; and the distraction was a non-sense syllable.

Hedrick drew the following conclusions:

> (a) the accuracy of children's performance increased with age;
> (b) the relative intensity of the unwanted message was the variable most affecting the accuracy of the younger children's listening abilities;

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[10] C. C. Manning, A Study of the Intelligibility of Competing Messages as a Function of Relative Intensity and Message Similarity, Doctoral Dissertation (Seattle: University of Washington, 1964) p. 70.

(c) the content of the distraction message was the variable most affecting the accuracy of the third grade children's listening abilities;
(d) there were no significant differences in selective listening abilities between boys and girls.[11]

Hedrick's findings compare with those of Maccoby and Konrad regarding the increase in ability to select from competing messages, from kindergarten through grade three. Some important differences in procedure should be noted. Maccoby and Konrad presented both the wanted and unwanted messages at the same intensity level, while Hedrick systematically varied the intensity relationships. Maccoby had found that in order to make the task difficult enough, it was necessary to "blur" the messages. Hedrick achieved the necessary range of difficulty with intensity and content variation.

There are implications for both regular and special education in the research on competing messages. For example, hard-of-hearing children have difficulty in the classroom not only with the sound level of the information that is presented but also with any distracting noises (speech or non-speech), that are present. There is also some evidence that children with an apparent minimal type of brain damage have difficulty with a competing message task. Further research is needed to determine whether a tape-recorded competing message test might be developed for use by the classroom teacher or the language specialist as a diagnostic tool for auditory perceptual problems with children who have reading problems or with those who are easily distractible and have difficulty attending to what is being said in class.

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[11] Dona Hedrick, A Developmental Investigation of Children's Abilities to Respond to Competing Messages Varied in Intensity and Content, Doctoral Dissertation (Seattle: University of Washington, 1967).

On the basis of their research, Manning and Hedrick developed a tape-recorded auditory perceptual training program for normal classroom use that was field-tested in several school districts in Alameda County, California, under a Title III ESEA grant.[12] The purpose of the perceptual program was to determine whether elementary and secondary school students could be trained to increase their performance ability identifying correctly spoken messages in the presence of varying kinds and amounts of auditory distraction within the confines of the average classroom.

Manning and Hedrick designed the training tapes with the aim of providing group practice in the following kinds of auditory perceptual tasks: tuning in and attending to designated speech signals; demonstrating vigilant behavior (responding only to specific recurring auditory signals randomly occurring over a period of time in the presence of a continuous and interesting spoken message); demonstrating ability to focus on, track, and discriminate speech signals in the presence of varying kinds and amounts of distraction; and following directions accurately (in the presence of varying kinds and amounts of distraction).

Two sets of lessons have been developed: Level A for grade two and Level B for grade five and secondary classes. Level A consists of a tape-recorded screening test and eleven training tapes. In both the test and the training lessons, the task is to follow oral directions under a variety of competing message conditions. On some tapes a competing speaker gives different directions with no other distractions; in others, environmental noise (whispering or background conversation) are added;

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[12] Belle Ruth Witkin, Programs in Oral Communication: Better Listening for Better Learning, Releasing the Reticent, Alameda County Superintendent of Schools, Haywood, California. U.S. Office of Education Grant No. 4-7-673047-380 (July, 1967).

on a third kind of tape, one speaker reads a story during which a clicker or bell is sounded in the background at random intervals. Whenever the clocker or bell sounds, the child has to perform a task such as drawing a circle around an "X." The most difficult task is that in which the two speakers give competing messages with other distractions such as music or whispering in the background.

The training series consists of eleven tapes, each lesson running from six to thirteen minutes. The distracting conditions are varied in loudness relative to the wanted message, with the loudness relationship built into the tape recording and thus not subject to manipulation of the volume control by the teacher. Because speech is a rapid flow of information, the timing of the tapes is set so that students must respond quickly. Each student is supplied with an answer booklet consisting of drawings of familiar objects, and instructions are such as: "Draw a line under horse. . . . Make an X on tub." The distraction message may consist of the same general instruction with only the last word changed or it may consist of a different instruction. There is a teacher's manual and students are given the opportunity to correct their booklets immediately after each task.

The Level B tapes and pre- and post-tests are similar to Level A except that the task is to choose the correct word either by writing the word or choosing from multiple choice lists. In some lessons, one male and one female voice are used to make the listening conditions easier; in others, two male speakers are used. Phonemic similarity of the competing messages is varied as are the signal-distraction ratios.

This auditory training program has been field-tested in sixteen classes in Alameda County using four grade levels: two, five, eight and eleven and two socio-economic levels. Control classes received pre- and post-tests but no training. Preliminary analysis indicated that the Level A training made a statistically significant difference for the high socio-economic second grade classes. It was found that the Level B lessons were too difficult for many of the fifth grade students, and the results on the eighth and eleventh grade classes were inconclusive.[13]

Part of the difficulty is that previous research of this kind as well as this program has not proven that attention through listening has or will improve auditory perception or improve listening comprehension.

Tracking

Tracking, rate-controlled speech compressed speech is an area of increasing research interest. Until recently researchers found it difficult to vary the rate of recorded speech without alternating the pitch of the recorded voice and thereby destroying the intelligibility of the speech.

One of the first breakthroughs came when Fairbanks, Everitt and Jaeger published the design for a machine that electronically compressed the time required to play tape-recorded speech and still preserve the tonal quality and pitch. Improvements have been made on Fairbank's model. A German design has been produced that will control the speed of the played-back speech by increasing the rate or by slowing it down. Such a tempo regulator can be connected to a regulation tape recorder. Speech compressors can retard speech to half its rate (speech usually ranges from 125 to 175 words per minute) or can accelerate it to about three times its rate.

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[13] L. L. Lasnick, Director, Programs in Oral Communication, Hayward, California 94544.

There are two major steps in the research on the educational implications of rapid listening. Foulke has been a leader in investigating the possibilities of faster information retrieval for blind students.[14,15] Orr, Friedman and Williams published a study on the trainability of listening comprehension of speeded speech for adults with normal vision. They found improvement in the ability to comprehend speeded speech after practice, and that up to a certain amount of compression, the practiced group showed improvement in comprehension and speed.[16]

Haley experimented for one month with text-book material compressed to 175 words per minute with high school senior English students having visual handicaps. Considerable improvement in comprehension was found but the students' attitudes toward compressed speech were varied (favorable toward prose, unfavorable toward poetry).[17]

Foulke and co-workers found that the comprehension of blind children was maximum at rates as high as 275 words per minute.[18]

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[14] E. Foulke, The Comprehension of Rapid Speech by the Blind, Part II, Final Progress Report, 1 September 1961 to February 29, 1964. U.S. Office of Education Cooperative Research Project No. 1370, Performance Research Laboratory, Department of Psychology, University of Louisville (Louisville, Kentucky, 1964).

[15] E. Foulke, "The Retention of Information, Presented at an Accelerated Word Rate," International Journal for the Education of the Blind, XVI (1966), 11-15.

[16] D. B. Orr, H. L. Friedman and Jane C. Williams, "Trainability of Listening Comprehension of Speeded Discourse," Journal of Educational Psychology, LVI (1965), 148-56.

[17] R. Harley, "An Experimental Program in Compressed Speech at the Tennessee School for the Blind," ed. E. Foulke, Proceedings of the Louisville Conference on Time Compressed Speech, October, 1966 (Louisville, Kentucky: Center for Rate Controlled Recordings, University of Louisville, 1967), pp. 63-66.

[18] E. Foulke and Co-workers, "The Comprehension of Rapid Speech by the Blind," Exceptional Children, XXIX (1962), 134-41.

(Braille reading is 90 words per minute and the average rate of recordings for the blind is 175 words per minute.) Foulke and Stricht also showed that moderate compression of speech (250 to 275 words per minute) appeared practical for blind students. Mean intelligibility scores as high as 84 per cent were found for compressed speech at 425 words per minute. There was also a high correlation between ability to comprehend compressed speech and reading rate.[19]

Woodcock and Clark evaluated the differences in comprehension of elementary school children of narrative passages recorded at rates from 78 to 428 words per minute. It was found that listening rates most efficient for learning as well as retention varied between 228 to 328 words per minute rather than the rate of 178 words per minute usually considered average.[20] Stricht found similar results with enlisted men.[21] Both Barbasz's[22] and Gerber's[23] results support the intelligibility of compressed speech.

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[19] E. Foulke and T. G. Sticht, "A Review of Research on Time Compressed Speech," Proceedings of the Louisville Conference on Time Compressed Speech, October, 1966 (Louisville, Kentucky: Center for Rate Controlled Recordings, University of Louisville, 1967), pp. 3-20.

[20] R. W. Woodcock and Charlotte R. Clark, "Comprehension of a Narrative Passage by Elementary School Children as a Function of Listening Rate, Retention Period, and I.Q.," Journal of Communication, XVIII (1968), 259-71.

[21] T. Sticht, "Use of Compressed Speech for Military Training Purposes," Center for Rate Controlled Recordings Newsletter (Louisville, Kentucky: Center for Rate Controlled Recordings, University of Louisville) II (1968), 2-3.

[22] A. F. Barabasz, "A Study of Recall and Retention of Accelerated Lecture Presentation," The Journal of Communication, XVIII (1968), 283-87.

[23] S. E. Gerber, "Dichotic and Diotic Presentation of Speeded Speech," Journal of Communication, XVIII (1968), 272-82.

Normal listeners were found to prefer speech at 30 per cent time compression by Zemlin, Daniloff and Shriner. They found that blind students prefer 35 to 40 per cent time compression. They conclude:

> If the generalization is made that both the normal-sighted and the blind have an initially similar conception of the difficulty of speech, then it is clear that the blind tolerate speech at conditions rated three or four times higher in difficulty relative to normal in exchange for increased rate of flow of information.[24]

They state, too, that listeners may tolerate additional time compression provided that the readers are male, possibly because of the alteration of the phonetic quality in the female voice when at higher rates of compression.[25]

The central auditory abilities of children in normal and lower reading groups of primary elementary grades were studied by Flowers. He gave four perceptual tests: low-pass filtered speech, compressed speech, accelerated and filtered speech combined and competing messages. The competing messages were word lists and a children's story presented at a zero decibels signal/distraction ratio. The accelerated speech was presented at 280 words per minute. He found significant differences between the two reading groups in filtered speech, accelerated speech, and competing messages.[26]

Flowers concludes that the measures of tracking and compressed speech: ". . . may have prognostic and limited diagnostic value with

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[24] W. R. Zemlin, R. G. Daniloff and T. H. Shriner, "The Difficulty of Listening to Time-Compressed Speech," Journal of Speech and Hearing Research, XI (1968), 869-74.

[25] Ibid., p. 879.

[26] A. Flowers, Central Auditory Abilities of Normal and Lower Group Readers, U.S. Office of Education Cooperative Research Project S-076, State University of New York (Albany, New York, 1964).

respect to reading achievement and/or disability."[27] The measures may be used to provide early identification of children who may have difficulties in learning phonics.

In general, research reports that children and adults find some accelerated speech intelligible and comprehensible at about 275 to 300 words per minute range. Subjects can learn to comprehend compressed material through practice listening tasks. High level motivation is a key factor during practice sessions. No particular practice method is mentioned in the research. However, Orr and Freedman state that spaced practice is more efficient than massed practice.[28]

Further research is needed to explore the relationship of learning and reading. Orr points out that one of the most important areas of the unknown of learning, concerns the relationship of comprehension of accelerated speech to the broadening theory of human information processing and language processing:

> . . . the use of compressed speech as a tool to study the basic nature of human information processing provides a degree of control over a dimension of human communication hitherto determined exclusively by natural conditions. It might be hypothesized, for example, that with control over the rate of stimulus presentation, it might be possible to force responses indicative of the nature of the auditory mediating processes. It may also be possible to probe more deeply into the assumed parallelism of auditory and visual information and acquisition processes. Certainly, clear differences exist (e.g., internal versus external pacing of the input, and serial versus quantum input), but what are the implications of these differences for the processing phenomenon itself?[29]

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[27] Ibid., p. 20.

[28] D. B. Orr and H. L. Friedman, "Effect of Massed Practice on the Time-Compressed Speech," Journal of Educational Psychology, LIX (1968), 6-11.

[29] D. B. Orr, "Time Compressed Speech--A Perspective," Journal of Communication, XVIII (1968), 288-92.

The rate of thought processing is approximately five times the rate of speech. Nichols found that good listeners use this time gap more efficiently than poor listeners.[30] Compressed speech might be used to train listeners to attend to and to track messages more effectively. Orr states that there is no reason to assume that people cannot be taught to think faster or make more efficient use of the time for absorbing and processing information. He suggests use of auditory pacing as a means of studying sensory facility of comprehension and reading improvement through reading and listening at various rates.[31]

There is a use for controlled speech for individuals with speech, language, or dialect difficulties. Slowed speech could be used for speech-sound discrimination, for teaching intonation patterns, and for improving articulation. Rate-controlled speech could be put on tape loops or language master cards to be played at will by the student.

Training in listening to compressed speech might be used to impress habits of attention and rapid retrieval or information which could be transferred to listening in real time.

Auditory Discrimination

Auditory discrimination, the ability to distinguish phonemes, seems to have been the most thoroughly investigated aspect of auditory perception. Much remedial speech work centers on discrimination of various kinds. The phonetic inventory is a test of speech-sound

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[30] R. G. Nichols, "Factors Accounting for Differences in Comprehension of Materials Presented Orally in the Classroom," Doctoral Dissertation (Iowa City: State University of Iowa, 19[illegible]8).

[31] D. B. Orr, "Note on Thought Rate as A Function of Reading and Listening Rates," Perceptual and Motor Skills, XIX (1964), 874.

discrimination and therefore is a most basic diagnostic tool used by a speech therapist.

Auditory discrimination was defined as: ". . . a judgment calling for a distinction or comparison among sounds," by Kronvall and Diehl.[32] They considered this discrimination of phonemic differences as an acquired skill in recognizing the sound structure of one's own native language.

Wepman considered adequate auditory discrimination to be essential for the acquisition of language and for learning to read. He summarizes what speech clinicians have learned over the years about auditory discrimination:

> 1. There is evidence that the more nearly alike two phonemes are in phonetic structure, the more likely they are to be misinterpreted.
> 2. Individuals differ in their ability to discriminate among sound.
> 3. The ability to discriminate frequently matures as late as the end of the child's eighth year. A few individuals never develop the capacity to any great degree.
> 4. There is a strong positive relation between slow development of auditory discrimination and inaccurate pronunciation.
> 5. There is a positive relation between poor discrimination and poor reading.
> 6. While poor discrimination may be at the root of both speech and reading difficulties, it often affects only one of the two.
> 7. There is little if any relation between the development of auditory discrimination and intelligence as measured by most intelligence tests.[33]

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[32] E. L. Kronvall and C. F. Diehl, "The Relationship of Auditory Discrimination to Articulatory Defects of Children With No Known Organic Impairment," Journal of Speech and Hearing Disorders, XIX (1954), 335-38.

[33] J. Wepman, "Auditory Discrimination, Speech, and Reading," Elementary School Journal, LX (1960), 326.

> Children should be studied as they reach school age to determine whether their auditory abilities have reached the level of maturation where they can benefit from phonic instruction in reading or from auditory training in speech. Unless this is done, we will continue to make the error of approaching all children as though they can learn equally well through the same modality. Children who are poor in discrimination will be given the same instruction as others with good discrimination, etc. The need to individualize instruction, at least to the point of grouping visual learners and auditory learners separately at the onset of reading instruction, seems an obvious way to minimize the problem.[34]

Synthetic speech was used to investigate discrimination of speech sounds within as well as across phoneme patterns. Liberman, Harris, Kinney and Lane used this method, finding that it offered the possibility of studying innate as well as linguistically acquired auditory discrimination function. Their tests are basically phonetic rather than phonemic as used by speech clinicians.[35]

Mange constructed an auditory flutter fusion rate test, which is another test of auditory discrimination. This test measures the rate at which rapidly presented discrete bursts of white noise fuse perceptually into a continuous sound. Mange was primarily interested in relating this ability to the functional misarticulation of the sound of /r/.[36] However, the investigation of auditory flutter fusion might lead to a better understanding of auditory perception.

Knowledge of the importance of auditory discrimination in language development and in learning a second language or a variant

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[34] *Ibid.*, p. 332.

[35] A. M. Liberman, Katherine S. Harris, JoAnn Kinney, and H. Lane, "The Discrimination of Relative Onset-Time of the Components of Certain Speech and Non-Speech Patterns," *Journal of Exceptional Psychology*, LXI (1961), 379-88.

[36] C. V. Mange, "Relationships Between Selected Auditory Perceptual Factors and Articulation Ability," *Journal of Speech and Hearing Research*, III (1960), 67-74.

dialect of a first language is particularly crucial for teachers of the disadvantaged and the culturally different. For racial and ethnic minorities who speak a non-standard dialect of English or for whom English is a second language, the acquisition of speech sounds for any dialect is learned early and is well established by the time a child begins school. Omissions, additions, substitutions, or distortions of the speech sounds in the standard dialect may be due to problems of auditory discrimination or to the phonology and morphology of the child's native dialect. Teachers are confused at times as to whether deviant speech patterns are due to faulty articulation, non-standard usage, or the basic linguistic structure of the speaker. There is a need for an inter-disiplinary approach to research in language development and reading development, to utilize the knowledge from speech science, linguistics, and psychology.

Auditory Memory Span

Sounds must be kept in memory and retrieved for an individual to judge whether two or more speech sounds are different or alike. Simultaneous comparisons are not possible. Therefore, auditory discrimination is dependent in part on auditory memory span. Anderson defines auditory memory span as: ". . . the number of discrete elements grasped in a given amount of attention and organized into a unity for purposes of immediate reproduction or immediate use."[37]

There is a lack of experimentation with memory for individual speech sounds. Two tests were devised by Anderson: one that used eight

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[37]V. A. Anderson, "Auditory Memory Span As Tested By Speech Sounds," American Journal of Psychology, LII (1939), 95.

vowels and diphthongs and the second that used six silent consonants.[38] Metraux published norms for children ages five to twelve.[39] Beebe devised tests of nonsense syllables to compare English-speaking children with German-speaking children ages four to eight.[40]

Mange developed an auditory synthesis test composed of phonetic memory tasks. He tape-recorded individual continuant sounds, spliced them together, forming various series of three sounds, containing sounds and sequences which produce a known word. He concluded: "It was assumed that the ability to perform well on this test required an auditory-cortical function of a higher level than that required for auditory-peripheral reception.[41]

A battery of ten tests to analyze the dimentions of phonetic ability in young adults was devised by Witkin. This study was the result of the recognition that there was a wide range of ability among college students in mastering the skills of phonetics which is largely dependent on auditory perception. Witkin postulated the existence of a specialized aptitude, analogous to an artistic or athletic talent, that might be designated as phonetic talent. This she defined as skill in dealing with tasks of sound discrimination, imitation, analysis and synthesis, divorcing speech sounds from orthography and in learning new sounds.

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[38] Ibid., pp. 95-99.

[39] Ruth W. Metraux, "Auditory Memory Span for Speech Sounds of Speech Defective Children Compared with Normal Children," Journal of Speech Disorders, VII (1942), 33-36.

[40] Helen H. Beebe, "Auditory Memory Span for Meaningless Syllables," Journal of Speech Disorders, IX (1944), 273-76.

[41] C. V. Mange, "Relationships Between Selected Auditory Perceptual Factory and Articulator Ability," Journal of Speech and Hearing Research, III (1960), 67-74.

The auditory synthesis test consisted of a series of twenty-four sounds uttered by a speaker in isolation in the order in which they would occur in a word. The sounds in each series were tape-recorded and separated by one-second pauses, with both the volume and pitch kept constant. The subjects were asked to recall the sounds and write the correct word.

Witkin's test was similar to Mange's except that the words increased in length from three to eight phonemes and there were usually fewer sounds than letters. This made the test difficult enough for the college students.

Other tests in Witkin's battery which pertained to auditory memory were the phonetic anagrams and the reversed sounds test. In the phonetic anagrams, the researcher recorded a series of isolated vowels and consonants, ranging from three to five, which could be rearranged to form the sounds of a familiar word, such as one might do with letters in a game of anagrams. The task was to write any word that could be formed from the sounds, using all the sounds heard. The subject had to be able to remember and mentally manipulate sounds without regard for orthography.

In the test of reversed sounds, the subject heard a word spoken and was asked to write a new word made up of the same sounds in the stimulus words but in the reverse order. The subject had to be able to mentally analyze the stimulus word, remember the order and reverse the sounds to form another word. This test involved auditory memory, sorting, comparing, auditory synthesis and the ability to deal with sounds independently of orthography.

Witkin correlated these perceptual tests with measures of academic achievement, age, sex, intelligence, verbal facility and speech experience.

The most striking result of the analysis was the finding that the perceptual tests defined three separate factors of phonetic ability: a general phonetic factor requiring auditory discrimination, auditory memory, vocal control, flexibility in adapting to new speech-sound tasks, and ability to deal with speech sounds independently of orthography; the reverse sounds and phonetic anagrams tests were good predictors of success in learning phonetic transcription; and the auditory perception measures were independent of measures of intelligence, age, sex, articulation ability and school achievement.[42]

Witkin's study showed that there is considerable intercorrelation among auditory perceptual abilities (discrimination, synthesis and memory span). Since speech production is rapid, the auditory perceptual tasks (attention, focussing, tracking, discrimination, sorting, scanning, sequencing) must be accomplished instantaneously. It is easy to see that tasks used in studies that attempt to isolate a single aspect of auditory perception may, in fact, be testing many more abilities.

Auditory Sequencing

Auditory sequencing is the recall of sounds in proper temporal sequence. Sequential speech behavior is necessary for the acquisition of language skills. Words and sentences are a series of sounds presented in proper order: a major dimension of language. The importance of auditory sequencing has been recognized, but little attention has been given it experimentally with children who hear normally.

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[42]Belle Ruth Witkin, "An Analysis of Some Dimensions of Phonetic Ability," Doctoral Dissertation (Seattle: University of Washington, 1962).

McCarthy and Kirk in the Illinois Test of Psycholinguistic Abilities identified psycholinguistic abilities and disabilities in children between the ages of two and one-half and nine. The nine tests in the battery were developed from a communication model which includes channels of communication, levels of organization, and corresponding processes. The test is dependent upon auditory memory in the auditory-vocal sequencing test, resembling a digit repetition test except for difference in intonation, rate of utterance, and repetition of the same digit.[43] Research has been done with this test, particularly in reference to the reading and language abilities of retarded and neurologically impaired children.[44] This research tends to prove that there is some indication that auditory sequential memory impairments are related to reading disabilities.

Aten and Davis studied perception, short-term storage, and oral reproduction of serially ordered verbal and non-verbal auditory stimuli by children with mild or minimal cerebral dysfunction. It is essential to know the strength of these children's auditory-oral channels. Three non-verbal tests were used: rhythmic, pure-tone sequencing, judgment of tonal duration sequence, and rhythmic pure-tone sequence. The stimuli were pure tone rather than speech sounds; responses were made by pointing to appropriate blocks. Subjects were required to repeat nonsense syllables in sequence, digits, multi-syllabic words and oral sequences

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[43] J. J. McCarthy and S. A. Kirk, The Construction, Standardization and Statistical Characteristics of the Illinois Test of Psycholinguistic Abilities, Institute for Research on Exceptional Children (Urbana: University of Illinois, 1963).

[44] Barbara Bateman and Andrea Pickman, Appendix, Bibliography of I.T.P.A. Literature, 1960-1967, Interpretation of the 1961 Illinois Test of Psycholinguistic Abilities (Washington: Special Child Publications, 1968), pp. 97-108.

of syllables and to unscramble sentences composed with random word order in the verbal tests.[45]

The neurologically impaired children, in comparison with a group of normal children, were significantly deficient in performance on all three non-verbal tests: backward-digit span, serial noun span, multi-syllabic word repetition, scrambled sentence arrangement and oral sequential accuracy. Aten and Davis noted that time-ordered difficulties and reduced attention span contributed to the psycho-linguistic problems of language learning.[46]

The researchers also found:

> The greatest clinical significance seemed to be in responses to scrambled sentences. This test undoubtedly measures a similar type of reformulative skill as that demanded by backward repetition of digits, but it requires also the ability to organize in accord with the rules of syntax. . . . It is reasoned that the greater the demand for linguistic retention, the greater the need for an alert and intact cortex.[47]

They conclude:

> . . . the children with minimal or mild brain dysfunction performed more poorly as evidenced in shorter perceptual spans, and less accurate reproduction of sequential information than did a comparison group of normal children.[48]

Auditory perceptual test batteries such as Aten and Davis' have identified deficiencies associated with certain types of functional articulation disorders, dysfluencies and language-learning disturbances.

Some of the tests given in the Atkin and Davis study (backward digits, scrambled sentences) were similar to tasks given by Witkin in the phonetic battery for college students with normal auditory perception, in

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[45] J. Aten and J. Davis, "Disturbances in the Perception of Auditory Sequence in Children with Minimal Cerebral Dysfunction," Journal of Speech and Hearing Research, XI (1968), 236-45.

[46] Ibid., p. 236. [47] Ibid., p. 243. [48] Ibid., p. 244.

which a great deal of variability in accuracy of responses was found between subjects, particularly in the auditory synthesis, reverse sounds and phonetic anagrams tests.[49] The Witkin and the Aten-Davis studies are evidence that perceptual tasks that involve storage, short-term recall, and mental manipulation of auditory stimuli present difficulties not only to neurologically impaired children but to normal adults also.

Short-term storage capabilities of children with non-organic articulation problems were studied by Smith. He used recall of single digit sets, or sequential digit sets, and of digits under a competing message condition. The children with non-verbal articulation problems recalled significantly fewer digits, both in immediate and delayed recall for all three types of digit sets than did the children with normal speech.[50]

Huffman and Reynolds used operant conditioning for training pre-school children to emit a three-sequence response to a three-sequence verbal stimulus. The most efficient procedure found was that of repeating the verbal stimulus continuously in the presence of an appropriate visual stimulus.[51]

First-grade children's auditory memory span was investigated by Locke. The children had to imitate accurately three German syllables tape-recorded by a female, native German speaker. The auditory memory

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[49]Belle Ruth Witkin, Programs in Oral Communication: Better Listening for Better Learning, Releasing the Reticent, Alameda County Superintendent of Schools, Hayward, California. United States Office of Education, Grant No. 4-7-673047-3080, ESEA Title III (July, 1967).

[50]C. R. Smith, "Articulation Problems and Ability to Store and Process Stimuli," Journal of Speech and Hearing Research, X (1967), 348-53.

[51]Lois Huffman and Leija McReynolds, "Auditory Sequence and Learning in Children," Journal of Speech and Hearing Research, XI (1968), 161-78.

ability was tested by a digit-span test. The children with high scores in the auditory memory span test were significantly better at imitating the German syllables than those children with low auditory memory scores. The original tested group was fifty-five per cent male; the low memory span group contained seventy per cent males. There was also an apparent tendency for those with high auditory memory span scores to have higher I.Q.'s.[52]

In the above mentioned study, Locke noted a point of interest for the field of research in auditory perception:

> It should be considered that practically everything a child does while serving as an experimental subject requires some level of attention. An inattentive child may experience some failure not only in the natural learning of articulation and language, but in the research tasks in which he subsequently becomes involved.[53]

Another study of normal primary-grade children was made by Young through special speech reception tests that could eventually be applicable to assessment with language disordered children. The phonetic limits test consisted of oral presentations of polysyllabic words that varied in degree of temporal completeness from one phoneme or syllable to the total word. He found an essentially normal distribution of scores, slightly high toward the right end, showing the task was within the experience of the subjects. Few of the subjects needed the entire word in order to make a correct identification.[54]

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[52] J. L. Locke, "Short-Term Auditory Memory, Oral Perception, and Experimental Sound Learning," Journal of Speech and Hearing Research, XII (1969), 179-84.

[53] Ibid., p. 188.

[54] N. B. Young, "Phonetic Limits of Word Recognition in Children" (Unpublished paper presented to American Speech and Hearing Association, Washington, D.C., November, 1966).

In his implications, Young suggests assessing this skill with children who have severe speech articulation problems.[55] Perhaps this test could be included in a battery of auditory tests including figure-ground, localization, measures of attention and temporal sequence abilities.

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[55] _Ibid._, p. 15.

CHAPTER III

SUMMARY

Research into the aspects of auditory perception (with the exception of speech-sound discrimination) is still in its early stages. There is no generally accepted model of auditory perception. The exact components, the order in occurrence and the inter-relationships are not completely known.

In the attainment of language, listening comprehension and speech, and the development of reading abilities, the individual must focus on and attend to complex auditory stimuli, distinguish figure from ground, track through time, sort, compare, discriminate, remember phonemic elements, and recall sequences. It is difficult to determine the boundaries of the perceptual process. However, there is little doubt that the tasks of listening comprehension (recall of main ideas, critical judgments) cannot be accomplished if there is impairment or dysfunction in any of the perceptual complex.

Current attempts at research in selective listening, namely, using competing messages, has drawn attention to this important factor. Studies of auditory discrimination have shown the relationship of faulty discrimination to speech and reading problems. It has also shown that deficits in memory span and in auditory sequencing affect discrimination.

The application of new technology, such as compressed speech, to educational problems holds considerable promise for the development of new teaching procedures. Most of the educational use of compressed speech has been with the blind as a means for quicker retrieval of information. The research has focused on the intelligibility, comprehension, and retention of rate-controlled speech. There are possibilities for using this technology to investigate the time gap between thought and speech, with the possibility of devising training programs which will increase the listener's ability to follow spoken language with mind-wandering. Whether or not such gains made under compressed speech conditions will transfer to listening in real time needs to be studied.

Some important questions remain to be answered for education. Some children learn better auditorially than visually. Therefore, auditory educational methods should assume a larger role in the educational process. The use of audio-visuals is growing, as well as tele-lectures, dial-access tape lectures, computer controlled instruction and other types of auditory presentations.

The field of auditory learning presents difficult conceptual and methodological problems. Joint effort among specialists in language development, linguistics, psychology, speech pathology and education would yield valuable information for language development.

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