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THE EFFECT OF AUDITORY DELAY, AGE, AND SEX ON
THE TOTAL LENGTH OF INFANTS' VOCALIZATIONS

Dissertation

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

Patricia Ball Hubbard, B.S., M.A.

* * * * *

The Ohio State University
1971

Approved by

Sheila M. Roff
Adviser
Department of Speech
VITA

March 27, 1942 . . . Born - Zanesville, Ohio

1961 . . . . . . . A.A., Stephens College, Columbia, Missouri

1963 . . . . . . . B.S., The Ohio State University, Columbus, Ohio

1965-1966 . . . . V.R.A. Trainee, Department of Speech The Ohio State University, Columbus, Ohio

1966 . . . . . . . M.A., The Ohio State University, Columbus, Ohio

1966-1968 . . . . Graduate Assistant, Department of Speech, The Ohio State University, Columbus, Ohio

1968-1969 . . . . Teaching Associate, Department of Speech, The Ohio State University, Columbus, Ohio


1970-1971 . . . . Speech Pathologist, Hearing and Speech Center of Columbus and Central Ohio, Columbus, Ohio

FIELDS OF STUDY

Undergraduate Major: Psychology

Graduate Major Area: Speech and Hearing Science

Graduate Minor Area: Experimental Psychology
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CHAPTER I

INTRODUCTION

Normal infants progress through developmental stages in the acquisition of speech and language. Early in life, their speech behavior is characterized by vocalizations which reflect their progress in the process of speech and language acquisition. During the first few months, their vocalizations are reflexive in nature and are responses to external and internal stimuli. The infant gradually learns to enjoy his own vocal behavior and engages in the vocal activity for its inherent pleasure. Infants' vocalizations later include meaningful words as development continues.

Some infants do not follow the normal pattern of speech and language acquisition. Infants who are deaf begin vocalizing but because of limited feedback to the auditory system lose interest in their own vocalizations and reduce the quantity of their vocal output. Their ability to profit from external stimulation from adults in the environment is limited by their auditory deprivation. Infants with reduced intellectual ability which is characteristic of mental retardation are limited in their
ability to utilize ordinary external stimulation for learning speech and language. Some infants are reared in institutional environments where speech and language stimulation is minimal. Other environments, such as are provided by certain socio-economic levels, resemble an institutional environment in the amount of stimulation provided to the infant. The infants do not receive sufficient stimulation from their environment for normal acquisition of speech and language. The result may be a deficit in speech and language.1,2


Vocalizations during the prelinguistic period are important to the infant. Normal infants typically engage in vocal play for its inherent rewards during the prelinguistic period. This period is the time when the infant experiments with the mechanisms involved with phonation, articulation, and respiration and develops associations between auditory and kinesthetic feedback.3 Vocal stimulation from parents is also

important to the infant. Parents are encouraged to

stimulate their infants by speaking to them as much as possible. Maximal stimulation from environmental sources is particularly important for those infants with a deficit in speech and language as the result of a hearing loss, intellectual deprivation, or environmental deprivation. A specific recommendation to parents or parent-substitutes is often to echo back to their infants the utterances that they have previously produced. This practice may be

sufficient to encourage the acquisition of speech and language in the normal infant, but the need for supplemental stimulation to facilitate the normal developmental process of speech and language acquisition exists in those infants who have experienced a deprivation. A problem may exist when the mother must concentrate on work activities in the home or outside the home and the child does not receive the amount of vocal stimulation that he might require. A replacement of or supplement to a mother's stimulation may be produced by other techniques.
Methodologies Specific to the Facilitation of Vocalizations

Several techniques have been examined for the facilitation of vocalizations that normally occur during the prelinguistic period. The use of visual feedback was found to sustain the interest of deaf infants in their vocal play and babbling. Increased visual stimulation with mirrors suspended over the cribs of deaf infants was effective in increasing their babbling.6

6Ibid., p. 79.

A method of delayed auditory feedback was employed by Copeland7 as a facilitator of vocalizations produced by eighty-eight retardates. These children were classified into two groups on the basis of their Wechsler Intelligence Scale for Children scores: a high verbal group, mean age of 14.6 years, mean WISC score of 60; and a low verbal group, mean age of 12.6 years, mean WISC score of 47. Two conditions, each five minutes in length, were employed. Auditory feedback was delayed 1.0 second in one condition, and in the other condition, electronically mediated
feedback was absent. The frequency of vocalizations increased significantly during the condition of delayed auditory feedback for both groups.

An attempt to counteract the detrimental effects of an early institutional environment was reported by Rheingold and Bayley. An experimental group of eight infants was given more attentive care for 7-1/2 hours per day between the ages of 8 and 10 months. A control group of eight infants was reared under routine institutional care. At the end of the two-month period, the experimental group differed from the control group on the measure of social responsiveness. A follow-up study was attempted when the infants were 22 months of age. Fourteen of the infants were located. Seven had been in the experimental group and seven in the control group. All were in foster homes except for one child. The only difference obtained between the groups was on the measure of amount of verbal behavior. More of the experimental subjects vocalized during the social tests.

Conditioning procedures have succeeded in increasing the quantity of vocalizations by orphanage infants during the prelinguistic period. The conditioning of the vocalizations of twenty-one institutionalized
infants was attempted by Rheingold, Gewirtz, and Ross.\footnote{Harriet L. Rheingold, Jacob L. Gewirtz, and Helen W. Ross, "Social Conditioning of Vocalizations in the Infant," Journal of Comparative and Physiological Psychology, 52, 1959, pp. 68-73.}

The median age of the infants was 3.0 months, and the experimental period was six days in length. The measure employed was the number of vocalizations produced by the infant in a three-minute period. On the first and last two days of the six-day period, the experimenter leaned over the crib with an expressionless face. On the middle two conditioning days, the experimenter's response to each vocalization was smiling, clucking, and touching the infant's abdomen. An observer counted the vocalizations. A significant increase in the mean number of vocalizations occurred from the second baseline day to the first conditioning day and from the first conditioning day to the second conditioning day. A decrease in vocalizations was noted on the first extinction day, and no differences in the number of vocalizations were obtained between the second extinction day and the second baseline day. The authors concluded that infants' vocalizations can be conditioned in a social situation, that the experimenter's responses are effective as a reinforcing stimulus, and that conditioning can occur in a three-month old infant. A
related study was designed by Weisberg\textsuperscript{10} to determine if
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due vocalizations of three-month old infants could be conditioned, if a non-social stimulus is an effective reinforcer, and if the reinforcing stimulus must be contingent on the infants' vocalizations to increase them. The non-social stimulus, a doorchime, was not effective, while the experimenter's reactions, similar to those used in Rheingold, Gewirtz, and Ross's study, increased the infants' vocalizations only if this reaction was contingent on their vocalizations. The effect of the presence of an adult during the conditioning process was investigated by Todd and Palmer\textsuperscript{11} who selected sixteen


institutionalized infants between 75 and 100 days of age as subjects. Vocalizations were counted for six days, two baseline days, two conditioning days, and two extinction days. During the baseline and extinction days, the child was alone for the recording. During the conditioning days, a vocalization activated a recording of an adult, female speaker saying, "Hello, baby," "Pretty baby," and "Nice baby." For half the subjects, an adult was present during
the conditioning days. Both groups increased their vocalizations significantly during conditioning, and the group conditioned in the presence of an adult showed the greatest increase in vocalizations.

The effects of reinforcing categories of speech sounds, vowels and consonants, were investigated by Routh.¹²


Thirty infants from an institution and from homes were divided into three experimental groups with ten infants in each group. These infants were between two months and seven months of age. After two days of baseline measurements recorded with an unresponsive adult present, three conditioning procedures were employed for three days. Reinforcement was similar to that used in Rheingold, Gewirtz, and Ross's study. This reinforcement was contingent on vowel sounds for one group and on consonant sounds for a second group. Reinforcement was provided for each vocalization for the third group. All three groups increased their vocalizations during the conditioning days. More consonant sounds were produced by the group who received reinforcement contingent on each consonant sound, while the group reinforced for the production of vowel sounds increased their production of vowel sounds.
In developing a method which could be applied to infants who have experienced a deprivation known to delay speech and language development, Goff and Hubbard\[^{13,14}\]


experimented with increasing the length of vocalizations of normal infants by a method of delayed auditory feedback in the manner of Copeland.\[^{15}\] Twenty infants, fifteen males and five females, were subjects for the study. Infants' vocalizations were recorded during three separate home visits. The infants played in their playpens during the recordings. A loudspeaker provided delayed auditory feedback of the infants' vocalizations. The results of the study indicated that the method of delayed auditory feedback is effective as a facilitator of the length of infants' vocalizations during the age interval studied, 10 to 12 months. The length of infants' vocalizations increased significantly from an initial condition without experimentally induced delay in auditory feedback to conditions of 0.5 second and 1.0 second delay in auditory feedback.
feedback. A significant increase from the initial condition of normal auditory feedback to another condition of normal auditory feedback which was randomized with the two conditions of delayed auditory feedback in the recording programs suggested a persistence of the stimulating effect of delayed auditory feedback on the length of infants' vocalizations.

Using the tape recordings of the infant vocalizations from the study by Goff and Hubbard, Ouzts examined the effects of the two conditions of delayed auditory feedback, 0.5 second and 1.0 second, on the fundamental pitch and pitch range of the infants' vocalizations. The mean fundamental pitch values of the infants' vocalizations increased under conditions of 0.5 second delay in auditory feedback. The fundamental pitch range of the infants' vocalizations increased during both conditions of auditory feedback.

Thirty infants were studied by Goff, Buxton, and Hubbard to determine the effect of four conditions of
delayed auditory feedback and five conditions of normal auditory feedback on the intensity of infants' vocalizations. It was found that the intensity of the infants' vocalizations increased for three conditions of delayed auditory feedback, 140 milliseconds, 250 milliseconds, and 1,000 milliseconds, and for the condition of normal auditory feedback always presented last in the recording program.

**Purpose of Study**

The purpose of the study was to apply a methodology of delayed auditory feedback to the facilitation of infants' vocalizations and to determine the effect of conditions of auditory feedback, age of infant, and sex of infant on the total length of infants' vocalizations. A delayed auditory feedback unit was employed to return the vocalizations back to the infants in the manner of Copeland and Goff and Hubbard.

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18Copeland, *op. cit.*

19Goff and Hubbard, *op. cit.*

The methodology employed in the study by Goff and Hubbard was modified to reduce the subjective aspects of the recording process. The manner of returning the infants' vocalizations during the conditions of delayed auditory feedback was changed from a loudspeaker to a set of earphones. A change in the recording environment from
the infants' homes to a sound-treated room reduced the environmental variables operating during the recording sessions. Instead of recording during three separate home visits, the recording of each infant's vocalizations was accomplished during one session.

Four conditions of delayed auditory feedback were investigated. Since methodology was altered, the conditions of 0.5 and 1.0 second delay in auditory feedback were included in the recording programs. Two conditions of delayed auditory feedback were added for investigation, 140 milliseconds and 250 milliseconds, so that the importance of a latency period between a vocalization and its repetition could be considered. A condition of normal auditory feedback preceded and followed each condition of delayed auditory feedback. In order to consider the possibility of a critical age range for the presentation of a facilitation method, three age groups of infants were studied: 6 to 9 months, 10 to 12 months, and 13 to 16 months. Five females and five males were selected for each age group so that sex of infant could be considered.

**Experimental Questions**

The following experimental questions were asked:

1. Is there a change in the total length of vocalizations that infants produce during conditions of normal auditory feedback and conditions of delayed auditory feedback?
2. Does the age of the infant make a difference with respect to the total length of vocalizations under conditions of normal auditory feedback and conditions of delayed auditory feedback?

3. Does the sex of the infant make a difference with respect to the total length of vocalizations under conditions of normal auditory feedback and conditions of delayed auditory feedback?

**Definition of Terms**

**Vocalization** is defined as any utterance, phonated or non-phonated, produced by the infants that was not a vegetative sound nor a crying type of vocalization.

**Delayed auditory feedback** is defined as the auditory feedback that occurred when the infants wore earphones.

**Normal auditory feedback** is defined as the auditory feedback that occurred when the earphones were removed from the infant's head.

**The length of infants' vocalizations,** the criterion measure employed in the study, is defined as the total length of vocalizations produced within a unit of time.

**Summary**

This chapter contained a discussion of the need for techniques that could be employed for the facilitation of speech and language acquisition. Several techniques
that have been tried for the facilitation of vocalizations that normally occur during the prelinguistic period were described. The purpose of the study was stated, and the experimental questions were presented. Special terms were defined for the purposes of the study. In Chapter II are a discussion of the normal development of speech and language and summaries of studies that are related to infant vocalizations during the prelinguistic period and to the effect of delayed auditory feedback on the speech behavior of children. Chapter III contains a discussion of the subjects, equipment, and procedures employed in the study. A description of the statistical analysis and results are included in Chapter IV. A summary of the study is presented in Chapter V.
CHAPTER II

RELATED LITERATURE

The purpose of the study was to investigate the effect of conditions of auditory feedback, age of infant, and sex of infant on the total length of infants' vocalizations. In this chapter are found a discussion of the normal development of speech and language and summaries of some of the studies that are related to infant vocalizations during the prelinguistic period and to the effect of delayed auditory feedback on the speech behavior of children. The discussion of the normal development of speech and language encompasses the prelinguistic period and the linguistic period. Studies of infant vocalizations during the prelinguistic period reveal an interest in their sound repertoires, the instrumentation employed for analysis of their non-crying vocalizations, their crying vocalizations, and the prosodic features of their vocalizations. The effect of delayed auditory feedback on both crying and non-crying vocalizations of children has been investigated.
Normal Development of Speech and Language

The speech and language behavior of infancy and childhood is comprised of two stages: prelinguistic and linguistic. During the prelinguistic period, utterances neither convey meaning to another person nor have a specific referent. During the linguistic period, utterances evoke responses from other individuals and have specific referents.²⁰


Throughout the first year of life, successive stages of vocal behavior are believed to be continuous until the child uses meaningful words. The vocalizations during the first two months of life are reflexive sounds and can be related to changes in the physiological condition of the infant or to environmental stimuli. After the third month, the establishment of feedback is evident in the infant's ability to stimulate its own vocal behavior. The following developments in vocal behavior occur after the sixth month: babbling becomes more regular in rhythm and is composed of repetitions of similar sounds; self-stimulation is observed, as only the speech of a significant person will interrupt the infant's babbling; inflectional patterns are added; and commonly used syllables are repeated, for example, mama, dada.
byebye, in babbling but not yet as responses to the stimulation of others. The last months of the first year of life are characterized by the child's beginning to react to others' speech with attempts at imitation. The adult can become an important part of the learning process in speech and language acquisition at this point, as the child will now increase his imitative responses if an adult interrupts his vocal play by saying the sound that he is using.21


Three stages of imitation are distinguished during the first year of life. The earliest stage of imitation appearing in the third or fourth month of life is rudimentary imitation, as the infant responds to speech with vocal behavior that is not an attempt to replicate the heard speech. The second stage is an absence of imitation when the infant is attending more to the circumstances of the speaking situation than to the speech itself. The third stage begins during the last few months of the first year when the infant attempts to reproduce the sound pattern that he hears.22

The stages of vocal behavior during the first year of life are explained in terms of the development of feedback loops: internal audiovocal loop, external audiovocal loop, external feedforward loop, and environmental feedforward loop. During the first two months, the internal audiovocal loop is open, as the infant demonstrates no evidence of self-hearing. The effect of the environmental feedforward loop during the first two months is observed in infant reaction to environmental noise. The external feedforward loop is evident during the first two months as the infant's cry causes adults in the environment to react. At three months of age, the environmental feedforward loop develops further, as the infant responds more differentially to auditory stimulation. The external feedforward loop continues to develop after the third month, as the infant begins to produce sounds for the purpose of eliciting parental reactions. The closing of the internal audiovocal loop is evident after the third month in the child's reaction to self-produced sounds. The internal audiovocal loop closes after the ninth month, as the infant repeats his own sounds. The development of the environmental feedforward loop continues after the ninth month, as the infant begins to react to certain spoken words and attempts to imitate sounds. The
echolalic period indicates that both the external and the internal audiovocal loops are closed.  

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The mechanisms that will be needed for speech and language during the linguistic period are tested by the infant during the prelinguistic period in his vocal play and babbling. The infant learns to combine phonation with articulation and gains control of the respiratory system. Associations are developed by the infant between the kinesthetic and the auditory sensations that occur as a consequence of vocalizations.  

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24 Fry, *op. cit.*, pp. 188-190.

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The transition from the prelinguistic period to the linguistic period is difficult to explain. A biological-nativistic approach and a learning theory approach are two major ways to account for language acquisition.  

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of theory construction has produced arguments which appear to be "needlessly extreme" and that there is a need
for researchers to attempt to combine the two major approaches.\textsuperscript{26}

\textsuperscript{26}Ibid., p. 150.

From a biological-nativistic point of view, Lenneberg\textsuperscript{27} discussed the onset of speech and language as consisting of "a gradual unfolding of capacities."

He believes that language is "the manifestation of genetically-determined, species-specific capabilities" and that the prelinguistic period is not a practice period for future linguistic development. Rather, he stated: "Certain important speech milestones are reached in a fixed sequence and at a relatively constant chronological age."\textsuperscript{28}


\textsuperscript{28}Ibid., p. 127.

Learning theory approaches are exemplified by Mowrer's autistic theory,\textsuperscript{29} Jenkins and Palermo's mediation

\textsuperscript{29}Hobart Mowrer, "Hearing and Speaking: An Analysis of Language Learning," Journal of Speech and Hearing Disorders, 23 1958, pp. 143-152.
theory, and Braine's contextual generalization theory.

Mowrer based his theory on principles of stimulus-response learning and on the concept of reinforcement. The acquisition of words comes about through the association of spoken words with affectionate care. Reproduction of words that the parent has uttered becomes a self-rewarding, autistic process. Jenkins and Palermo posited that a child acquires language by learning grammatical classes of language. Braine theorized that sentences produced by a child during the early stage of language learning are words attached to pivot words. A child experiences a phrase, learns the position of the pivot word, and generalizes to other contexts.

Black discussed the acquisition of communicative behavior in terms of a learning process. He suggested that the traditional explanation of what occurs in the initial stages of word and sentence learning is adequate, while the learning of rules, rather than more elemental
units of language, can account for later development. In this essay, Black presented a modification of a model of the speech mechanism as a closed cycle servo-system.  


This system employs feedback of the output to the place of control, comparison of output and input, and adjustment of the output to correspond to the functional form of the input. Black's modification is composed of two servo-systems which interact. In the speech acquisition process, one servo-system corresponds to the infant, while the second servo-system corresponds to an adult, generally a parent. The second person's monitoring system can operate to shape the infant's developing vocal behavior by comparing the infant's output to his own output. Similarities are reinforced, and differences are extinguished.

The stage of word acquisition marks the beginning of the linguistic period of language development. According to Darley and Winitz, 34 studies investigating


the appearance of the first word indicated that the average child uses his first word by approximately one year of age. During the period between 12 and 18 months, the child
acquires ten or twenty meaningful words. Jargon and echolalic responses are frequently heard during this period.\textsuperscript{35} Following this period, the linguistic areas of phonology, morphology, syntax, and semantics have been the topics of study.

Phonology has been studied from two standpoints: mastery of speech sounds and acquisition of phonemes. The development of the mastery of speech sounds in words was investigated by Poole\textsuperscript{36} and more recently by Templin.\textsuperscript{37}

The subjects for Templin's investigation were 480 children, 30 of each sex at eight age levels from three to eight years of age. Pictures were employed to elicit 176 sound elements for each child. A sound was considered mastered if 75 per cent of the children at each age level could articulate it correctly. Jakobson and Halle\textsuperscript{38} hypothesized that the child learns progressively more difficult phonemic contrasts. They suggested an orderly sequence of learning.
these contrasts in terms of their distinctive feature analysis of the phoneme. The simple differentiation of vowel and consonant is learned first, and the more complex differentiations are learned gradually.

The development of morphological rules was studied by Berko. The subjects for her study were preschool age children and first grade children. She employed nonsense words to test the child's ability to apply morphological rules. Significant differences in favor of the first grade children were obtained. Berko concluded that the ability to apply morphological rules increases with age.

Brown and Bellugi studied the development of English syntax by two children between 18 and 36 months of age. They visited each child at home every second week for at least two hours and made a tape recording and a written transcription of everything said to the child and by the child. Important actions and objects of attention were noted in the written transcription. Three processes were observed in the development of syntax: reduction, expansion, and induction of latent structure.
Approaches to the study of semantics of language development have differed. Ervin\textsuperscript{41} investigated the verbal determinants of word-association as a function of age.

Osgood, Suci, and Tannenbaum\textsuperscript{42} proposed the semantic differential as a technique for quantitative measurement of meaning.

**Studies of Infant Vocalizations**

Description of articulation and counts of vocabulary words were commonly employed for studying the progression of speech and language development. In attempting to describe articulatory development, Darwin\textsuperscript{43} listened to the vocalizations of his infant son. Darwin reported that his son began making sounds for pleasure when he was 46 days of age. He noted that one of the first sound combinations produced by his son was "da" at 5-1/2 months of age.


A collection of diary records, phonetic transcriptions, and vocabulary counts were published by Leopold\textsuperscript{44} who studied the utterances of his two daughters.


Three of the published volumes contain information about the speech and language development of his daughters from birth to two years of age. One of these volumes is devoted to articulatory development in a day by day account. Another volume contains a record of vocabulary development.

A series of articles based on two observers' phonemic transcriptions of infants' utterances were published by Irwin.\textsuperscript{45,46,47} Profiles and curves were presented in these articles to illustrate the developmental sequence of vowel sounds, consonant sounds classified according to place of articulation, and consonant sounds classified according to manner of articulation. The
contribution of each sound to the total consonant utterance was determined at each of the fifteen two-month age intervals studied. Irwin reported that velar and glottal sounds constitute about 98 per cent of the consonant sounds produced during the first months of life, that plosives and fricative sounds occur more frequently than semi-vowels or glides during the first year, and that front and middle vowels predominate during the first year, with back vowels increasing during the next one-and-one-half years.

The value of the magnetic tape recorder and the sound spectrograph was explored by Lynip\(^{48}\) who utilized these instruments to collect and analyze the vocalizations of one infant from birth to 56 weeks of age. Critical evaluation of Irwin's method of phonemic transcription was made, as Lynip's results indicated that the infants' utterances did not include any sound that was comparable to an adult's vowels or consonants until the end of the first year when his sounds began to approximate those produced by an adult. Lynip published the spectrographic records which support his conclusions.

Spectrographic analysis was employed by Winitz⁴⁹ to determine the formant frequencies of thirty-one vowels that were produced by five infants from 9 to 15 months of age. The particular vowel produced was agreed upon by at least seven judges prior to the spectrographic analysis. The frequencies of formant 1 and formant 2 were plotted and then compared to the same plotting for adult vowels. The infant vowels as a group were displaced upward and to the right of the adult vowels. Some overlap among formant frequencies of different vowels was noted. Winitz considered his results indicative of the inadequacy of the sound spectrograph for the analysis of infant vocalizations.

A Sono-Graph was utilized by Murai⁵⁰ for the analysis of the recorded vocalizations of four infants from 2 months to one year of age. Murai reported that the sound repertories of the infants increased daily and that this increase was reflected in great increases in the variation of the sono-graphic patterns with changes in the position of resonance and in the appearance of shorter utterances.


A tendency for sound development to proceed according to the law of the least physiological effort was noted. Murai reported an increase in resemblance between the infants' sounds uttered after their parents' sounds from the eighth to the eleventh month.

The crying vocalizations of forty infants, twenty boys and twenty girls, were studied by Irwin and Curry.51

The vocalizations of the infants during the first ten days of life were recorded phonetically by two observers. The average agreement between observers was reported as 85 per cent. Their results included the following: 92 per cent of the vocalizations were front vowels, 7 per cent were middle vowels, and 1 per cent were back vowels; the most frequent occurring vowels were /i/, /ɛ/, /æ/, and /ʌ/; the most frequent occurring vowel was /æ/; /i/ and /ɛ/ were the least frequent front vowels observed. Sex and age differences were not obtained. The authors concluded that vowel sounds develop from the front of the mouth to the back.

The hunger wails of one male infant were recorded phonographically by Fairbanks.52 The recordings were made

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on the infant's monthly birthdates from birth to nine months of age. Acoustical analysis of the pitch of the hunger wails was accomplished with an instrument developed for phonophotography and fundamental frequency measurement from phonograph records. Fairbanks reported that the analysis revealed an upward trend in the central tendency of the hunger wails during the first half of the nine-month period followed by a fairly consistent high level. The mean pitch of the wails was 556 Hz with a range of about five octaves.

In comparing the voices of twins, monozygoes and dizygotes, Ostwald recorded the spontaneous cries of sixteen pairs of twins during the first month of life. Analysis was accomplished with an half-octave band Sound Analyzer. Phonetic comparisons were made. The results of the statistical analysis were reported. No significant correlation was obtained between intra-pair similarity and monozygosity nor between intra-pair difference and dizygosity.

Normative data on the fundamental frequency, harmonic spectrum, duration, and sound pressure characteristics of the elicited cries of ten neonates were collected
The cries were recorded from 4 to 40 hours after birth, and a sound spectrograph was employed in the analysis. The authors reported that the infants differed significantly from each other on the measures of fundamental frequency and sound pressure level. An average cry was described as having a fundamental frequency of 413 Hz, a duration of 1.57 seconds, and a sound pressure level of 82.13 dB. The procedures used in this study were reported as suitable for studying infant cry and were recommended for use in similar investigations.

An attempt to develop a method for objective acoustical analysis and evaluation of infant cry was made by Truby and Lind. Cries were elicited from thirty infants between one and twelve days of age. The authors classified the cries into three types after spectrographic and oscillographic analysis: basic cry or phonation, turbulence or dysphonation, and shift or hyperphonation. A recording of each type of infant cry was made. This
record accompanies the publication. Spectrographic records included in the article permit comparison between acoustical and visual phenomena. The authors reported that not only were each infant's cries individual but that each cry sound was physically different from every other. The use of "cryprints" for classifying neuro-motor state of neonates was suggested.

Recordings of all the vocalizations produced by one male infant and one female infant during the first five months of life were collected by Lane and Sheppard.56

They were interested in the development of the acoustic correlates of the prosodic features of speech: duration, intensity, and fundamental frequency. Computer analysis was employed in the investigation. The authors presented graphs that describe the development of the three prosodic features as a function of age.

The pitch characteristics of the voices of six children between 12 and 24 months of age were studied by McGlone.57 He compared his results with data obtained in


other studies about the pitch of the vocalization of neonates and about the pitch of the voices of older preadolescent children. The author reported that the mean pitch level for his subjects was slightly higher than the level reported for the other age groups. McGlone's subjects had a greater pitch range than the neonates. This pitch range was similar to the pitch range of the group of older children nearing puberty.

In studying the effect of the intonational patterns used by adults on her daughter's use of intonational patterns in the utterance of her first words, Pike found that her daughter altered her inflectional patterns to resemble those used by adults in her environment. Pike's daughter altered her rising intonational pattern used on these words to correspond to the falling intonational pattern which was intentionally used by her parent. A return to the child's former pattern of a rising inflectional pattern on her first words was observed by Pike after her daughter had spent some time with another family who were unaware of the experiment and used the rising intonational pattern on these words. When Pike's daughter returned to her home environment where falling inflectional patterns were used on certain words, the child again altered her pattern.

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The Effect of Delayed Auditory Feedback on the Speech Behavior of Children

Among the first to examine the effects of delayed auditory feedback on the speech behavior of children were Chase, Sutton, First, and Zubin. Two conditions of auditory feedback were employed in the study: a voice amplified synchronous condition and a 200 millisecond delay condition. Measures of word rate, percentage of words repeated, percentage of syllables prolonged, percentage of intrusions, and percentage of syllables repeated were collected. The statistical analysis indicated that the twenty-six younger children, ages 4 to 6, were less affected by delayed auditory feedback than were the twenty-eight older children, ages 7 to 9, on the measures of word rate and percentage of syllables prolonged. Vocalization was elicited by asking the child to draw a man and then to tell a story about the picture. The authors reported that the older group expressed more awareness of the time delay involved and were more certain that they were hearing their own voices returned to them through the earphones than were the younger group.

Two auditory feedback conditions were employed in a study of four groups of children by Ratner, Gawronski,
and Rice. Each subject repeated a sentence under a synchronous feedback condition and under a delayed speech feedback condition of .63 second. The four male age groups consisted of Group I, from 6 years 9 months to 7 years 9 months; Group II, from 8 years 6 months to 9 years 11 months; Group III, from 10 years 7 months to 11 years 9 months; Group IV, from 12 years 6 months to 13 years 6 months, with ten subjects in each group. The one female group ranged in age from 8 years 2 months to 9 years 1 month. The measures obtained were sound pressure level, syllable duration, and number of articulatory errors. No significant differences were found for the sound pressure level measure. The authors reported significant differences between the age groups on the other two measures, indicating that the younger children, ages 6 to 10, were more affected by the delay in speech feedback than were the older children, ages 12 to 13.

Three age groups of children were studied by MacKay who employed six conditions of delay in auditory feedback. The three age groups of subjects were 4 to 6 years, 7 to 9 years, and 20 to 26 years. His results indicated that delayed auditory feedback affects the speech of children more than the speech of adults and that the delay for maximal interference is related to the age of subject. The older subjects were affected at the shorter delay times, while the younger subjects were affected maximally at the longer delay times.

The relationship of speech behavior under delayed auditory feedback to sex and age differences was investigated by Buxton. A significant relationship was obtained between the delay time producing maximal disruption of speech and chronological age and between the number of non-fluencies under delayed auditory feedback and maximum rate of speech under normal auditory feedback.
The crying of newborn infants was studied by Cullen, Fargo, and Chase\(^63\) to determine if auditory feedback is operative at this age. Two conditions were presented to the infants, a synchronous auditory feedback condition and a 200 millisecond delay condition. Significant differences between conditions were reported for cry duration. The average cry duration decreased by more than 100 milliseconds under delayed auditory feedback. The authors concluded that cry behavior may be under closed-loop auditory feedback control.

Children between 2 and 3 years and between 1 year 9 months and 2 years 2 months were the subjects for a study by Yeni-Komshian, Chase, and Mobley.\(^64\) These investigators were concerned with the presence of auditory feedback monitoring at these age levels. Two conditions, one of synchronous auditory feedback and one of 200 milliseconds of delayed auditory feedback, were presented to


obtain measures of average phonation time. Significant increases in this measure were reported for the ten older children, while the increase for the younger children was reported as being slight and variable.

A study by Cullen, Fargo, and Baker\textsuperscript{65} was designed to investigate the effects of delayed auditory feedback on the elicited crying of sixty-four newborn infants; thirty-four were males and twenty-six were females. The delay times employed were 0, 100, 200, 400, 600, and 900 milliseconds. Subjects were randomly assigned to one of the above groups or to a synchronous auditory feedback group. Measures of cry duration were first obtained and then averaged for each subject during each condition. A decrease in cry duration was typically found for the subjects in the 0, 100, and 200 millisecond delay groups, while an increase in cry duration was the finding for the 400, 600, and 900 millisecond delay groups. No relationship was obtained between delay time and the magnitude of the decrease in cry duration. The results for the 200 milli-

second condition obtained in an earlier study\textsuperscript{66} were not duplicated. The authors suggested that there may be a relationship between delay time producing consistent change in cry duration and the length of a cry unit. Matching subjects on cry duration during synchronous auditory feedback was suggested for future investigations.

A study of the auditory feedback monitoring system in children between 6 and 19 months of age was reported by Fargo, Port, Mobley, and Goodman.\textsuperscript{67} Twenty-eight infants were selected as subjects. Eleven between 6 and 10 months of age were classified as babblers, while seventeen were classified within the first word group. The testing period lasted one hour during which the experimenter alternated the delayed auditory feedback and the simultaneous auditory feedback conditions. This sequence was either DAF-SAF or SAF-DAF. Each infant's vocalizations were transcribed, and, on this basis, each infant was classified into one

\textsuperscript{66}Cullen, Fargo, and Chase, "The Development of Auditory Feedback Monitoring: I. Delayed Auditory Feedback Studies on Infant Cry."

of three language groups: predominantly or exclusively vocalic units, predominantly consonantal-vocalic units, or actual words. The measures included duration in millimeters, peak sound pressure level in decibels which was converted to a power ratio, and stress obtained by multiplying duration by power ratio. Seventeen of the twenty-eight children showed a change of some significance on at least one of the three parameters. Duration was the best measure of the delayed auditory feedback effect, according to the authors. Their results indicated that a decrease was more likely to occur than an increase in duration and sound pressure level. The authors noted that these results are the opposite of the delayed auditory feedback effect noted on adult speech but support the findings on infant cry. Neither sex nor test sequence predicted a significant delayed auditory feedback effect. Age was more reliable, since the only language group to attain a .01 level of significance on all three measures was the first word group. This result was attributed to the more advanced language development of the first word group. The authors concluded that the best indicator of a significant delayed auditory feedback effect was language development.

Summary

The purpose of the study was stated, and literature related to the study was reviewed. The normal development
of speech and language was discussed, and studies were reviewed about infant vocalizations and the effect of delayed auditory feedback on the speech behavior of children. The discussion of the normal development of speech and language included both the prelinguistic period and the linguistic period. The section on infant vocalizations included studies about the development of their sound repertories, the use of instrumentation in the analysis of their non-crying vocalizations, their crying vocalizations, and prosodic features of their vocalizations. Studies were reviewed that examined the effect of delayed auditory feedback on the crying and non-crying vocalizations of children. The third chapter contains a description of the subjects and a discussion of the experimental surroundings and equipment employed. The recording program is outlined, and the equipment and procedures for obtaining the measures employed in the statistical analysis are described.
CHAPTER III

PROCEDURES

The purpose of the study was to examine the effect of conditions of auditory feedback, age of infant, and sex of infant on the length of infants' vocalizations. In this chapter are found a description of the subjects, a discussion of the experimental surroundings and equipment, and an outline of the recording program. The equipment and procedures employed in obtaining the measures utilized in the statistical analysis are described.

Subjects

The subjects for the study were thirty infants from Columbus, Ohio. The infants were normal and in good health. Each mother reported an uneventful gestation period, birth history, and a normal development for her infant. In order to confirm a normal developmental history, the mothers of the infants completed a questionnaire relevant to their pregnancy and their infants' medical history. This questionnaire may be examined in Appendix A.

Criteria for selection of subjects

Two criteria for selection of subjects were age and sex. The infants were chosen so as to form three age groups:
6 to 9 months, 10 to 12 months, and 13 to 16 months. Five female infants and five male infants comprised each group. In the youngest group of infants at the time of the recording, three of the male infants were 9 months old, two female infants and one male infant were 8 months old, one male infant and one female infant were 7 months old, and two female infants were 6 months old. In the age group from 10 to 12 months, one male infant was 12 months old, two female infants and two male infants were 11 months old, and three female infants and two male infants were 10 months old when they were recorded. In the oldest age group, one female infant and two male infants were 16 months old, one female infant was 15 months old, one female infant and one male infant were 14 months old, and two female infants and two male infants were 13 months old at the time of the recording. The breakdown of age groups is represented in Table 1.

Table 1

AGE AND SEX OF SUBJECTS

<table>
<thead>
<tr>
<th>Age Group I</th>
<th>Age Group II</th>
<th>Age Group III</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-9 Months</td>
<td>10-12 Months</td>
<td>13-16 Months</td>
</tr>
<tr>
<td>Months Female Male</td>
<td>Months Female Male</td>
<td>Months Female Male</td>
</tr>
<tr>
<td>6 2</td>
<td>10 3</td>
<td>13 2</td>
</tr>
<tr>
<td>7 1</td>
<td>11 2</td>
<td>14 1</td>
</tr>
<tr>
<td>8 2</td>
<td>12 1</td>
<td>15 1</td>
</tr>
<tr>
<td>9 3</td>
<td>16 1</td>
<td>16 2</td>
</tr>
</tbody>
</table>
The birthdates of the infants and their ages at the time of their recording are listed in Appendix B.

**Socioeconomic level of subjects**

A questionnaire, "Index of Status Characteristics," developed by Warner, Meeker, and Eells, was employed for the estimation of socioeconomic level of each family. This questionnaire appears in Appendix A. The four categories that comprised the questionnaire were breadwinners' occupation, source of income, house type, and education of father. A rating on a seven-point scale was chosen for the family by the mother for each of the four categories. Each category had been weighted according to its importance in contributing to socioeconomic level. The rating chosen in each category was multiplied by a weighted number and the four final numbers were added to obtain a score which was used in the classification of each family into one of five socioeconomic levels: upper, upper-middle, lower-middle, upper-lower, and lower-lower.

Although each socioeconomic level was represented in the study, most of the infants were from upper-middle socioeconomic level families. Twenty-four of the infants were from upper-middle class families. Two of the infants
were from upper socioeconomic level families. Two infants were from lower-middle class families, one infant was from an upper-lower class family, and one infant was from a lower-lower class family.

**Experimental Surroundings and Equipment**

A sound-treated room, located in Derby Hall at the Ohio State University, was decorated to resemble an infant's nursery and was the setting for the recording sessions. In one corner of the room was a playpen for the infant, and in another corner, a chair for the mother. The walls of the room were covered with sheets on which were drawn colorful decals. A soft area rug covered the floor. Another room, which contained some of the experimental equipment, was adjacent to the sound-treated room. A double-paned glass window in the wall of the sound-treated room allowed observation of the infant and mother during the recording program.

The recording sessions occurred during a period of the day during which each infant was usually awake and content. Each infant occupied the playpen approximately two hours. The experimental conditions occupied one-and-one-half hours, while the preparation prior to each experimental condition occupied several minutes. The infants had the opportunity to adjust to the experimental surroundings during the explanation that was provided for
each mother about the procedures to be employed in obtaining the recordings. The importance of her silence during the experimental conditions was stressed. The purpose of the mother's presence in the room was to provide a familiar situation to the infant where he would feel comfortable to play and to vocalize. Toys that did not make noise were permitted in the playpen with the infants.

The experimenter and an assistant helped the mother place the infant in the playpen. Both the experimenter and assistant then left the sound-treated room. Since some of the infants were not content in the playpen for the entire recording program, occasional recording conditions occurred with the infant on the floor in the same area which the playpen occupied. Only if an infant continually attempted to remove the earphones was his mother asked to hold the headband so that the earphones were in the usual position.

In the sound-treated room, a microphone custom-made for the study was suspended over the center of the playpen. Three crystal microphone elements, Type MC 151, manufactured by the Astatic Corporation, were connected in parallel and composed the input system. The crystal elements provided increased sensitivity to the infants' vocalizations. The three elements were fitted into a metal container. This light-weight unit could easily be suspended from the ceiling of the sound-treated room over the playpen area. A set of custom-made earphones was used for the conditions
of delayed auditory feedback. The earphones were composed of two standard hearing-aid receivers, Model R-30-D, which were connected by a metal wire to form the headband. The metal wire was covered with foam rubber and colored material to assure the comfort of the infants. This set of earphones was lighter in weight than any standard set and thus reduced the amount of pressure on the infants' ears and head. The frequency response curve of the earphones and a block diagram of the equipment used to obtain the curve are presented in Appendix C. Pictures of the sound-treated room are included in Appendix D.

In the room adjacent to the sound-treated room, the delayed auditory feedback unit was located on a table under the double-paned glass window of the sound-treated room. The unit was developed by the Bell Telephone Laboratories. It was equipped with a stationary record head and an adjustable reproduce head which provided for simultaneous recording and play-back. The reproduce head could be adjusted to provide a series of delay times from 70 milliseconds to 1,000 milliseconds. This particular unit was chosen because of the wide range of delay times it would provide for the conditions of delayed auditory feedback. A standard electric timer, Model S-10, was employed to equalize the length of the experimental conditions. Figure 1 is a diagram showing the arrangement of the sound-treated room and the adjacent room containing the experimental equipment.
FIGURE 1

DIAGRAM OF THE SOUND-TREATED ROOM
AND THE ADJACENT ROOM SHOWING
THE EXPERIMENTAL EQUIPMENT

A - Sound-treated room
B - Playpen
C - Microphone
D - Earphones
E - Chair
F - Double-paned glass window
G - Adjacent room
H - Table
I - Delayed auditory feedback unit
J - Electric timer
K - Door
L - Door
Recording Program and Procedures

Nine experimental conditions, each 10 minutes in length, comprised the recording program. Each infant experienced all nine of the conditions of auditory feedback. Five of these experimental conditions were normal auditory feedback conditions during which the infant's vocalizations were recorded. During the normal auditory feedback conditions, the earphones were disconnected from the delay system. The other four experimental conditions were delayed auditory feedback conditions during which the infant wore the earphones and heard his vocalizations delayed a unit of time through the earphones. The four delay times employed in the conditions were 140 milliseconds, 250 milliseconds, 500 milliseconds, and 1,000 milliseconds. These four experimental conditions were randomized to minimize an order effect. Conditions of normal auditory feedback always preceded and followed conditions of delayed auditory feedback. The level control on the delay unit was kept constant at its maximum level throughout the recording program. The intensity level of the output through the earphones was equal to the intensity level of the input through the microphone.

A sample of the experimental conditions included in a recording program for one infant follows:

Condition 1 - normal auditory feedback.
Condition 2 - 250 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 500 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 140 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 1,000 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

After each 10-minute condition, a few minutes passed while the delay unit was adjusted and the tape changed in preparation for the subsequent condition. An assistant entered the sound-treated room and adjusted the earphones before each experimental condition. The recording program for each infant was approximately two hours in length. This estimate includes the time between conditions as well as the total recording time. The recording program for each infant is listed in Appendix E.

**Equipment and Procedures for Obtaining the Measures Employed in the Statistical Analysis**

The recorded vocalizations of the infants were fed from a Magnecord tape recorder, Model 1022, to a Brüel and Kjaer graphic level recorder, Type 2304, with a 50 decibel potentiometer. The speed of the paper from the graphic level recorder was 10 millimeters per second, and the writing speed of the pen was 300 millimeters per
second. The lower limiting frequency was 80 Hz. A standard electric timer, Model S-10, was employed to verify the length of each experimental condition.

The beginning and end of each vocalization were first located on the tape recordings and then were marked with a pencil on the graphic level recorder paper as the stylus of the graphic level recorder traced the sound. Only those portions of the recordings that were recognized as vocalizations were transferred to the graphic level recorder paper. This procedure eliminated vegetative and crying vocalizations. At the beginning of each condition, the infant's name and a description of the experimental condition that followed were indicated.

The length of each vocalization as traced on the graphic level recorder paper was measured with a millimeter ruler from the markings previously made to indicate the beginning and end of each vocalization. The measures of the length of each vocalization were totaled within each 10-minute experimental condition. These data were used in the statistical analysis to be described in the following chapter.

Summary

The purpose of the study was to examine the effect of nine experimental conditions of auditory feedback, age of infant, and sex of infant on the length of infants'
vocalizations. In this chapter are found a description of
the subjects and a discussion of the experimental
surroundings and equipment employed. The recording program
was outlined and the equipment and procedures for obtaining
the measures employed in the statistical analysis were
presented. A description of the statistical analysis and
a discussion of the results are included in the next chapter.
CHAPTER IV

STATISTICAL ANALYSIS AND RESULTS

The purpose of the study was to examine the effect of conditions of auditory feedback, age of infant, and sex of infant on the length of infants' vocalizations. Thirty infants, fifteen males and fifteen females, represented three age groups. They experienced four conditions of delayed auditory feedback. A normal auditory feedback condition preceded and followed each condition of delay. In this chapter there are statements of the hypotheses, definition of the criterion measure, and discussion of the statistical treatment of the data and results.

Hypotheses

The following hypotheses, stated in null form, were tested by measuring the length of infants' vocalizations under nine experimental conditions of auditory feedback:

I. There is no difference in the length of infants' vocalizations under five conditions of normal auditory feedback and four conditions of delayed auditory feedback.
II. There is no difference in the length of vocalizations between three age groups of infants, 6 to 9 months, 10 to 12 months, and 13 to 16 months, under five conditions of normal auditory feedback and four conditions of delayed auditory feedback.

III. There is no difference in the length of vocalizations between male and female infants under five conditions of normal auditory feedback and four conditions of delayed auditory feedback.

**Criterion Measure**

The criterion measure was the total length of vocalizations determined by a millimeter ruler from the graphic level recorder paper for each experimental condition. Each 10-minute experimental condition was comparable to 6,000 millimeters. The measures of total vocalization time in millimeters for each infant and for each experimental condition are presented in Table 5 of Appendix F.

**Statistical Analysis**

The statistical analysis employed was described by Winer$^{69}$ who entitles the design, "Three Factor Experiment

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with Repeated Measures (Case II)." The three factors considered in the study were age of infant, sex of infant, and conditions of auditory feedback. This analysis was chosen in order to obtain information about the three main factors and their interactions.

Results of the analysis

Hypothesis I, that there is no difference in the length of infants' vocalizations under five conditions of normal auditory feedback and four conditions of delayed auditory feedback, was rejected at the 1 per cent level of confidence. The obtained $F$-ratio was 4.71. The value necessary for significance at the 1 per cent level with 8 and 192 degrees of freedom is 2.60.

Hypothesis II, that there is no difference in the length of vocalizations between three age groups of infants, 6 to 9 months, 10 to 12 months, and 13 to 16 months, under five conditions of normal auditory feedback and four conditions of delayed auditory feedback, and Hypothesis III, that there is no difference in the length of vocalizations between male and female infants under five conditions of normal auditory feedback and four conditions of delayed auditory feedback, were not rejected. No significant interactions were obtained between the three factors. See Table 2.
<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Square</th>
<th>F-ratio</th>
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<td></td>
<td></td>
<td></td>
</tr>
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<tr>
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<td>688,034.56</td>
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<tr>
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<tr>
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<tr>
<td><strong>Within Subjects</strong></td>
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<td>240</td>
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<tr>
<td>C (conditions)</td>
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</tr>
<tr>
<td>AC</td>
<td>4,707,501.79</td>
<td>16</td>
<td>294,218.86</td>
<td>1.30</td>
</tr>
<tr>
<td>BC</td>
<td>1,686,930.53</td>
<td>8</td>
<td>210,866.32</td>
<td></td>
</tr>
<tr>
<td>ABC</td>
<td>3,199,420.02</td>
<td>16</td>
<td>199,963.75</td>
<td></td>
</tr>
<tr>
<td>C x Subj. w. groups</td>
<td>43,319,924.67</td>
<td>192</td>
<td>225,624.60</td>
<td></td>
</tr>
<tr>
<td>error (within)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant beyond the 1 per cent level of confidence $> 2.60$, 8, 192 df.
A test of critical difference

A critical difference test, as described by Lindquist,\(^7\) was employed to test the significance of the differences between means of the length of infants' vocalizations during the nine experimental conditions. A table of \(t\) values was consulted. The \(t\) value for 8 and 192 degrees of freedom at the 1 per cent level of confidence is 2.34. The number used for MS within was 225,624.60 reported in Table 2. Since no significant differences were found between groups, the population was considered to be homogeneous. The number used for \(n\) was 30. The critical difference value was 286.99.

Differences between the means of the length of infants' vocalizations during the nine experimental conditions were obtained and are presented in Table 3. The significant differences between the means of the length of infants' vocalizations are indicated in the table.

Results of critical difference test

Eleven of the differences between the means of the length of infants' vocalizations exceeded the critical difference value of 286.99. The length of vocalizations
TABLE 3

TABLE OF CRITICAL DIFFERENCES BETWEEN THE MEANS OF
THE LENGTH OF INFANT VOCALIZATIONS, EXPRESSED IN
MILLIMETERS (10 mm/sec), UNDER NINE CONDITIONS
OF AUDITORY FEEDBACK: CONDITIONS 1, 3, 5,
7, 9 - NORMAL AUDITORY FEEDBACK:
CONDITIONS 2, 4, 6, 8 -
DELAYED AUDITORY FEEDBACK

<table>
<thead>
<tr>
<th>Conditions</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>419.20*</td>
<td>163.93</td>
<td>612.17*</td>
<td>150.17</td>
<td>248.53</td>
<td>296.63*</td>
<td>340.93*</td>
<td>491.10*</td>
</tr>
<tr>
<td>2</td>
<td>255.27</td>
<td>192.97</td>
<td>269.03</td>
<td>170.67</td>
<td>122.57</td>
<td>78.27</td>
<td>71.90</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>448.24*</td>
<td>13.76</td>
<td>87.60</td>
<td>132.70</td>
<td>177.00</td>
<td>327.17*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>462.00*</td>
<td>363.64*</td>
<td>315.54*</td>
<td>271.24</td>
<td>121.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>98.36</td>
<td>146.46</td>
<td>190.76</td>
<td>340.93*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>48.10</td>
<td>92.40</td>
<td>2.57</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>44.30</td>
<td>194.47</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>150.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Exceeds critical difference value of 286.99.
that occurred during Condition 1 of normal auditory feedback which was always presented first in the recording programs was found to be significantly less than the length of vocalizations that occurred during Conditions 7 and 9 of normal auditory feedback. The significant difference between Condition 1 of normal auditory feedback and Condition 9 of normal auditory feedback was particularly interesting as Condition 1 was always presented first in the recording programs and Condition 9 was always presented last in the recording programs. The length of vocalizations that occurred during Condition 9 of normal auditory feedback was significantly greater than the length of vocalizations that occurred during Conditions 3 and 5 of normal auditory feedback. See Table 4 and Figure 2.

The length of vocalizations that occurred during Condition 1 of normal auditory feedback was significantly less than the length of vocalizations that occurred during three of the conditions of delayed auditory feedback: Condition 2 of 140 milliseconds of delayed auditory feedback, Condition 4 of 250 milliseconds of delayed auditory feedback, and Condition 8 of 1,000 milliseconds of delayed auditory feedback. The length of vocalizations that occurred during Condition 4 of 250 milliseconds of delayed auditory feedback which was randomized in the recording programs was significantly greater than
TABLE 4
MEAN VOCALIZATION TIME, EXPRESSED IN MILLIMETERS (10 mm/sec), FOR THE FIVE CONDITIONS OF NORMAL AUDITORY FEEDBACK: CONDITIONS 1, 3, 5, 7, 9

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>458.60</td>
<td>622.53</td>
<td>608.77</td>
<td>755.23</td>
<td>949.70</td>
</tr>
</tbody>
</table>
FIGURE 2

MEAN LENGTH OF VOCALIZATIONS, EXPRESSED IN MILLIMETERS (10 mm/sec), AS A FUNCTION OF THE CONDITION OF NORMAL AUDITORY FEEDBACK FOR ALL THIRTY SUBJECTS COMBINED: CONDITIONS 1, 3, 5, 7, 9
Conditions 3, 5, and 7 of normal auditory feedback. The length of vocalizations that occurred during Condition 4 of 250 milliseconds of delayed auditory feedback was significantly greater than the length of vocalizations that occurred during Condition 6 of 500 milliseconds of delayed auditory feedback. See Table 5 and Figure 3.

Figure 4 illustrates the mean length of infants' vocalizations in millimeters as a function of the experimental condition for all thirty infants combined. The ordinate or vertical axis portrays vocalization time in millimeters. The range extended from 458.60 millimeters in Condition 1 of normal auditory feedback to 1070.77 millimeters in Condition 4 of 250 milliseconds of delayed auditory feedback. The horizontal axis or abscissa represents the experimental conditions:
1 - normal auditory feedback, always presented first.
2 - 140 milliseconds of delayed auditory feedback.
3 - normal auditory feedback.
4 - 250 milliseconds of delayed auditory feedback.
5 - normal auditory feedback.
6 - 500 milliseconds of delayed auditory feedback.
7 - normal auditory feedback.
8 - 1,000 milliseconds of delayed auditory feedback.
9 - normal auditory feedback, always presented last.
TABLE 5

MEAN VOCALIZATIONS TIME, EXPRESSED IN MILLIMETERS (10 mm sec), FOR THE FOUR CONDITIONS OF DELAYED AUDITORY FEEDBACK: CONDITION 2 - 140 MILLISECONDS, CONDITION 4 - 250 MILLISECONDS, CONDITION 6 - 500 MILLISECONDS, CONDITION 8 - 1,000 MILLISECONDS

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>877.80</td>
<td>1070.77</td>
<td>707.13</td>
<td>799.53</td>
<td></td>
</tr>
</tbody>
</table>
FIGURE 3

MEAN LENGTH OF VOCALIZATIONS, EXPRESSED IN MILLIMETERS (10 mm/sec), AS A FUNCTION OF THE CONDITION OF DELAYED AUDITORY FEEDBACK FOR ALL THIRTY SUBJECTS COMBINED: CONDITION 2 - 140 MILLISECONDS, CONDITION 4 - 250 MILLISECONDS, CONDITION 6 - 500 MILLISECONDS, CONDITION 8 - 1,000 MILLISECONDS
FIGURE 4
MEAN LENGTH OF VOCALIZATIONS, EXPRESSED IN MILLIMETERS (10 mm/sec), AS A FUNCTION OF THE EXPERIMENTAL CONDITION FOR ALL THIRTY INFANTS COMBINED:
CONDITIONS 1, 3, 5, 7, 9 - NORMAL AUDITORY FEEDBACK
CONDITIONS 2, 4, 6, 8 - DELAYED AUDITORY FEEDBACK
The mean vocalization time in millimeters for the thirty infants during each experimental condition are presented in Table 6.

**TABLE 6**

MEAN VOCALIZATION TIME, EXPRESSED IN MILLIMETERS (10 mm/sec), FOR THE NINE CONDITIONS OF AUDITORY FEEDBACK: CONDITIONS 1, 3, 5, 7, 9 - NORMAL AUDITORY FEEDBACK: CONDITIONS 2, 4, 6, 8 - DELAYED AUDITORY FEEDBACK

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>458.60</td>
<td>877.80</td>
<td>622.53</td>
<td>1070.77</td>
<td>608.77</td>
<td>707.13</td>
<td>755.23</td>
<td>799.53</td>
<td>949.70</td>
</tr>
</tbody>
</table>

Figure 5 illustrates the total length of infants' vocalizations in millimeters for each age group as a function of the experimental condition. The ordinate or vertical axis portrays vocalization time in millimeters. The range extended from 4191 millimeters by the middle age group, 10 to 12 months, in Condition 1 of normal auditory feedback to 1, 516 millimeters by the youngest age group, 6 to 9 months, in Condition 4 of 250 milliseconds of delayed auditory feedback. The horizontal axis or abscissa represents the experimental conditions.
TOTAL LENGTH OF VOCALIZATIONS, EXPRESSED IN MILLIMETERS (10 mm/sec), AS A FUNCTION OF THE EXPERIMENTAL CONDITION FOR EACH OF THE THREE AGE GROUPS:

CONDITIONS 1, 3, 5, 7, 9 - NORMAL AUDITORY FEEDBACK
CONDITIONS 2, 4, 6, 8 - DELAYED AUDITORY FEEDBACK
Summary

The study was designed to examine the effects of three factors, conditions of auditory feedback, age of infant, and sex of infant, on the length of infants' vocalizations. Hypothesis I, that there is no difference in the length of infants' vocalizations under five conditions of normal auditory feedback and four conditions of delayed auditory feedback, was rejected. Hypothesis II, that there is no difference in the length of vocalizations between three age groups of infants, 6 to 9 months, 10 to 12 months, and 13 to 16 months, under five conditions of normal auditory feedback and four conditions of delayed auditory feedback; and Hypothesis III, that there is no difference in the length of vocalizations between male and female infants under five conditions of normal auditory feedback and four conditions of delayed auditory feedback, were not rejected. This chapter contained statements of the hypotheses, definition of the criterion measure, and discussion of the statistical treatment of the data and results. In the next chapter are a summary of the study, a discussion of the results, consideration of the limitations of the study, and suggestions for future research and application of methodology.
CHAPTER V

SUMMARY

The purpose of the study was to apply a methodology of delayed auditory feedback to the facilitation of infants' vocalizations and to determine the effect of conditions of auditory feedback, age of infant, and sex of infant on the length of infants' vocalizations. The subjects were thirty infants with normal developmental histories. There were three age groups, 6 to 9 months, 10 to 12 months, and 13 to 16 months, with five females and five males included in each age group. A recording program consisted of four 10-minute conditions of delayed auditory feedback, 140 milliseconds, 250 milliseconds, 500 milliseconds, and 1000 milliseconds, presented randomly, and five conditions of normal auditory feedback, also for 10-minute periods each. A condition of normal auditory feedback preceded and followed each condition of delay.

Each infant was brought by his mother to a sound-treated room which was decorated to resemble a nursery and was placed in a playpen over which a microphone was suspended. Vocalizations of the infants were recorded
by means of a magnetic tape recording. The recording equipment was situated in a room adjacent to the sound-treated room. During the conditions of delayed auditory feedback, the infants wore custom-made earphones. During the conditions of normal auditory feedback, the earphones were removed. The mother remained in the sound-treated room with the infant throughout the recording session. Only one visit by each infant was required, and each visit lasted for approximately two hours.

The recorded vocalizations of the infants were fed from the magnetic tape recorder to a graphic level recorder. The beginning and end of each vocalization were marked with a pencil on the graphic level recorder paper as the stylus of the graphic level recorder traced the sound. The length of each vocalization as traced on the graphic level recorder paper was measured with a millimeter ruler. The total length of vocalizations in millimeters for each infant and for each experimental condition was the criterion measure to be submitted to statistical analysis.

The hypotheses under test were: I, there is no difference in the length of infants' vocalizations under five conditions of normal auditory feedback and four conditions of delayed auditory feedback; II, there is no difference in the length of vocalizations between three age groups of infants, 6 to 9 months, 10 to 12 months,
and 13 to 16 months, under five conditions of normal auditory feedback and four conditions of delayed auditory feedback; and III, there is no difference in the length of vocalizations between male and female infants under five conditions of normal auditory feedback and four conditions of delayed auditory feedback. Hypothesis I was rejected. Hypothesis II and Hypothesis III were not rejected.

A test of critical difference was employed to test the differences between means of the length of infants' vocalizations during the nine experimental conditions. The total length of infants' vocalizations increased significantly from Condition 1 of normal auditory feedback that was always presented first in the recording program to three of the conditions of delayed auditory feedback, 140 milliseconds, 250 milliseconds, and 1,000 milliseconds. A delay in auditory feedback of 250 milliseconds produced the greatest increase in the total length of infants' vocalizations from the first condition of normal auditory feedback. The conditions of 140 milliseconds and 1,000 milliseconds were also effective in significantly increasing the total length of vocalizations from the first condition of normal auditory feedback.

The total length of infants' vocalizations increased significantly from Condition 1 of normal
auditory feedback, always presented first in the recording programs, to Conditions 7 and 9 of normal auditory feedback. The significant difference obtained between Condition 1 of normal auditory feedback and Condition 9 of normal auditory feedback was particularly interesting because their presentations were invariably at the beginning and end of the recording programs. The differences in the total length of infants' vocalizations between Condition 9 of normal auditory feedback and Conditions 3 and 5 of normal auditory feedback were also statistically significant. A gradual increase in total length of vocalizations was noted throughout the conditions of normal auditory feedback, with only one inconsistency—that of a slight decrease in total length of vocalizations from Condition 3 of normal auditory feedback to Condition 5 of normal auditory feedback. This difference was not statistically significant. It is interesting to note that Goff and Hubbard\(^7\) found a statistically significant

\[^7\text{Goff and Hubbard, op. cit.}\]

difference in the amount of infants' vocalizations during a condition of normal auditory feedback that was presented first in the recording programs and another condition of normal auditory feedback that was randomized with two conditions of delayed auditory feedback in each
infant's recording program. It was suggested that a persistence of the stimulating effects of delayed auditory feedback occurred.

A significant difference in the total length of infants' vocalizations was obtained between the 250 millisecond condition of delayed auditory feedback and Conditions 3, 5, and 7 of normal auditory feedback. The difference between the total length of infants' vocalizations during the 250 millisecond condition of delayed auditory feedback and the 500 millisecond condition of delayed auditory feedback was significant.

Although Table 9 of Appendix F indicates that the male infants vocalized more as a group during the recording sessions than did the female infant group, the difference between sexes in the length of vocalizations was not statistically significant. An examination of Table 10 of Appendix F reveals that the youngest age group, 6 to 9 months, vocalized more than did the oldest age group, 13 to 16 months, who vocalized more than did the middle age group, 10 to 12 months. However, because these differences were not statistically significant, there was no evidence of one age range being more critical than another.

Limitations of Study

The mothers' presence in the sound-treated room during the experimental conditions may have had an effect
on the infants' vocalizations, as the presence of an adult can serve as an effective social reinforcer.\footnote{Todd and Palmer, op. cit.} However, each infant's mother was present in the sound-treated room during all the experimental conditions, which may have made any effect a constant one.

The infants were not recorded in their home environments but were brought to the experimental setting. The new environment may have affected their vocal behavior. However, both mother and infant appeared to be comfortable within the sound-treated room decorated to resemble an infant's nursery, and also they were given some time for adjustment to the experimental surroundings.

The choice of a 10-minute period for each experimental condition was an arbitrary one. The possibility exists that a shorter or longer experimental condition would provide a more reliable measure of length of vocalizations.

**Suggestions for Future Research**

The results of the study indicated that the infant's own vocalizations are facilitating to the length of his vocalizations when returned to him by the method of delayed auditory feedback. Since the facilitation of vocalizations by this method is possible with normal
infants, it now seems important to examine the effect of the method of delayed auditory feedback on the vocalizations of infants who have experienced a deprivation known to affect speech and language development adversely. The method should be explored with a group of infants who have a hearing loss, with a group of infants who have been deprived intellectually, and with a group of infants who have received limited stimulation from their environments. A modification of procedures would be necessary for the study of a group of infants with a hearing loss, as amplification of the delayed auditory feedback of their vocalizations would be a consideration. The possibility of filtering infants' vocalizations prior to returning them through delayed auditory feedback should be examined. For example, this procedure might be studied with a group of infants who have a hypernasal voice quality as a result of a cleft palate.

Other implications for research suggested by the study include the following:
1. Determination of the optimal length of an experimental condition for obtaining valid and reliable measures of the length of infants' vocalizations.
2. Extension of the age limits of the study to include infants under six months of age.
3. Comparison of the effect of other voices on infants' vocalizations with the effect of the infant's own voice, employing the method of delayed auditory feedback.
4. Modification of the recording program to examine the effect of total recording time on the length of infants' vocalizations.

5. Examination of the quality of infants' vocalizations during delayed auditory feedback procedures. Several aspects of infants' vocalizations that could be studied longitudinally are the length of individual vocalizations and inflectional patterns.

6. Investigation of the persistence of the facilitating effects of delayed auditory feedback by comparing the vocalizations of an experimental group of infants who experiences conditions of delayed auditory feedback and conditions of normal auditory feedback with the vocalizations of a control group of infants who experiences only conditions of normal auditory feedback.

7. Investigation of infants' vocalizations during conditions of external stimulation with their mothers speaking to them and during conditions of no external stimulation.

8. Study of infants' vocalizations during conditions in which their mothers repeat their vocalizations as accurately as possible and during conditions in which their mothers do not restrict their vocalizations to repetitions of their infants' vocalizations.

9. Comparison of infants' vocalizations during conditions in which their mothers' speech is contingent on their
vocalizations and during conditions in which their mothers' speech is not contingent on their vocalizations.

**Application of Methodology**

Further investigation into the application of delayed auditory feedback as a method of facilitating infants' vocalizations appears to be justified. That infants increase the intensity of their vocalizations, raise the fundamental pitch of their vocalizations, extend the pitch range of their vocalizations, and increase the amount of their vocalizations under delayed auditory feedback has been evident from the results of recent researches. The current study is supportive of findings that the method of delayed auditory feedback increases the amount of vocalizations. Further investigation may result in an adaptation of the methodology for use in the home or clinic and may be useful especially for those infants who have experienced an auditory deprivation, an intellectual deprivation, or an environmental deprivation.

After the method of delayed auditory feedback has been explored further, recommendations for its application as a facilitator of infants' vocalizations may become specific. Since facilitating effects of delayed auditory feedback have been demonstrated for young infants only, the question could arise as to its appropriate use for older children who are beyond the prelinguistic period
of speech and language development. The use of earphones may not be advisable or even necessary. In a previous study, it was found that an increase in amount of vocalization occurred when the feedback was delayed by free-field presentation at a delay of 1.0 second. Thus, the latency period of return of vocalizations may not need to be shortened in order to be effective.

Specific recommendations might include application of the method as a substitute for environmental stimulation or for providing stimulation supplementary to that provided by the environment. For example, the method might be applied only during periods when the infant is particularly vocal, such as after a meal or a nap or when the infant is playing in a playpen. Needless to say, until further investigation is accomplished, the application of the method should be attempted cautiously.
APPENDIX A

QUESTIONNAIRES
Underline or circle one of the seven levels in the breadwinner's kind of occupation.

<table>
<thead>
<tr>
<th>PROFESSIONALS</th>
<th>PROPRIETORS</th>
<th>BUSINESSMEN</th>
<th>WHITE COLLAR WORKERS</th>
<th>MANUAL WORKERS</th>
<th>SERVICE PERSONNEL</th>
<th>LANDOWNERS-FARMERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Doctor; dentist; engineer; judge; lawyer; minister; professor; school superintendent, etc.</td>
<td>1. Investment of $75-100,000 in business or industry; varies by community size.</td>
<td>1. Top management - president; manager; executive of corporation, public utility bank, etc.</td>
<td>1. Executive secretary of status organization; CPA, editor of reputable newspaper, magazine; executive level of government.</td>
<td>1.</td>
<td>1.</td>
<td>1. &quot;Gentlemen farmers,&quot; landowners not directly supervising operation; the &quot;patrons&quot; of community activities.</td>
</tr>
<tr>
<td>2. High school teacher, trained nurse, chiropodist, chiropractor, mortician, minister (no college education), veterinarian.</td>
<td>2. Reputed value of $20-70,000; a very good business but not the largest kind.</td>
<td>2. Assistant-department and office manager or supervisor; manager of large branch; manufacturers agent.</td>
<td>2. Accountant; insurance, stock and bond, real estate men in reputable firms; columnist, editorial writer, etc.</td>
<td>2.</td>
<td>2.</td>
<td>2. Landowners, operators, and managers of large properties with active urban life.</td>
</tr>
<tr>
<td>3. Grade school teacher, assistant to undertaker, optician, city veterinarian, pharmacist, any unionized profession.</td>
<td>3. Value or equity reputed $5-20,000 in a good but rather small business.</td>
<td>3. Manager of branch stores and businesses (no office staff), buyers and salesmen with &quot;connections,&quot; (office and secretary).</td>
<td>3. Bank and broker's clerk; secretary; senior postal clerk; railroad agent; supervisor in public utilities; county and civic officials; newspaper reporters.</td>
<td>3. Small contractor who works with his men.</td>
<td>3. Commercial air pilot.</td>
<td>3. Owners and operators of good mechanized farms, with hired hands.</td>
</tr>
</tbody>
</table>
Underline or circle one of the seven alternatives in each of the three columns.

<table>
<thead>
<tr>
<th>I Source of Income</th>
<th>II House Type</th>
<th>III Education of Father</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Savings and investments, inherited: 50 percent or more of income</td>
<td>1. Large houses (9 rooms or more) in good condition with adequate grounds</td>
<td>1. Completed 1 or more years of graduate work at college or university</td>
</tr>
<tr>
<td>2. Savings and investments, gained by earner (not retirement pensions)</td>
<td>2. Large houses in medium condition. Medium houses (7 rooms) in good condition. Best apartments.</td>
<td>2. Graduated from 4-year college, university, or professional school.</td>
</tr>
<tr>
<td>3. Profits and fees - including higher executives who share profits.</td>
<td>3. Medium houses in medium condition. Large apartments in well-kept buildings.</td>
<td>3. Attended college 2 or more years, or equivalent higher education.</td>
</tr>
<tr>
<td>4. Salary or commission, including retirement earned thereby.</td>
<td>4. Large and medium houses in fair condition. Apartments in buildings in medium condition.</td>
<td>4. Graduated from high school, or equivalent secondary education.</td>
</tr>
<tr>
<td>5. Wages based upon hourly rates or piece-work; time-card personnel.</td>
<td>5. Small houses (5 rooms) in good condition. Good apartments in remodeled houses.</td>
<td>5. Attended high school; completed at least one year but did not graduate.</td>
</tr>
<tr>
<td>6. Private aid or assistance; may be supplemented by part-time work.</td>
<td>6. Small houses in medium or fair condition. Apartments in fair condition.</td>
<td>6. Third to eighth grade (older persons). Shifting to eighth grade (young adults).</td>
</tr>
<tr>
<td>7. Public relief and nonrespectable income, according to reputation.</td>
<td>7. All houses and apartments in bad condition. Store fronts, etc. Dwelling not intended for homes.</td>
<td>7. Below third grade (older persons). Shifting to below eighth grade (young adults).</td>
</tr>
</tbody>
</table>
I. Developmental Factors
A. Birth History
1. What was mother's condition during pregnancy? ___________________________
2. Was the delivery normal? Prolonged? Instruments used? Caesarian?________
3. Was there evidence of injury at birth? What? __________________________
4. Were there evidences of weakness or poor health at birth? What?________

B. Growth
1. Was he ever a feeding problem? When? How severe? _________________
2. Has he increased in height normally? Has he gained weight normally?________
3. Age of teething________________________

C. Locomotion
1. Age of sitting up Age of creeping Age of walking________
2. Does he seem to have normal coordination for his age?__________________

D. Speech Development
1. Did he babble and coo during the first ten months?____________________
2. At what age did he use single words meaningfully?____________________

II. Medical History
A. List diseases and their effects and severity:
   Diseases Ages Severity and Effects

B. List severe injuries, ages, and effects:
   Injuries Ages Severity and Effects

C. List operations and ages for each:
   Operations Ages

D. List kind and number of physical examinations child has had.
APPENDIX B

THE INITIALS, BIRTHDATES, AND AGES OF SUBJECTS
AT THE TIME OF RECORDING
<table>
<thead>
<tr>
<th>Initials</th>
<th>Birthdate</th>
<th>Age at Recording</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6-9 Month Females</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. W.</td>
<td>November 22, 1967</td>
<td>8 months</td>
</tr>
<tr>
<td>A. T.</td>
<td>February 8, 1968</td>
<td>6 months</td>
</tr>
<tr>
<td>C. L.</td>
<td>January 10, 1968</td>
<td>8 months</td>
</tr>
<tr>
<td>C. D.</td>
<td>February 22, 1968</td>
<td>6 months</td>
</tr>
<tr>
<td>K. M.</td>
<td>February 24, 1968</td>
<td>7 months</td>
</tr>
<tr>
<td><strong>6-9 Month Males</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R. S.</td>
<td>December 14, 1967</td>
<td>9 months</td>
</tr>
<tr>
<td>B. S.</td>
<td>December 14, 1967</td>
<td>9 months</td>
</tr>
<tr>
<td>M. S.</td>
<td>December 23, 1967</td>
<td>8 months</td>
</tr>
<tr>
<td>K. T.</td>
<td>February 19, 1968</td>
<td>7 months</td>
</tr>
<tr>
<td>M. K.</td>
<td>January 13, 1968</td>
<td>9 months</td>
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<tr>
<td><strong>10-12 Month Females</strong></td>
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<tr>
<td>D. M.</td>
<td>October 15, 1967</td>
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<tr>
<td>J. O.</td>
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</tr>
<tr>
<td>L. F.</td>
<td>December 19, 1967</td>
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<tr>
<td>A. T.</td>
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<tr>
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<td>Age at Recording</td>
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<td>------------------</td>
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<tr>
<td>J. U.</td>
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APPENDIX C

FREQUENCY RESPONSE CURVE OF EARPHONES

AND

DIAGRAM OF EQUIPMENT USED TO OBTAIN CURVE
FIGURE 7

DIAGRAM OF EQUIPMENT EMPLOYED TO OBTAIN CURVE

A - Hewlett Packard Audio Oscillator, Model 200 AB

B - Brüel and Kjaer Artificial Ear, Type 4212, utilizing a 2 c.c. coupler and 500 gram weight

C - Bruel and Kjaer Frequency Analyzer, Type 2105
APPENDIX D

PICTURE OF RECORDING AREA
FIGURE 8
PICTURE OF PLAYPEN AND EARPHONES
IN SOUND-TREATED ROOM

90
APPENDIX E

RECORDING PROGRAMS
6-9 Month Females

A. W.
Condition 1 - normal auditory feedback.
Condition 2 - 250 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 140 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 500 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 1 second of delayed auditory feedback.
Condition 9 - normal auditory feedback.

A. T.
Condition 1 - normal auditory feedback.
Condition 2 - 1 second of delayed auditory feedback.
Condition 3 - normal auditory feedback
Condition 4 - 140 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 500 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 250 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

C. L.
Condition 1 - normal auditory feedback.
Condition 2 - 500 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 140 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 1 second of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 250 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

C. D.
Condition 1 - normal auditory feedback.
Condition 2 - 140 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 250 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 1 second of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 500 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.
K. M.
Condition 1 - normal auditory feedback.
Condition 2 - 500 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 250 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 140 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 1 second of delayed auditory feedback.
Condition 9 - normal auditory feedback.

6-9 Month Males

R. S.
Condition 1 - normal auditory feedback.
Condition 2 - 500 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 250 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 1 second of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 140 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

B. S.
Condition 1 - normal auditory feedback.
Condition 2 - 500 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 1 second of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 140 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 250 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

M. S.
Condition 1 - normal auditory feedback.
Condition 2 - 140 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 1 second of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 500 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 250 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.
K. T.

Condition 1 - normal auditory feedback.
Condition 2 - 140 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 500 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 1 second of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 250 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

M. K.

Condition 1 - normal auditory feedback.
Condition 2 - 500 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 250 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 140 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 1 second of delayed auditory feedback.
Condition 9 - normal auditory feedback.

10-12 Month Females

D. M.

Condition 1 - normal auditory feedback.
Condition 2 - 500 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 140 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 250 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 1 second of delayed auditory feedback.
Condition 9 - normal auditory feedback.

J. O.

Condition 1 - normal auditory feedback.
Condition 2 - 500 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 250 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 1 second of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 140 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.
### L. F.

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### A. T.

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### M. S.

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### J. S.

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**10-12 Month Males**

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<td>250 milliseconds of delayed auditory feedback</td>
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<tr>
<td>9</td>
<td>normal auditory feedback</td>
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</table>
J. W.

Condition 1 - normal auditory feedback.
Condition 2 - 500 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 140 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 250 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 1 second of delayed auditory feedback.
Condition 9 - normal auditory feedback.

E. C.

Condition 1 - normal auditory feedback.
Condition 2 - 140 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 1 second of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 250 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 500 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

P. K.

Condition 1 - normal auditory feedback.
Condition 2 - 1 second of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 500 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 250 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 140 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

D. R.

Condition 1 - normal auditory feedback.
Condition 2 - 140 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 500 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 1 second of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 250 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.
13-16 Month Females

C. A.

Condition 1 - normal auditory feedback.
Condition 2 - 1 second of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 500 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 250 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 140 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

C. F.

Condition 1 - normal auditory feedback.
Condition 2 - 140 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 500 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 250 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 1 second of delayed auditory feedback.
Condition 9 - normal auditory feedback.

L. E.

Condition 1 - normal auditory feedback.
Condition 2 - 1 second of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 140 milliseconds of auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 500 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 250 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

S. R.

Condition 1 - normal auditory feedback.
Condition 2 - 500 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 250 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 140 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 1 second of delayed auditory feedback.
Condition 9 - normal auditory feedback.
K. E.

Condition 1 - normal auditory feedback.
Condition 2 - 250 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 1 second of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 500 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 140 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

13-16 Month Males

A. M.

Condition 1 - normal auditory feedback.
Condition 2 - 500 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 1 second of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 140 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 250 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

B. W.

Condition 1 - normal auditory feedback.
Condition 2 - 140 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 250 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 1 second of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 500 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

J. A.

Condition 1 - normal auditory feedback.
Condition 2 - 140 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 500 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 250 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 1 second of delayed auditory feedback.
Condition 9 - normal auditory feedback.
J. K.

Condition 1 - normal auditory feedback.
Condition 2 - 250 milliseconds of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 1 second of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 500 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 140 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.

J. U.

Condition 1 - normal auditory feedback.
Condition 2 - 1 second of delayed auditory feedback.
Condition 3 - normal auditory feedback.
Condition 4 - 250 milliseconds of delayed auditory feedback.
Condition 5 - normal auditory feedback.
Condition 6 - 500 milliseconds of delayed auditory feedback.
Condition 7 - normal auditory feedback.
Condition 8 - 140 milliseconds of delayed auditory feedback.
Condition 9 - normal auditory feedback.
APPENDIX F

TABLE OF RAW DATA AND TABLES IN WHICH THE DATA WERE ARRANGED TO ACCOMMODATE THREE GROUPS: A₁ = 6 TO 9 MONTHS, A₂ = 10 TO 12 MONTHS, A₃ = 13 TO 16 MONTHS; TWO SUBGROUPS: B₁ = FEMALE INFANTS, B₂ = MALE INFANTS; NINE CONDITIONS:

1 = NORMAL AUDITORY FEEDBACK, 2 = 140 MILLISECONDS OF DELAYED AUDITORY FEEDBACK, 3 = NORMAL AUDITORY FEEDBACK, 4 = 250 MILLISECONDS OF DELAYED AUDITORY FEEDBACK, 5 = NORMAL AUDITORY FEEDBACK, 6 = 500 MILLISECONDS OF DELAYED AUDITORY FEEDBACK, 7 = NORMAL AUDITORY FEEDBACK, 8 = 1000 MILLISECONDS OF DELAYED AUDITORY FEEDBACK, 9 = NORMAL AUDITORY FEEDBACK.
### TABLE 7

**TOTAL VOCALIZATION TIME IN MILLIMETERS (10 mm/sec)**

For each infant for each experimental condition:

- Conditions 1, 3, 5, 7, 9 - Normal Auditory Feedback,
- Conditions 2, 4, 6, 8 - Delayed Auditory Feedback.

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TABLE 8
THE LENGTH OF INFANTS' VOCALIZATIONS TOTALED FOR THE
FIVE INFANTS IN EACH SUBGROUP

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<th>C9</th>
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<td>26,334</td>
<td>18,676</td>
<td>32,123</td>
<td>18,263</td>
<td>21,214</td>
<td>22,657</td>
<td>23,986</td>
<td>28,491</td>
<td>205,502</td>
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TABLE 9
THE LENGTH OF INFANTS' VOCALIZATIONS TOTALED FOR THE FEMALE AND MALE SUBGROUPS AND THE NINE EXPERIMENTAL CONDITIONS

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<th>Male B2</th>
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<tbody>
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<td>6-9 Months - A₁</td>
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<td>38,257</td>
<td>76,264</td>
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<td>10-12 Months - A₂</td>
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<td>30,475</td>
<td>60,538</td>
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<tr>
<td>13-16 Months - A₃</td>
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<td>41,330</td>
<td>68,700</td>
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<td>95,440</td>
<td>110,062</td>
<td>205,502</td>
</tr>
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<td>3</td>
</tr>
<tr>
<td>---------------------</td>
<td>----</td>
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<td>26,334</td>
<td>18,676</td>
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TABLE 11
THE LENGTH OF INFANTS' VOCALIZATIONS TOTALED FOR THE THREE AGE GROUPS

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<th>7</th>
<th>8</th>
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<th>Total</th>
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</thead>
<tbody>
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### TABLE 12

THE LENGTH OF INFANTS' VOCALIZATIONS TOTALED FOR THE NINE EXPERIMENTAL CONDITIONS OF AUDITORY FEEDBACK

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<td>7. 7,260</td>
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<td>8. 11,796</td>
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<td>9. 4,141</td>
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<tr>
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<td>10. 3,650</td>
<td>15. 4,987</td>
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BIBLIOGRAPHY


