AN ANALYSIS AND COMPARISON OF INFANTS' SPEECH
WITH THEIR MOTHERS' SPEECH

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AN ANALYSIS AND COMPARISON OF INFANTS' SPEECH
WITH THEIR MOTHERS' SPEECH

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CHAPTER I

IMITATION IN LANGUAGE DEVELOPMENT OF INFANTS

Introduction

Within the realm of language development, psycholinguists, psychologists and speech pathologists have devoted much attention to the area of speech development during infancy. Various investigators (1, 3, 11, 22, 25) studied infants' vocalizations in respect to the specific stages of speech development. According to the conclusions made from these studies, it is general consensus that in the process of speech development, the child begins to imitate the vocal behavior of his linguistic community and especially the vocal behavior of that subcommunity which exists between the infant and his parents.

In 1960, Jun-Ichi Murai related that

The study of speech development during infancy is of tremendous importance for the clarifying of human development from two points of view.

1. Infancy is the prelinguistic period, and no meaningful utterance appears until the child is about one year old, except for one or two words.

2. The different races or nations each have different phonological systems. In view of these facts, and Jespersen's statement that "The organs of speech are in essential points formed alike in all races...." It may be said from the developmental point of view, that the early prelinguistic utterances which are not influenced by the phonological system are common throughout the world.
The very important period in which the sounds are affected by their phonological systems and are classified in them is considered to come to and just after the babbling period (28, p. 27).

Carroll, in 1961, discussed another aspect of language development study which has previously received little attention. One portion states:

Within a speech community there are many types and variations of languages and dialects, varying principally with geographical location but also with socio-economic status and occupation. The kind of language the child learns—in all its detailed aspects of sound and meaning is most likely to be that of his parents, which will seldom be precisely the dialect of the investigator. This rather obvious fact has been ignored in many studies of child language shortcomings. For example, some have erroneously assumed that there is one "standard" set of phonemes which all children are gradually approximating (3, pp. 332-333).

The present study deals with Murai's second point stated above. It is an investigation of certain aspects of that relationship which exists between the development of language of a child and the speech of his mother. With careful attention to the viewpoint expressed by Carroll, an attempt was made to investigate the evolving speech pattern of the child as he is influenced by the speech patterns of his mother.

A review of the literature indicated that Murai's and Lynip's studies were the only two found that had been done on objective spectrographic analysis and comparison of infants' speech with the speech of their parent, father in the former study and mother in the latter. However, this
portion of each study was secondary as well as exploratory. Murai related a need for investigation in this area with the following:

The process by which infants become capable of uttering sounds similar to their parents' sounds and by which they grow to utter sounds has a very important meaning in language and behavior development (28, pp. 31-32).

In addition, Carroll stated that the dialect differences in language development varying principally with geographical location and socio-economic status and occupation had been ignored (3).

Statement of Problem

Both Murai and Carroll (3, 28) related a need for further investigation of infant speech development. A combination of these ideas gave the basis of this study and established the problem of the thesis—can one determine the age at which infants begin to develop speech similar to the speech patterns (intonation, phonemic content, distinctive feature content, place and manner of articulation) of their mothers' speech?

It was the hypothesis of this study that there is a certain age range at which infants' speech begin to develop the speech patterns (intonation, phonemic content, distinctive feature content, place and manner of articulation) of their mothers' speech.
This study was not intended to generalize norms of speech development in infants; rather, the purpose was to analyze and describe objectively, the vocal behavior of three infants and answer the following questions: Is it possible to determine at what age those infants' speech begins to develop the speech patterns (intonation, phonemic content, distinctive feature content, place and manner of articulation) of their mothers' speech?

Definition of Terms

The definition of terms will be presented in two parts. The first part will include terms that refer to normal speech development. The second part will relate to terms that are included in the procedure for analyzing and comparing the infants' speech and mothers' speech.

Normal Speech Development

The following terms will be defined: the birth cry, crying, babbling, imitation, and the first word.

Birth cry.--"The infant cries at birth or shortly afterwards. This is a purely reflexive type of activity and results from air being drawn rapidly over the vocal cords, thus causing them to vibrate"(11, p. 56). Irwin and Chen related that the cry of the newborn is uttered with force and loudness, and is characterized by regularity of breathing (6). Berry and Eisenson stated the following:
The birth cry and all the infant's vocalizations during the first two or three weeks of his life seem to be reflexive, total bodily expressions in response to stimuli within and without him. As such, the expression is innate, and takes place without intent or awareness on the part of the infant. Vocalization itself arises as a result of a column of air reflectively expelled from the lungs passing between vocal folds tensive enough to produce sound. Though the infant's early sounds are produced without purpose and lack specific meaning, they constitute a response to a world in regard to which the infant has formulated no intentions and from which he has received no meaning (1, pp. 18-19).

McCarthy stated that the birth cry is of significance for the development of language because it constitutes the first use of the delicate respiratory mechanism which are to be involved in speech. Its function is entirely physiological, having to do with the establishment of normal respiration and the oxygenation of the blood. It is also the first time that the child hears the sound of his own voice, and, as such has significance for language development (26).

Crying.—Crying appears to be unintentional accompaniment from general muscular tension of the baby (11, 23, 32, 34). Results from the study by Leneberg, Rebelsky, and Nichols demonstrated that crying and other sounds in the first three months of life were approximately the same for infants born to normally hearing and speaking parents and to congenitally deaf parents (19); also, these developmental vocalizations evolved as the infant matured. The investigators reported that internal states, rather than
environmental factors appear to elicit the crying response. After the first three months, however, they observed that the vocalizations of the two groups of infants began to differ. This difference they attributed to the babies' differing environments (19).

Hurlock stated that shortly after birth, the cry of infants shows variations in pitch, intensity and continuity (11). The cries of the infant come from the physiological conditions of the infant, generally hunger, pain, discomfort, or fatigue (11, p. 57). At about the end of the first two or three weeks, one is able to note differences in the infant's cries (11, p. 19). Although the different cries are still produced reflexively and without intent on the part of the infant, he is announcing in his reactions to internal stimulation what his physical needs are (1, p. 19).

Babbling.—Babbling is designated as the second phase of language development by Berry and Eisenson, Hurlock, Lewis, and others (1, 11, 22, 25, 26). Wood defined babbling as "a stage in the acquisition of speech during which the child carries on vocal play with its random production of different speech sounds"(37, p. 51). Berry and Eisenson, Lewis and McCarthy (1, 22, 23, 25, 26) maintained that the infant enjoys producing these sounds and that babbling is a delightful play activity for the infant.
Lewis stated that

When a child is babbling he gives us the impression that he derives satisfaction from the utterance itself, that he is playing with sounds; playing with his vocal organs in the same way as he plays with movements of his fingers and his toes (23, p. 20).

McCarthy stated

The baby obtains enjoyment from listening to his own voice may be seen by the fact that he often smiles and laughs at the sounds he is making, and, further, by the fact that deaf babies less than normal seem to lose interest when they cannot hear their voices (26, p. 516).

According to Gesell and Hurlock (8, 11), babbling begins about the second or third month after birth. Van Riper stated that babbling usually begins about eight weeks after birth and usually consists of the sounds ee, ah, uh, and other sounds, such as m, b, and g, which are made in the front of the mouth (34, p. 78). Berry and Eisenson observed that "a variety of babbling sounds with variations in pitch and loudness will probably be among the first to be heard" (1, p. 20). Lynip (24) remarked that the infant in his study began to repeat syllables at fifteen-week stages.

Hurlock commented that babbling reaches its peak by the eighth month. Babbling gradually gives way to real speech because it is not used as a form of communication; rather it is a type of playful activity. Its real value from the point of speech development is the exercise it is giving
the vocal mechanism as a preliminary control which will make possible imitation of words spoken by others (11, p. 81). Murai noted also the increasing repertoire of infants' vocalizations and that sounds began to be repeated at about six months (28).

Lewis stressed the importance of the human voice as a stimulus for the infant in all its stages of language development (23, pp. 38-69). The first stage considered was the babbling period. The following is Lewis' account of the infants' responses to speech up to the babbling period.

By the end of his first month the normal child responds by crying to various intense noises, among these being the sound of another child crying. At this same time the sound of an adult voice has the effect of soothing him. In his second month he responds to an adult voice by smiling and often by speaking (23, p. 41).

He questions the beginning of the babbling response. In his attempt to answer this question he discussed three explanations for it. First, that there is an innate tendency for the child to respond to speech by speech; second, that the child responds by expression to expression; and third, that vocal responses to speech arises from intervention of the adult into the child's activity of babbling. He related that the third explanation was the commonest of all observations made of the babbling stage. His explanation is based upon Baldwin's hypothesis of "circular reaction," which is as follows:
In the course of repetitive babbling, a pattern of alternating hearing and utterance is set up; if an adult repeatedly imitates one of a child's own sounds while he is babbling the heard sound becomes a part of the pattern of alternation, so that ultimately it remains effective in evoking speech which may resemble the stimulus both in phonetic and in intonational form (23, p. 81).

Lewis continued that it is extremely doubtful whether a view which relies entirely upon Baldwin's theory as an explanation of the effect of the adult's intervention into the child's babbling is tenable. In order to determine the meaning of the child's vocal response to speech, one would have to take into account each of the following factors that are involved: the primary stimulus effect of a heard voice, the expressive response to expressive speech, and the effect of the adult's intervention into the child's activity of babbling (22, p. 81).

Lewis assumed that the infant's delight and satisfaction in babbling might be realized at two levels (23, pp. 20-21). First, the infant may enjoy feeling and hearing the production of each sound. Next, he learns to repeat a sound or string of several sounds together. The child becomes delighted in the production of a regular pattern constituted by repetitions. The pattern is composed of elements of rhythm, stress, variations of pitch, and regular variations of sound groups (23, pp. 20-21).
Gesell et al. described the normal language development of a baby six to eight months of age as follows:

The infant who mewed at four weeks and cooed at sixteen weeks, is now twenty-eight weeks old and crows and squeals. Over a period of twelve weeks, the infant has produced an abundant spontaneous vocalizations, producing vocalizations, producing vowels, consonants including syllables and diphthongs. He is almost ready for defined, duplicated utterance of consonant vowel combinations which lead to his first words. He is familiar with his home environment and specific persons and attends to their facial expressions, gestures, and postural attitudes. He relates to physical objects, tones and inflections of voice, however, he does not comprehend words (8, p. 23).

McCarthy (26) pointed out that there are a number of theories as to the way in which speech develops from the early vocalizations. In general, two opposing points of view appear: one, that learning goes on by a very gradual process of building up the complex from the simple; the other, that the original phonetic equipment of the individual is very large and that learning takes place by a process of adjusting, and eliminating, the sounds used to the language learned (26, p. 516).

Berry and Eisenson, Hurlock and Lewis (1, 11, 23) are of the opinion that the infant obtains the sounds needed for his native language from selection of sounds from his babbling repertoire of sounds.

**Imitation.**--Harriman defined imitation as "a behavior sequence elicited by observing a similar behavior sequence in another person" (10, p. 86). Murai (28) understood that
imitation is considered to mean only the mimetic reproduction of identical sounds. McCarthy (25) stated that the term "imitation" has been used in several different ways in the literature. She presented Decroly's distinctive forms of imitation as follows:

1. Imitation with and without intention to imitate which is sometimes designated as spontaneous, or voluntary imitation.
2. Imitation with or without comprehension.
3. Immediate or deferred imitation.
4. Exact and inexact imitation (25, p. 517).

McCarthy continued that it is over the last of these that so much controversy has centered. The most limited use of the term refers only to exact mimetic reproduction of the identical sounds said to the child as a model. She said that most present-day psychologists seem to agree with the opinion of Taine, who wrote in 1876 that new sounds are not learned by imitation of the speech of others, but rather that they emerge in the child's spontaneous vocal play as a result of maturation, and that the child imitates only those sounds which have already occurred in its spontaneous babblings (26, p. 517).

Simon (32, p. 36) remarked that imitation may more appropriately be described as the addition of outside stimulation to the former self-stimulation, or feedback. He also stated that during this period of transition from the prelinguistic to the linguistic period the adult can become a factor in the learning process.
Berry and Eisenson asserted that at about nine or ten months of age, the child may be heard imitating sounds which others have made, and which are prevalent in his environment. They added that sounds which the child recognized, such as those he had himself made during the babbling stage, were likely to be imitated first (1, p. 21). Lynip observed that beginning with the fortieth week of life, the infant tried to imitate the words his mother used (24).

In Murai's study he observed that imitative sounds and the meaningful ones began to occur at about the same period between the eighth month and the tenth month (28, p. 31). In review of the literature, McCarthy concluded that imitative behavior is reported most often after the ninth month and is especially prominent around the end of the first year and the beginning of the second year when language proper is just beginning to emerge (26, p. 517).

Lewis compiled information from his study of infant development as well as from other observers and subdivided the imitative process into three stages. He reported the following information:

The three stages of imitation, we see, are intimately bound up with the whole development of a child's responses to the meaning of what he hears and his own meaningful use of speech. Stage one, beginning to attract his attention and this sharpening of awareness stimulates him to respond vocally. Then he begins to speak to him, and the sounds he hears become a stimulus for him to attend to these circumstances. The sounds now call forth from him other kinds of responses than the purely vocal. We see this as the lapse of
Imitation. Then as he begins to attend to these circumstances, imitation is reborn. He utters imitated sounds with meaning (22, p. 25).

In an earlier work Lewis designated the third stage as follows:

The beginning of the third stage has been placed during the tenth month, an intermediate point among the varying estimates of the different observers. Their records show that about this time certain marked changes occur in the frequency and the nature of the child's imitative responses. These changes are: (a) A readier imitation of sounds drawn from the child's own vocabulary. (b) The more certain imitation of intonation form. (c) The appearance of delayed imitation. (d) The more definite imitation—perhaps the first imitation—of sound-groups new to the child. (e) The development of "echolalia" (22, p. 88).

Lewis (22) defined echolalia as a marked tendency in a child to imitate immediately what he hears, sounds may have been said without any intention of securing imitation from him. There is some controversy as to the regularity and importance of echolalia. Lewis regarded this type of imitation as characteristic of feeble-minded children (22, p. 102). Berry and Eisenson expressed a similar view and related "that the Mongolian idiot, . . . possesses an amazing ability to echo long tongue-twisting sound combinations without experiencing the slightest intellectual reaction to what he is echoing"(1, p. 21).

This study is concerned primarily with the imitation period which follows the babbling period. This stage is significant because "the child reveals a definite acoustic awareness of other persons"(1, p. 21). McCarthy contended
that the mere fact that the child learns the language of his environment is evidence of the importance of imitation. Children imitate all aspects of the behavior of others. This is especially apparent in motor and verbal areas (26, p. 517). McCarthy quoted Shirly, who wrote in his book in 1933 that in his view of the importance of the imitation period when "this period calls attention to the fact that there is a marked tendency to imitate the intonations and inflections of the voice regardless of the specific sounds" (26, p. 517). The child's imitation process of an adult, his mother, is of major concern in this study.

First word.— Berry and Eisenson, in their definition of the first word or "talking," stated that the child intentionally uses conventionalized sound patterns (words) and that his observable behavior indicates that he anticipates a response appropriate to the situation and the words he is uttering (1, p. 21). This view is in accord with that of Lewis, who wrote that a child's first utterance of words with meaning seems even more spectacular than the beginning of his responses to words. He has spoken his first word (22, p. 29).

Before the child can truly speak, he must first be able to comprehend speech. Lewis (23) expressed that comprehension, or "understanding speech" means that the child responds with appropriate mental or motor behavior to the spoken words of other persons. Likewise, McCarthy (26)
stated that the child understands the language of others considerably before he actually uses language himself. This comprehension process is quite detailed and will not be covered in this paper.

Like all stages of speech development, the age of the first meaningful word varies with different children. Between twelve and eighteen months of age, the "average child" really begins to talk (1, p. 21). Carroll remarked that the first active, meaningful, "voluntary" use of vocal language is usually found at about the end of the first year (3, p. 338). Leopold, a linguist who has written four volumes on the acquisition of speech by his daughter, gave four possible ages, eight, nine, sixteen, and seventeen months, as the age of the first word (21, p. 2).

Darley and Winitz made a study of the age of appearance of the first word for twenty-six groups of children. Results were that the average child begins to say his first word by approximately one year (7). McCarthy's compilation of the first word in the biographical studies on the subject revealed that the appearance of the first word ranged eight to twenty months (26, pp. 524-525).

Statements by Lynip and McCarthy concluded discussion of language development. Lynip contended that

Speech development follows a pattern much the same for all children. While it is true that some children learn to talk more quickly than others, this acceleration is an accompaniment of rapid...
development along other lines, notably muscle coordination. What deviates from a characteristic pattern exist are, for the most part, the product of different environmental conditions than those commonly found (24, p. 246).

McCarthy related that regardless of the language learned, all children learn in much the same manner the world over. She continued that the rates of learning vary with the native endowment of the children, the samplings observed, and the environmental stimulation they receive (26).

Procedures for Analysis of Speech

This section of the paper is concerned with the procedures, methods, and instruments that were used to analyze the speech patterns of the babies and mothers in this study. Specific terms will be defined and pertinent studies that utilized these methods will be reviewed.

International phonetic alphabet.—The International Phonetic Alphabet (IPA) consists of a number of symbols which may be employed to represent the sounds of many languages, with modifying marks which are useful for showing several kinds of differences in articulation of sounds in the speech of persons speaking a variety of dialects. Throughout, the basic concept is that each symbol shall, within limits to be mentioned, stand for a given sound. Only one sound is represented by a symbol. One of the limitations of the International Phonetic Alphabet is that it cannot be
completely "international" since there are dialect differences in the sound systems of various languages which are too elaborate to be recorded in this way (2, p. 21).

M. M. Lewis was a pioneer in using the International phonetic alphabet in making his notes on the study of the beginning of language. His system was first used in his book *Infant Speech* (22). Leopold placed primary dependence on phonetic symbol representations of the earliest words of the infant in his study (20).

Orvis Irwin, Han Paio Chen, and Thayer Curry made the first definite attempts at objective accuracy in recording pre-speech utterances of infants (14, 12, 13, 14, 15, 16, 24). These men wrote a series of articles dating from 1941 to the present time. Lynip stated that these investigators took the following steps toward making a scientific analysis of infant sounds: (1) adopted the use of the International Phonetic Alphabet and shorthand note-taking as a method for obtaining data; (2) established a kind of observer reliability by having two and three note-takers make their observations simultaneously; and (3) devised a plan or recording by "behavior units." This otherwise stated as involving the recording of the utterances of a single breath (24, p. 254).

Intonation patterns.—Lewis considered intonation patterns to consist of syllables, stress patterns, and pitch patterns. He stated that the infant is able to imitate the intonational
form of others. In the imitation stage, the number of syllables, the stress pattern, and the pitch pattern are all imitated (22, p. 94). Lewis reviewed other studies which revealed that infants responded to these intonational patterns at ages seven and a half months, eight, nine, and ten months of age (22, p. 94).

Lieberman investigated the subjects of speech perception, intonation, and acoustics. In one of his works (21) he proposed to demonstrate that the linguistic use of intonation reflects an innately determined and highly organized system, rather than a set of unrelated facts that are fortuitously similar in many languages. The author related the following:

In the first months of life during the babbling stage, and indeed during the very first minutes of life, children employ "meaningful" intonational signals. The cries are at first, meaningful only in that they have a physiological reference. We believe that these signals, which appear to be innately determined, provide the basis for the linguistic function of intonation in adult speech (21, p. 41).

The investigator cited Lowenfeld, Buhler, and Hetzer (21), who reported that infants from the age of two months onward responded positively to the human voice, while infants from the age of three months onward responded positively to friendly tones and negatively to angry tones of voice. The observed responses in these studies were eye and head movements.

Lieberman conducted an experiment on intonation that was aimed at confirming Lewis' subjective comments. He used
quantitative acoustic measurements that were related to the imitation of intonation signals. The results showed that mimicry of the average fundamental frequency range occurred at about ten months. The investigator used two subjects, a ten-month-old boy and a thirteen-month-old girl whose vocalizations were recorded under three different conditions. These conditions were vocalizing alone, vocalizing in an identical play situation with their father and then with the mother. The results were that the average fundamental frequency of the male infant's babbling was 340 cycles per second (cps) with his father; the fundamental frequency was 390 cps with his mother. Both of these fundamental frequencies were lower than that of the child's solitary babbling or crying. The girl also apparently attempted to mimic the fundamental frequency of her parents (21).

Lewis (22) and Leopold (20) noted that intonation is one of the first speech signals that has a linguistic reference.

Distinctive features.—Just as the International Phonetic Alphabet is used for analyzing vowel and consonant sounds of speech, distinctive features are also utilized as a type of sound analysis. Jakobson and Halle stated the following:

Linguistic analysis gradually breaks down complete speech units into morphemes as the ultimate constituents endowed with proper meaning and
dissolves these smallest vehicles into their ultimate components, which are capable of differentiating distinctive features. The distinctive features are concerned with simple and complex units which serve merely to differentiate, cement, and partition or bring into relief the meaningful units (17, pp. 215-216).

The distinctive features are used to analyze both vowels and consonants in the same manner; that is, by their acoustic and genetic qualities. The acoustic quality refers to the prosodic features of intensity, duration, and frequency. The genetic aspect refers to place and manner of articulation.

There are two classes of distinctive features, prosodic and inherent. The prosodic features are those which determine frequency, intensity, and duration of a sound. The inherent features amount to eleven oppositions, out of which each language makes its own selection. All the inherent features are divided into two classes that might be termed "sonority" features (intensity and time) and tonality features (pitch). The distinctive features are applied according to their acoustic quality, which is shown on the sound spectrograph, as well as genetic quality (place and manner of articulation). The sonority features consist of the following nine binary polar qualities: vocalic/non-vocalic, consonantal/non-consonantal, compact/diffuse, tense/lax, voiced/voiceless, nasal/oral, discontinuous/continuous, strident/mellow, checked/unchecked. The tonality features are grave/acute, flat/plain (17, pp. 227-235).
The Definitions of Terms in Distinctive Feature Analysis

According to Jakobson, Halle, and Fant (18), a distinctive feature is normally recognized by the receiver if it belongs to the code common to him and to the sender, is accurately transmitted, and has reached the receiver. In the present study the sender was the mother and the receiver, the infant; the code common to both of the subjects was the English language.

This section of the paper explains the fundamental source features, resonance features, and tonality features of distinctive features. The definitions were taken from Jakobson, Halle, and Fant (18).

**Fundamental Source Features**

This class consists of two binary oppositions: vocalic versus non-vocalic and consonantal versus non-consonantal.

**Vocalic versus non-vocalic.**—Phonemes possessing the vocalic feature have a single periodic ("voice") source whose onset is not abrupt.

The vocalic formants have small damping, which expresses itself in the relatively narrow bandwidth of the formants. Because of the negative slope of the "voice" spectrum, the lower formants have greater intensity. But because of the ear's higher sensitivity to loudness in the region, about
one to two kilocycles (kc) it appears likely that in perception the effect of the declining spectrum tends to be equalized.

Consonantal versus non-consonantal.---Vowels have no obstructive barrier along the median line of the mouth cavity, whereas consonants have a barrier sufficient to produce either complete occlusion or a turbulent noise source.

Vowels are phonemes which possess the vocalic feature and have no consonantal feature. A limited number of combinations of positions of the first three formants are significant for the identification of vowels. Other things being equal, vowels are louder than other speech sounds. Thus, intensity level, duration, rise and decay furnish supplementary identifying criteria for vowels.

Consonants are phonemes possessing the consonantal feature and having no vocalic feature. Certain features of consonants are perceived most readily by the influence they exert over the formants of adjacent vowels, but even in the absence of any adjacent vowel, all the features of a consonant are perfectly recognizable.

Interrupted versus continuant.---The steps have complete closure followed by opening. The constrictives have
incomplete closure; but the narrowing considerably reduces the contribution of the cavities behind the point of articulation. The continuant liquids, that is, laterals like /l/, combine a median closure with a side opening, whereas, in the interrupted liquids, like /r/, complete or partial cut-off of the air stream is effected by one or more taps of the apex of the tongue or of the uvula.

The abrupt onset distinguishes the interrupted consonants (stops) from the continuant consonants (constrictives). The onset of constrictives is gradual. The main characteristic of stops is a sharp wave front preceded by a period of complete silence, for which, under certain conditions, a mere vibration of the vocal bands may be substituted. The spectrograms show a sharp vertical line preceded either by a period of silence or a "voice bar."

**Strident versus Mellow.**—Sounds that have irregular waveforms are called strident. Strident phonemes are primarily characterized by a noise which is due to turbulence at the point of articulation. This strong turbulence, in its turn, is a consequence of a more complex impediment which distinguishes the strident from the corresponding mellow consonants; the labio-dentals from the bilabials, the hissing and hushing sibilants from the velars proper. A supplementary barrier that offers greater resistance to the air stream is necessary in the case of the stridents.
Thus, besides the lips, which constitute the sole impediment employed in the production of the bilabials, the labio-dentals involve also the teeth. In addition to the obstacles utilized in the corresponding mellow consonants, the sibilants employ the lower teeth and uvulars. The rush of air against such a supplementary barrier following the release of the strident stops yields the characteristic fricative effect that distinguishes these from other stops.

In the spectrogram strident sounds are represented by a random distribution of black areas. They are opposed to sounds with more regular waveforms. The latter are called mellow and have spectrograms in which the black areas may form horizontal or vertical striations. The proper measure for this property is an auto-correlation function. Mellow sounds have wider auto-correlation than the corresponding strident, if the sounds in question have been properly normalized.

Voiced versus Voiceless.—The voiced or "buzz" phonemes versus the voiceless or "hiss" phonemes are characterized by the superposition of a harmonic sound source upon the noise source of the latter. Voiced phonemes are emitted with concomitant periodic vibrations of the vocal bands and voiceless phonemes without such vibrations.

The spectrum of voiced consonants include formants which are due to the harmonic source. The striking
manifestation of "voicing" is the appearance of a strong, low component, which is represented by the voice bar along the base line of the spectrogram.

**Resonance Features**

This class includes three types of features generated in the basic resonator: (1) the compactness feature; (2) three tonality features; and (3) the tenseness feature. It also includes the nasalization feature due to a supplementary resonator.

**Compact versus Diffuse.**—The essential articulatory difference between the compact and diffuse phonemes lies in the relation between the volume of the resonating cavities in front of the narrowest stricture and those behind this stricture. The ratio of the former to the latter is higher for the compact than for the corresponding diffuse phonemes. Hence, the consonants articulated against the hard or soft palate (velars and palatals) are more compact than the consonants articulated in the front part of the mouth. In the case of vowels the compactness increased with an increase in the cross-sectional area of any constricted passage. Thus, open vowels are the most compact, while close vowels are the most diffuse.

Compact phonemes are characterized by the relative predominance of one centrally located formant region (or
formant). They are opposed to diffuse phonemes in which one or more non-central formants or formant regions predominate.

**Tonality Features**

This sub-class of the resonance features comprises three distinct dichotomous features capable of interacting variously with one another: (1) the gravity feature, (2) the flattening feature, and (3) the sharpening feature.

**Grave versus acute.**—In identifying the gravity feature of a consonant it is often profitable to observe the second formant in the adjacent vowel, if any; it is lowered in the case of grave consonants, and raise if the consonant is acute. Acoustically this feature means the predominance of one side of the significant part of the spectrum over the other. When the lower side of the spectrum predominates, the phoneme is labeled grave; when the upper side predominates, the phoneme is termed acute. Two measures suggest themselves as proper for this feature: (1) the center of the area, and (2) the third moment about the center of the area. It is necessary before applying these criteria to normalize the spectra in some way. At present the proper normalizing function is still undetermined.

The gravity of a consonant or vowel is generated by a larger mouth cavity, while acuteness orginates in a smaller and more divided cavity. Hence, gravity characterizes
libial consonants as against dentals, as well as velars
versus palatales and similarly, back vowels articulated with
a retraction of the tongue versus front vowels with advanced
tongue. Usually, however, a notable auxiliary factor in the
formation of grave phonemes (back vowels and labial con-
sonants as well as velars if opposed to palatales) is a
contraction of the back orifice of the mouth resonator,
through a narrowing of the pharynx, whereas, the corresponding
acute phonemes (dental and palatal consonants and front
vowels) are produced with a widened pharynx.

Flat versus plain.--Flattening is chiefly generated by
a reduction of the lip orifice (rounding) with a concomitant
increase in the length of the lip constriction. Hence, the
opposition, flat versus plain, has been genetically termed
"orifice variation," and the opposition, grave versus acute,
"cavity variation."

Flattening manifests itself by a downward shift of a
set of formants, or even of all the formants in the spectrum.

Sharp versus plain.--To effect this feature, the oral
cavity is reduced by raising a part of the tongue against
the palate. This adjustment, called palatalization, is made
simultaneously with the main articulation of a given conso-
nant and is linked with a greater dilation of the pharyngeal
pass in comparison with the corresponding plain consonant.
The pharyngeal dilation of the plain consonants is further augmented for the sharpened ones. The pharyngeal contraction of the plain grave consonants is supplanted by a dilation for the sharpened one. Hence, the behavior of the pharynx is particularly important in the sharpening of the grave consonants and may, under certain circumstances, become its main factor.

**Tense versus lax.**—In contradistinction to the lax phonemes the corresponding tense phonemes display a longer sound interval and a larger energy. In a tense vowel the sum of the deviation of its formants from the neutral position is greater than that of the corresponding lax vowel. A similar deviation may be presumed for the spectrum of the tense consonants in comparison with their lax counterparts. In consonants, tenseness is manifested primarily by the length of their sounding period, and in stops, in addition, by the greater strength of the explosion.

**Nasal versus oral.**—The oral (or more exactly, the non-nasalized) phonemes are formed by the air stream which escapes from the larynx through the mouth cavity only. The nasal (or more exactly, nasalized) phonemes are, on the contrary, produced with a lowering of the soft palate, so that the air stream is bifurcated and the mouth cavity is supplemented by the nasal cavity.
The spectrum of the nasal phonemes shows a higher formant density than that of the corresponding oral phonemes. Between the first and the second vowel formants there appears below, rather than above, the lowest formant of the corresponding oral vowel.

**Review of the Literature**

In review of the literature, five studies were found that were related to the present study on infant speech development and analysis.

In 1951 Lynip made a study of the analysis of preverbal utterances of infants. The purpose of this study was to explore the values of the magnetic recorder and the sound spectrograph for the collection and analysis of infant sounds. Lynip's study was concerned with how an infant learns to produce adult sound values. He observed only one subject almost continuously from its birth to the time it uttered intelligible words at fifty-two weeks. He was concerned with what changes take place in the infant's sound formations as it develops. He thought the topic of whether the sound of the infant is similar to the adult sound was irrelevant. Lynip made observations under the principles of genetic research control. His application of these principles resulted in the following procedures:

- General biographical data concerning the family of the infant studies were obtained before the birth of the infant; a written record was kept
of major developments in the family during the course of the study. Magnetic recordings were made of the infant's utterances during the infant's regular day routine. The tape recordings were made on weekly basis. In addition, a diary of data was kept on the activities of the infant's home environment. Motor development was also noted in relationship to speech development (24, p. 231).

Speech development of the child was studied and each stage of development was presented. Results of the study agreed with previous research during the babbling period in that "... by far the greater majority of the sounds which a child uses after it has learned to talk, and many in addition to these, are rightly formed by him within the first eight months of his existence" (24, p. 238).

The spectrographic formants were made of the infant when she was between the age levels of fifteen and thirty-eight weeks. The spectrographic formants made from the magnetic recordings revealed that the infant's utterances, although they were strung together, and seemingly somewhat like an adult's sounds, were seldom, if ever, more than distantly related to an adult's sounds. Fricatives, stops, nasals, and glides were not found to be formed in the infant's babblings with anything more than a faint resemblance to an adult's sounds. Utterances made with the mouth wide open were the closest relatives to mature language syllables, but even in these, resonance patterns differed widely from the adult's sounds (24, p. 238).
The investigator stated that the reasons why only dim outlines of future sound forms were seen in the spectrograms of babbling were readily understandable. He continued that this fact is evident in that the vibrations produced by adults' vocal cords are modulated by the nasal, oral, and pharyngeal cavities—which cavities in the infant are only beginning to assume the relative size and shape they later have (23, p. 238).

Lynip noted that although the infant's imitations appeared to match those of an adult at first, repeated playings revealed that though there was a similarity, there was a lack of clarity to the infant's utterances. He observed that the infant's vocalizations revealed no purely new sound produced and no exact imitation was possible; no reproduction of sounds that was made in the past was accomplished in the imitative period (24, pp. 241-245).

The author (24) noted resonances, tone, tonal range and shapes of sounds from initial stages of utterances and compared them with those of the time when the child began to use words meaningfully, at fifty-six weeks. He concluded that speech development is sound-shaping development, a growth process proceeding from the vague, indistinct, and fortuitously shaped to the clear, distinct, and controlled (24, p. 247).

In Lynip's summary of his research, he suggested several projected studies that could be investigated in the future.
He remarked that his study was a pilot investigation and a survey type which involved only one infant. He stated that there was a need for further investigation of this type which would involve many groups of infants. In addition, he stated that follow-up researches are necessary to obtain a sharply defined picture of the process, whereby an infant learns to talk. Lynip suggested a coordinated program of four studies centered around the four areas of development towards speech: (1) the birth cry and later crying; (2) the independent, non-crying sounds—from the one-syllable to the babbling stage; (3) the babbling to the imitative stage; and, (4) the imitative to the time when understandable words are employed. As a complementary study, he suggested that a study be made of different racial groups or different language groups to determine exactly what variation in beginnings and development those environmental factors have on speech (24, pp. 257-258).

In Lynip's study, he criticized the method of recording infant sounds employed in the investigations of Irwin and his colleagues (12, 13, 14, 15, 16). This method was to transcribe into the symbols of the International Phonetic Alphabet the speech sounds made by an infant on the exhalation phase of the breath cycle. His conclusions were noted above in the review of his research.

Nine years after Lynip's study, Harris Winitz challenged Lynip's contentions. In 1960 Winitz (35) made a spectrographic investigation of infant vowel sounds. It was the purpose
of his study to examine the validity of Lynip's assumptions and conclusions and to present a preliminary spectrographic analysis of a small number of infant vowels. Winitz noted that the sound spectrograph is an instrument which measures certain physical characteristics of sound, such as intensity, duration, and frequency. On the other hand, phonetic transcription is a tool of linguistic analysis, requiring the identification of phonetic elements by the human ear. He further stated that "whether there is a necessary and consistent relationship between these two sets of measurements is an empirical question that can only be settled by adequate investigation and not taken for granted" (35, pp. 172-173). The author stated that investigators who are interested in the phonetic qualities of infants' sounds are by definition restricted to phonetic impressions. "Physical measurements of infants' sounds cannot be made to represent phonetic transcriptions unless shown to be perfectly correlated" (35, p. 173).

Winitz also questioned Lynip's statement that only data recorded and represented by physical means are objective. Winitz pointed out that observations, regardless of the acquisitions, require some kind of discriminatory response from a person, whether it be tactile, auditory, or visual. On the other hand, a certain degree of subjectivity is present in all interpretations placed on spectrographic records. These
interpretations would include the observer's decision by visual inspection of the regions of energy concentration in the spectrum of a vowel sound. "In psychological research, 'objectivity' is often measured by a coefficient of agreement among observers. This process was used in the research by Irwin and his colleagues" (35, 173).

The author indicated that the basic data against which any instrumental method of phonetic analysis must be validated are the phonetic analyses made by competent observers. He continued that the spectrograph may not, in the present state of knowledge, provide appropriate and interpretable evidence on which to arrive at conclusions about speech sounds (35, p. 174). He supplied support of this statement in relative literature of experimental phonetics. A summary of those studies is that the same physical characteristics of sound (in this case, frequency and duration) were perceived as different phonemes by observers. Winitiz concluded with the following:

Although considerable acoustical information could be gained from spectrographic studies of infants' speech it would seem naive and without justification to compare, without identifying phonetically, the spectrographic record of sounds uttered by adults and infants. Investigators interested in the phonetic development of speech may find spectrographic analysis a useful complement to other research techniques but not a replacement for any present means of observation (35, p. 177).

The second objective of the study which was to determine vowel formant frequencies for infants was discussed. Five
Infants ranging from nine to fifteen months were the subjects in the study. The infants were held by their mothers in an anechoic chamber (a room essentially free from sound reverberation) and positioned approximately fifteen inches from a nondirectional microphone. The spontaneous speech utterances of each infant were recorded for approximately one-half hour.

Sixty-seven vowels were selected according to specific criteria and dubbed onto a large tape reel for ten graduate students to transcribe. Thirty-one vowels which had been agreed upon by seven or more of the judges as to the actual vowel uttered were subjected to spectrographic analysis. The results revealed variations in formant pictures of adult and infant vowels; also, some overlap among formant frequencies of different vowels and considerable variation of the formant frequencies of the same vowels were noted (35, p. 178).

The present study is based upon some phases of research by Jun-Ichi Murai which were done in 1961. Some parts of his study have been reviewed in the introduction of this study. In the investigation Murai was concerned primarily with how the sound repertoires of infants enlarge. He discussed the controversy between the integration theory and the differentiation theory. The integration theory is the process of progressive integration of elementary units. The differentiation theory is the progressive differentiation of a number of primitive mass sounds (28, p. 30).
The second objective of Murai's research was to make an investigation of infant speech to determine the directions to be found in the development of vowels and consonants in relation to the positions of articulation. Shultz stated that infants' phonetic utterances evolve from labial sounds toward gutteral sounds. Labial sounds require the least physiological effort, while guttural sounds require great effort (28, pp. 30-31). However, Irwin stated that back consonants, especially glottals, predominate at first, labial and dental sounds appear in the later period, and vowels develop from front to back in contrast to consonants (28, p. 30).

Four infant subjects were used in the study: a girl from two months to one year of age; a girl from two months to eight months; a girl from six months to one year; and a boy from two months to eight months. Their fathers were three psychologists and a phonologist.

In addition to tape recordings of the infants' vocalizations, daily records for each child were kept concerning (1) time of sleeping, feeding, crying, and uttering, (2) description of their utterances with International Phonetic Symbols, and (3) observations of the conditions under which the sounds were uttered. Each month the children were given a developmental test, a modification of the Gezell Developmental Schedules. The infants' vocalizations were taped every two weeks; tape recording schedules were selected according to the infants' most active periods of utterances.
Like Lynip, Murai observed infant utterances in speech development stages. Murai observed that the imitative sounds and the meaningful ones began to occur at about the same period between the eighth and tenth months. In Lynip's report he stated that

Exact mimetic imitation has not been formed but neither has this child been observed to produce the same sound he produced in previous weeks. This infant's utterances were constantly changing any way and the conclusion is that with innate tendency to try to echo adult sound, the modification tended toward the matching of an adult's sound (28, p. 31).

According to the results that Murai obtained at the eighth month, the sounds the infants uttered after their parents' utterances (mam mam) and (ba ba), resembled the latter fairly closely as whole patterns. From his spectrographic analysis, the father's pattern and his infant's pattern at eleven months old are shown to have grown more similar than their patterns of the eighth month (28, p. 31).

A comparison of Lynip's and Murai's studies indicate some differences in their findings, especially their reports on the age at which the babies' speech resembled the speech of their parents.

In 1968 W. C. Sheppard and H. L. Land (30) made an investigation of the prosodic features of infant vocalizations. The prosodic features include fundamental frequency, intensity, and duration. These measures were analyzed as functions of age.
Two infants, one male and one female, were used in the study. Complete and continuous recordings of all the vocalizations of the infants during the first five months of life were collected.

During the delivery of both infants, medical personnel wore lapel microphones. The outputs of the microphones were recorded on magnetic tape. Complete records of later vocalizations of the infants at the hospital were recorded by placing them in private rooms containing a microphone wired to a fast-acting voice-operated switch and to a tape recorder. When the children were carried home, they were placed in plexiglass "air cribs" that eliminated sources of sound within the crib and attenuated external sound, and thus created a good recording environment. A record was kept on the forms of environmental events affecting the infants (30, pp. 97-98).

The investigators prepared a master tape for each child which contained three ninety-five second samples of the vocal behavior during every fourth day of life for the first four days. Composite statistics which described the three prosodic features of the vocalizing in each sample were plotted separately as a function of age at the time of the sample. The development of prosodic features of the infants' vocal behavior was analyzed by extracting three acoustic parameters of the vocalizing fundamental frequency (Hz), amplitude (dB), and duration (msec), during each of the 108 samples, using
analog electronic devices. The outputs of these parameter extractions were sampled every 25 milliseconds by an analog, then processed by an on-line digital computer (PDP-4, Digital Equipment Corporation). The amplitude and frequency inputs were sampled and corrected by the computer. Afterwards, the digital values were reconverted to voltages and plotted as a function of time, on a strip-chart recorder (30, p. 98).

Three parameters of the techniques of prosodic analysis determined the definition of an utterance in this study, and hence, the magnitude of various response statistics. These are the amplitude, frequency, and temporal thresholds. All three measures were explored; however, temporal thresholds were investigated more thoroughly.

After the preliminary processing, the computer determined for each 95 second sample, the number of utterances as defined previously, the duration of each utterance, and the means and standard deviation of the fundamental frequency, and amplitude of each of the utterances. Pooling these statistics for each of the utterances in a sample, the computer then determined their frequency distributions over the entire sample.

The study revealed that the frequency distribution of duration was greatly right-skewed, whereas, the frequency distributions of fundamental frequency and amplitude were not.
Accordingly, the statistics presented were based on the linear values of the parameters, with the exception of duration, for which both arithmetic and geometric means were reported.

The trends in prosodic features were plotted as a function of age. The coefficient of variation between utterances in fundamental frequency of the infants revealed that the infants' pitch did not fluctuate more or less as they grew older. The average coefficient of variation within utterances in amplitude of both infants remained nearly constant. This result indicated that the variability in amplitude within utterances is greater than the variability in fundamental frequency within utterances. The coefficient of variation between the duration of utterance of the infants decreased, which indicated that the average duration of utterances within a sample became more uniform as a function of age (30, pp. 105-107).

Sheppard and Lane related that both behavioral and physiological changes may enter into the final account of the development trends observed in the study.

In 1968 Paula Menyuk conducted a study using distinctive feature analysis. It was the purpose of her paper to analyze, in terms of distinctive feature content, available data concerning correct usage of consonants during the morpheme construction period, the data obtained on the consonant
substitutions made by children during the developmental period, those made by children with articulation problems, and the available data on the confusion of adults.

Menyuk quoted Jakobson's proposal "that in the acquisition of the phonological classes and phonological rules of one's language, a regular and valid sequence in the developmental source can be observed (27, p. 138). She reasoned that this sequence is presumably based on the child's increasing capacity to further differentiate speech sounds by the distinctive features of the sounds in his language. For example, at some stages of development, the child may distinguish sounds into + nasal (b/vs./n/ or /d/ vs. /n/) but be unable to distinguish between sounds in terms of place of articulation (/b/ vs. /d/ or /m/ vs. /n/).

The author investigated the features of gravity, diffuseness, stridency, nasality, continuancy, and voicing. The data used was obtained from American children over an age range of two and a half to five years, and Japanese children over an age range of one to three years. The data on adult consonant substitutions were obtained from the results of an experiment in which subjects were asked to recall a list of syllables composed of consonant plus [a]. The data on children with articulation problems were obtained by transcribing the consonant substitutions produced by children.
while spontaneously generating sentences, and by analysis of the results of the Templin-Darley articulation test which had been administered to a group of children diagnosed as having articulation problems.

The results of the analysis of the data indicated that the distinctive features of the speech sounds of the language that were examined play differing roles in the perception and production of these sounds. It was possible to observe the same order in acquisition and relative degree of mastery or correct usage of sounds containing the various features by groups of children from two differing linguistic environments, indicating that a hierarchy of feature distinction may be a linguistic universal, probably dependent on the developing perceptive and productive capacities of the child. Menyuk found that the features which dominated these children's correct usage of consonants at the beginning stages of morpheme construction were +nasal, +grave, and +voice. It was observed that in the substitutions of adults in recall of consonant, and the consonant substitutions in the productions of children who were developing language normally, and those who were not, the features of voicing and nasality were among the best maintained in the substitutions. She postulated that the features $^+$ nasal and $^+$ voice were easiest to perceive, recall, and produce.
Menyuk related that + strident and + continuant features were best maintained in recall of consonants by adults. On the other hand, consonants containing + strident and + continuant features were correctly mastered last by both Japanese and American children.

The sounds /f/ and /v/ were mastered earlier than the other stridents, and the stops /t/ and /d/ were less frequently substituted in the development of the phonological system than their continuant complements / +s / and / +z / . The sounds that were mastered last and most frequently substituted were + continuant and - grave / +s / and / -z / . Results from the study indicated that the + grave feature was used relatively earlier and mastered sooner by both Japanese and American children. The children with articulation problems most frequently maintained the features + grave in their substitutions than did the other two groups. The features of place + grave and + diffuse were least maintained in the recall of consonants by the adults and in the production substitutions of children who acquired the phonological rules of their language.

The most frequent errors in consonant substitutions by adults took place among the plosives and the fricatives (an error of place) but not between them. The most frequent errors in consonant substitution by children developing
normal language normally took place among the plosives, fricatives, and semi-vowels and liquids (an error of place).

In concluding the results of her study, Menyuk related that distinction between sounds which differ from each other only in one feature (place of articulation) seemed to cause the greatest difficulty both in recall by adults and production by children. The one other feature distinction that was frequently not observed was continuancy. The tendency seemed to be non-observation of a single feature differentiation in the most frequent consonant substitutions of the child who was developing language normally.

Summary

A review of normal language development has been made and each stage of language development defined. The criteria and means of speech analysis have been defined. Related studies on the subject of analysis of infant speech have been presented. Lynip, Murai, Sheppard and Winitz made investigations of infant speech sounds and analyzed them by means of the sound spectrograph. Lynip's study was a pilot study as well as a survey type which pioneered the use of the sound spectrograph in infant speech analysis. Murai and Winitz utilized the sound spectrograph and included the use of the International Phonetic Alphabet, a technique that Lynip criticized. Although both Lynip's and Murai's
studies mentioned the beginnings of infant imitation of their parents' speech, these data were incidental in their studies. In addition, both researchers found different age levels at which this imitative behavior began to appear. Menyuk's study utilized distinctive feature analysis. This investigation studied the acquisition and proportion of correct usage of consonants by Japanese and American children; the consonant substitutions of children developing normal language and of children with articulation problems; and confusion in adults' recall of consonants. A system of distinctive features was used to describe the behavior observed. It was found that features played a hierarchial role in terms of acquisition and proportion of correct usage, as well as in terms of resistance to perceptual and productive confusion. The features also played differing roles depending on the task, the age of the subject, and their status in learning the sound system of their language (27).
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CHAPTER II

SUBJECTS AND PROCEDURE

The purpose of this study was to observe three infants and their mothers and investigate the following: "Is it possible to determine at what age these infants' vocalizations began to develop the speech patterns (intonation, phonemic, phonetic and distinctive feature content) of their mothers' speech?"

Subjects

Three Negro infants and their mothers were selected for this study. According to the infants' performance on the Gesell Growth Trends Chart, and informal medical reports from their mothers, the infants were normal and healthy. The babies ranged in age from nine months, three weeks old to fourteen months. All infants were females, and lived in Denton, Texas. Two of the babies lived with their mother only; the other infant lived with both parents.

Each mother and her infant were selected according to the following criteria:

1. The mother's speech was easily recognized as Southern Negro dialect.
2. The mother was with her child a significant amount of time daily.
3. The infant was an only child in the family.
4. The infant did not attend nursery school.
5. According to the mother, there was nothing unusual about the pregnancy.
6. There was no serious illness or injury in the baby's history to suggest brain damage, organic disorders or mental retardation.
7. The infant was healthy and had normal development according to the Gesell Growth Trends Chart. Each infant was observed according to specific behavior trends for his age level. (See Appendix.)
8. The mother was willing to cooperate.
9. The mother appeared to communicate well with her infant by talking to her.

Similar studies on language development in infants employed a small number of subjects (3, 4, 7, 8). Osgood supports the utilization of such a small sample with the following statement:

Language is so standardized an aspect of culture, . . . that a very small number of informants usually proves to be adequate. If necessary, the linguist will even be satisfied with a single informant in the belief that systematic divergence from the shared habits of the community as a whole are likely to be of minimal significance (4, p. 9).

Procedure

Each subject was seen an average of once every two weeks. Infant I was seen on ten occasions over a period of fifteen weeks; Infant II was seen on six occasions over a period of thirteen weeks. Infant III was observed four times over a period of eight weeks; however, her crying became a problem, and she was dropped from the study. A
twenty- to thirty-minute tape recording of each subject's vocalizations was made in his daily routine.

The initial tape recording of each child was made at the following age levels: Infant I—sixty weeks, Infant II—forty-two weeks, and Infant III—thirty-nine weeks. The tape recorder was concealed from the infants' sight, and an attempt was made to conceal the microphone also. However, most of the babies were aware of the microphone. Nevertheless, their seeing the microphone did not hinder their vocalizations; it usually aroused their curiosity and helped to increase their vocal activity.

The mother acted as the stimulus in eliciting vocal responses from the infant; at that time only the mother and baby were present. The total recording time ranged from twenty to thirty minutes. Oftentimes the tape recording was interrupted when the infants began to cry excessively and/or did not make vocalizations.

Environment

The present study was carried out in each infant's home. The testing environment was kept as quiet as could be expected in a home setting. The rooms for the tape recordings were selected according to their general quiet environment as well as the child's familiarity with the rooms. The recording situation was kept as natural as possible for each infant. However, the situation was so
arranged as to stimulate the infants to increase their vocalizations; for example, if an infant was found to utter sounds when he saw a toy, he was given the toy at recording time. Selection of recording time was based upon (1) the time when the infants’ utterances were very active and (2) the convenience of the mother and the investigator.

Equipment

A Stereophonic Wollensak Model A 12-22705 tape recorder and the accompanying Model B-162-2 microphone were utilized in recording the speech of the mothers and babies in the study. Favorite toys of each infant (dolls, balls, telephone, blocks, stuffed animals and others) were used in the tape recording sessions. These toys were used as stimulants to aid in increasing the infants’ vocalizations while playing.

Method

Selection of Vocalizations

In the selection of the infants’ vocalizations, the tape-recorded vocalizations of each of the infants at different age levels, from the thirty-nine-weeks stage to the seventy-four-weeks stage, were chosen. From the bi-monthly tape recordings of the two infants' speech, those vocalizations were selected that were recognized as isolated sounds, repetitive chains of sounds, words, and phrases. The
speech sounds which met the following criteria were selected from the tape: (a) appeared to be "fairly good" examples of the English vowel and consonant phonemes as listed by Carrell and Fairbanks (1, 2); (b) were not lacking in intensity or masked by ambient noises made from the child's movements, or his environment.

The tape recordings and selected samples of the mothers' speech that were observed in the infants' vocalizations were reviewed. While phonetic transcriptions were made of essentially all of the meaningful vocalizations, the investigator selected those utterances of the infants and mothers that were meaningful and contiguous. The speech sounds which met the previously mentioned criteria were selected for study according to International Phonetic Alphabet analysis and distinctive feature analysis. The speech sounds of the infants and their mothers were dubbed onto a larger tape reel for analysis.

Method of Analysis

The vocalizations of the infants and speech of their mothers were analyzed with the International Phonetic Alphabet. Stress and intonation patterns, terminal juncture, and distinctive feature analysis were also analyzed. Each of these procedures was not employed in the analysis of every selected sample of speech. Each type of analysis will be discussed separately.
Initially, the investigator made a tape recording of each of the mother's speeches as the mother read "The Rainbow Passage."

**International Phonetic Alphabet**

The recorded passage as well as the data obtained on the bi-monthly recordings of the subjects' speech were transcribed by the observers. The selected samples of speech of the infants and their mothers were played as the observers transcribed the speech into the International Phonetic Alphabet.

**Distinctive Feature Analysis**

From the selected samples of tape recorded speech of the infants and their mothers were obtained those syllables, words, or phrases that the children attempted to imitate after their mothers and those sound combinations (vowel, consonant, consonant vowel) that appeared to be similar. Those samples of speech were subjected to distinctive feature analysis to determine what distinctive features were absent or present in the infant's vocalizations and which ones were absent or present in the speech of the mother. The results were compared. Raw data included the following results:

1. The International Phonetic Alphabet transcription of selected samples of speech of the infants and mothers in the study.

2. The stress and intonation patterns and terminal juncture of selected samples of speech of the infants and mothers in the study.
3. The distinctive feature analysis of selected samples of vocalizations of the speech of the subjects.

The data were analyzed and compared to investigate the following:

1. Is it possible to determine the age at which the infants in this study begin to imitate the vocal patterns (stress and intonation, terminal juncture) of their mothers?

2. At what age do these infants begin to develop the same or similar phonetic sounds in their vocalizations as those characterized by their mothers' speech?

3. What is the distinctive feature content of the speech of the infants and their mothers?
CHAPTER BIBLIOGRAPHY


CHAPTER III

EVALUATION AND RESULTS

The data obtained from the analysis of the subjects' (infants and mothers) vocalizations in this study were analyzed by three procedures that were discussed in detail in Chapter I. The procedures included the transcription of the vocalizations with the International Phonetic Alphabet, analysis of stress and intonation patterns and terminal junctures, and distinctive feature analysis. Each of these procedures was not employed in the analysis of every selected sample of speech. The selection process of the subjects' vocalizations and the analysis procedures were discussed in Chapter II.

The results of the study included the analysis and comparison of two of the three infants and mothers that were tape-recorded at the beginning of the study. The infants and mothers reported are Infant I and II. The vocalizations of Infant III were not used because after the tape recordings were reviewed, it was observed that the infant's vocalizations consisted primarily of crying sounds and some random babbling that did not appear to be imitative of the mother.
The purpose of this study was to investigate whether it is possible to determine the age range at which the infants' vocalizations begin to imitate the speech patterns of their mother's speech.

**Treatment of Data**

**Phonetic Analysis**

All selected samples of speech were transcribed into symbols of the International Phonetic Alphabet. Each phonetic sound was analyzed separately according to the number of times the mother produced a sound and the number of times the infant imitated the sound at each age level. The result of analysis of each sound was plotted on a graph as a function of the infants' age.

**Analysis of Stress and Intonation Patterns**

The raw data was analyzed by determining the proportion of times the infants imitated the stress and intonation patterns and terminal juncture of the speech of their mothers. The proportion of imitation $P$, was defined as the ratio of the number of times the infant imitated the primary and secondary stress patterns and fading and rising terminal junctures of their mothers' speech to the number of times the mother used these intonation patterns. Table I in this chapter shows analysis of the data at each age level of the infants. Each
selected sample of speech was analyzed according to this procedure. For example, if the mother produced the following: $\text{[b e, b I]}$, and the infant imitated her mother and produced $\text{[b e b I]}$, Table I would show that the infant correctly imitated the primary stress 1.00, the secondary stress 0.00 and the fading terminal juncture 1.00.

Kenyon and Knott defined stress as follows:

Stress is the general term for prominence of a sound or syllable, whether that prominence is produced by force of utterance, by pitch, duration of sound, or (as usually), by some combination of these elements (6, p. xvii).

This study employed, in its analysis, the stress marks that Kenyon and Knott used in their work. The phoneticians described the stress marks as follows:

The mark (') above the line and before a syllable indicates that that syllable has the principal accent. The corresponding mark (,) below the line and before a syllable has an accentuation somewhat weaker than the main one (6, p. xviii).

The intonation contours (pitch and juncture) which were utilized in analysis were taken from Stageberg. Stageberg referred to stress, pitch, and juncture as supra-segmental phonemes, and stated that all three are phonemes as they accompany the segmental phonemes (vowels and consonants). Although many degrees of pitch are employed in speaking, Stageberg stated that speakers use only four levels as follows: "4. extra high, 3. high, 2. normal, and
1. low. Level two is designated as the normal pitch of speaking voice and from this the voice makes departures upward and downward (8, p. 57)."

Stageberg stated that the meaningful patterns established by intonation contours have three methods of closure which are called terminal junctures (8, p. 58).

He further explained:

The first terminal which occurs at the end of a sentence or statement is characterized by a rapid fade away of the voice into silence and by a considerable prolongation of the preceding word with pitch level 3. It is symbolized by \( /\downarrow\). The second terminal is the rising terminal. It is a short, slight rise in pitch from the last level heard, but does not go all the way up to the next level. It is symbolized by \( /\uparrow\) and commonly occurs at the end of yes-or-no questions (8, p. 58).

**Distinctive Feature Analysis**

Distinctive feature analysis was based upon the results of phonetic transcriptions of the subjects' speech. The result of feature analysis of the data was analyzed by determining the proportion of times each infant imitated the features of her mother's speech at certain age levels. The term proportion of imitation was defined as the ratio of the number of times the child imitated the features of the mother's speech to the number of times the mother produced these features. As the infant develops, it is hypothesized that he will begin to imitate the sounds of his mother's speech more as he matures. As the child develops linguistically, the proportion of imitation should
approach a value of one. For example, if the infant imitated the feature +voiced three times at a certain age level and the mother had used the same feature six times, the proportion of imitation, \( P \), equals 0.50. If the value of \( P \) is greater than one, it is assumed that the infant used a particular sound more times than the mother produced the sound.

**Analysis and Comparison of the Subjects' Vocalizations**

**Phonetic Analysis**

Figures one through five compare the number of times the mothers produced a front vowel and the number of times the infants imitated the vowel sound.

![Graph](Image)

**Fig. 1**—A comparison of the number of times the mothers produced the \( [i] \) sound to the number of times the infants imitated the sound.
Fig. 2--A comparison of the number of times the mothers produced the [ ] sound to the number of times the infants imitated the sound.

Fig. 3--A comparison of the number of times the mothers produced the [ ] sound to the number of times the infants imitated the sound.
Fig. 4--A comparison of the number of times the mothers produced the \( \varepsilon j \) sound to the number of times the infants imitated the sound.

Fig. 5--A comparison of the number of times the mothers produced the \( \varepsilon j \) sound to the number of times the infants imitated the sound.
The first five figures indicated that Infant II imitated the front vowels [i], [ɪ], [ɛ] and [æ] at the forty-seven, forty-nine and fifty-two weeks age levels with a close imitation of the [ɛ] at the fifty-eight weeks age level. Infant I imitated the [ɪ] sound more frequently at the sixty through sixty-six weeks age level than any of the other front vowels. Commencing with age seventy-two weeks, Infant I consistently imitated each front vowel that her mother produced.

Figures six and seven present a comparison of the infants' imitations of their mothers' productions of central vowels.

Fig. 6--A comparison of the number of times the mothers produced the [ɛ] sound to the number of times the infants imitated the sound.

Figures six and seven showed that the mothers did not produce either of the central vowels; however, at age forty-seven weeks, Infant II produced an [æ] sound, which was probably
substituted for another sound. Infant I showed a similar pattern of production, not exact imitation of a middle vowel at ages sixty-two and sixty-four weeks. Infant I imitated the sound at the seventy-two weeks age level.

![Graph showing proportion of imitation over age in weeks for mothers and infants.]

**Fig. 7**—A comparison of the number of times the mothers produced the sound to the number of times the infants imitated the sound.

Comparisons of the number of times the infants imitated the back vowels that were produced by their mothers are shown in figures eight through eleven.

Analysis of the number of imitations of the back vowels showed that Infant I correctly imitated her mother's productions of back vowels beginning with the sixty-six weeks age level with production of the sound. Although Infant II produced the sound at the forty-nine weeks age level, the sound was not produced by her mother. This production would suggest that the sound was substituted for another sound. Infant I correctly imitated the sound at the seventy-four weeks age level. At age sixty-eight weeks Infant I
made a correct imitation of the \[\text{C} \otimes \text{O} \] sound. She also produced the sound at the seventy-two weeks age level, although it was not produced by her mother. It is noted that Infant II produced the \[\text{C} \otimes \text{O} \] back vowel at the fifty-eight weeks age level, while Infant I correctly imitated the sound at age sixty-eight weeks.

Figures twelve and thirteen represent the diphthongs that were produced and imitated in the selected samples of speech.

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**Fig. 8**—A comparison of the number of times the mothers produced the \[\text{C} \otimes \text{O} \] sound to the number of times the infants imitated the sound.

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**Fig. 9**—A comparison of the number of times the mothers produced the \[\text{C} \otimes \text{O} \] sound to the number of times the infants imitated the sound.
Fig. 10--A comparison of the number of times the mothers produced the [a] sound to the number of times the infants imitated the sound.

Fig. 11--A comparison of the number of times the mothers produced the [au] sound to the number of times the infants imitated the sound.
In figure eleven it is noted that Infant II produced the [aI] diphthong quite frequently, and correctly imitated the sound at age fifty-four weeks. The [aI] diphthong also occurred in the speech of Infant I in which she consistently imitated her mother's production of the diphthong at ages seventy-three and seventy-four weeks. The infant also correctly imitated her mother's production of the [ɔI] sound at the seventy-four weeks age level in Figure thirteen.

The bilabial sounds [b], [m], and [p] are plotted in figures fourteen through sixteen and comparisons of the infants' imitations of the sounds are presented.

Fig. 12--A comparison of the number of times the mothers produced the [aI] sound to the number of times the infants imitated the sound.
Fig. 13--A comparison of the number of times the mothers produced the [CO] sound to the number of times the infants imitated the sound.

Fig. 14--A comparison of the number of times the mothers produced the [b] sound to the number of times the infants imitated the sound.
Fig. 15—A comparison of the number of times the mothers produced the [m] sound to the number of times the infants imitated the sound.

Fig. 16—A comparison of the number of times the mothers produced the [p] sound to the number of times the infants imitated the sound.
The figures showed that Infant II correctly imitated the \( b \) sound at age forty-seven weeks and imitated this particular sound more than any of the other bilabials. Infant I showed some imitations as she matured to seventy-four weeks. She followed a similar pattern with an increase in the imitation of the \( m \), and \( P \) bilabials as she increased in age.

Figures seventeen through twenty represent the linguo-alveolar sounds that were produced and imitated in the selected samples of speech.

![Graph showing proportion of imitation over age]

**Fig. 17**—A comparison of the number of times the mothers produced the \( t \) sound to the number of times the infants imitated the sound.

Of the linguo-alveolar sounds, only the voiced and voiceless stops \( d \) and \( t \), and nasal \( n \) were imitated. At forty-nine weeks, Infant II produced the \( t \) sound and imitated the mother's speech at the fifty-two weeks age.
Fig. 18--A comparison of the number of times the mothers produced the [d] sound to the number of times the infants imitated the sound.

Fig. 19--A comparison of the number of times the mothers produced the [n] sound to the number of times the infants imitated the sound.
Fig. 20—A comparison of the number of times the mothers produced the [l] sound to the number of times the infants imitated the sound.

Fig. 21—A comparison of the number of times the mothers produced the [s] sound to the number of times the infants imitated the sound.
level. Figure eighteen indicated that Infant II imitated the [d] sound the same number of times, or fairly close to her mother's productions at ages forty-seven weeks, and increased the number of imitations as she matured. Infant I imitated her mother consistently on the [d] sound. In figure nineteen the nasal [n] sound only appeared in the speech of Mother and Infant I. The infant made correct imitations of this sound at age sixty-eight weeks. It was noted in figures twenty and twenty-one that the infants did not imitate the [l] and [s] sounds at any time.

![Graph showing proportion of imitation over age in weeks]

Fig. 22--A comparison of the number of times the mothers produced the [g] sound to the number of times the infants imitated the sound.

The voiced and voiceless lingua-velars [g] and [k] and unvoiced glottal fricative [h] sound appear in figures twenty-two through twenty-four.
Fig. 23--A comparison of the number of times the mothers produced the [k] sound to the number of times the infants imitated the sound.

Fig. 24--A comparison of the number of times the mothers produced the [h] sound to the number of times the infants imitated the sound.
Although Infant I imitated the voiceless lingua-velar \textipa{[k]} sound at the sixty-eight and seventy-two weeks age levels in figure twenty-three, neither infant imitated the voiced \textipa{[g]} sound. It was noted that Infant I produced the voiceless glottal fricative \textipa{[h]} sound once in comparison to her mother's two productions.

Figures twenty-five through twenty-seven present the labio-dental and lingua-palatal consonants that the mothers produced in the selected speech samples.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig25.png}
\caption{A comparison of the number of times the mothers produced the \textipa{[v]} sound to the number of times the infants imitated the sound.}
\end{figure}

The labio-dental \textipa{[v]} sound and the lingua-palatal consonants \textipa{[\textipa{r}]} and \textipa{[d\textipa{3}]} occurred in the speech of the mothers; however, the infants did not imitate the sounds.
Fig. 26--A comparison of the number of times the mothers produced the sound to the number of times the infants imitated the [r] sound.

Fig. 27--A comparison of the number of times the mothers produced the [dʒ] sound to the number of times the infants imitated the sound.
Analysis of Stress and Intonation Patterns

Table I presents the proportion of times each infant imitated the primary and secondary stress patterns, fading terminal and rising terminal junctures that were observed in their mothers' speech.

TABLE I

PROPORTION OF TIMES THE TWO INFANTS IMITATED STRESS AND INTONATION PATTERNS OF THEIR MOTHERS' SPEECH

<table>
<thead>
<tr>
<th>Age</th>
<th>Primary Stress</th>
<th>Secondary Stress</th>
<th>Fading Terminal Juncture</th>
<th>Rising Terminal Juncture</th>
</tr>
</thead>
<tbody>
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<td>47</td>
<td>.66</td>
<td>2.00</td>
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</tr>
<tr>
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<tr>
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<td>.66</td>
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</tr>
<tr>
<td>64</td>
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<td>0.00</td>
<td>1.00</td>
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<tr>
<td>66</td>
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<tr>
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</tr>
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<td>0.00</td>
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<td>0.00</td>
</tr>
</tbody>
</table>

*Ages of the infants are expressed in weeks*
Table I indicates that both infants imitated the primary stress patterns of their mothers' speech at all age levels. The secondary stress pattern was not imitated as frequently as the primary stress. Both infants showed a pattern of frequently imitating only one syllable of a two-syllable word. Perhaps this pattern would account for a lower proportion of imitations of the secondary stress pattern. Both infants imitated the fading terminal juncture at all age levels. The rising terminal juncture occurred only twice in the speech samples, in which the mothers asked the infants a question. It was observed that the infants appeared to answer the question and repeated the word with a fading terminal juncture, which denoted declaration.

**Distinctive Feature Analysis**

Tables II and III present the proportion of imitation, P, which is defined as the ratio of the number of times the infants imitated the distinctive features to the number of times the mothers produced the feature. The nine binary oppositions are listed in the tables with the first of each nine binary oppositions in Table II and the second binary opposition listed in Table III. A comparison of the information from these two tables shows that the forty-seven to forty-nine weeks age level, Infant II imitated the features +voiced and +voiceless at about the same proportion as her mother produced them. However, Infant I, at sixty-two
TABLE II

PROPORTION OF TIMES THE TWO INFANTS IMITATED THE DISTINCTIVE FEATURES OF THEIR MOTHERS' SPEECH

<table>
<thead>
<tr>
<th>Age</th>
<th>Voiced</th>
<th>Consonant</th>
<th>Compact</th>
<th>Grave</th>
<th>Flat</th>
<th>Nasal</th>
<th>Tense</th>
<th>Continued</th>
<th>Strident</th>
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<tr>
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<td>54</td>
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<td>58</td>
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<tr>
<td>62</td>
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</tbody>
</table>

*Ages are expressed in weeks*
through seventy-four weeks showed a higher proportion of imitation of the +voiced feature than the +voiceless. Both infants showed significantly more imitations of the +non-consonant feature than the +consonant feature throughout the age levels. A trend of increased imitation of the +consonant feature was observed at forty-nine through fifty-eight weeks and sixty-two weeks through seventy-four weeks age levels.

Infant II imitated the feature +diffuse more frequent than the +compact feature at ages forty-seven through fifty-eight weeks; whereas, Infant I imitated the +compact feature more frequent than the +diffuse feature at ages sixty-four through seventy-four weeks. Infant II fluctuated in her imitations of +grave and +acute features; however, Infant I consistently imitated the +grave more frequent than +acute feature at all age levels.

The tables show little imitation of the +flat and +plain features. Zero proportion of imitation indicates that either the mother produced the +flat and +plain features and the infant did not imitate the features, or that the infant produced the features without imitation of her mother. Throughout all age levels, both infants imitated the +oral feature more frequent than the +nasal feature. This high degree of imitation presumably resulted because the mother produced more phonemes with a +oral feature than
TABLE III

PROPORTION OF TIMES THE TWO INFANTS IMITATED THE DISTINCTIVE FEATURES OF THEIR MOTHERS' SPEECH

<table>
<thead>
<tr>
<th>#Age</th>
<th>V</th>
<th>N-C</th>
<th>D</th>
<th>A</th>
<th>P</th>
<th>O</th>
<th>L</th>
<th>I</th>
<th>M</th>
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<td>1.00</td>
<td>1.00</td>
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</tr>
</tbody>
</table>

*Age of infants expressed in weeks

V—Voiceless
N-C—Non-consonant
D—Diffuse
A—Acute
P—Plain
O—Oral
L—Lax
I—Interrupted
M—Mellow

A nasal feature each time the mother produced a phoneme with this feature.

A comparison of the +tense and +lax features revealed that both infants imitated the +lax feature more frequent
than the + tense feature. A similar pattern was observed for the features + continuant and + interrupted. Analysis of these features indicated that the + interrupted feature was more frequent than the + continuant feature. The + strident feature was not imitated by either infant; however, + mellow was imitated a significant number of times at ages sixty-eight and seventy-two weeks.

A comparison of each of the nine binary oppositions is charted in Table IV according to rank order of imitation. An analysis of the data on distinctive features, indicated that the infants in the present study imitated the features + grave, + non-consonant, + oral, + lax, + diffuse, + interrupted, + voiced, + plain and + mellow more than their binary opposing features.

Summary

Thirty-one samples of speech that were selected from tape recordings of Infant I and II and their mothers were analyzed and compared. The subjects' vocalizations were recorded over a period of sixteen weeks. The analysis of the raw data was categorized in the following manner: phonetic analysis and comparison of the mothers' and infants' vocalizations; analysis and comparison of stress and intonation patterns, terminal junctures of the mothers' and infants' speech; distinctive feature analysis and comparison of the speech of the mothers and infants. Comparison of phonetic
TABLE IV
RANK ORDER OF THE TWO INFANTS' IMITATION OF DISTINCTIVE FEATURES

<table>
<thead>
<tr>
<th>Rank Order</th>
<th>Infants (Age 47-74 Weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Grave</td>
</tr>
<tr>
<td>2</td>
<td>Non-consonant</td>
</tr>
<tr>
<td>3</td>
<td>Oral</td>
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<td>Lax</td>
</tr>
<tr>
<td>5</td>
<td>Diffuse</td>
</tr>
<tr>
<td>6</td>
<td>Interrupted-Voiced</td>
</tr>
<tr>
<td>7</td>
<td>Accute</td>
</tr>
<tr>
<td>8</td>
<td>Compact</td>
</tr>
<tr>
<td>9</td>
<td>Voiceless</td>
</tr>
<tr>
<td>10</td>
<td>Consonant</td>
</tr>
<tr>
<td>11</td>
<td>Plain</td>
</tr>
<tr>
<td>12</td>
<td>Mellow</td>
</tr>
<tr>
<td>13</td>
<td>Tense</td>
</tr>
<tr>
<td>14</td>
<td>Flat</td>
</tr>
<tr>
<td>15</td>
<td>*Nasal</td>
</tr>
<tr>
<td>16</td>
<td>Continuant</td>
</tr>
<tr>
<td>17</td>
<td>Strident</td>
</tr>
</tbody>
</table>

*Nasal--It was indicated that the mothers produced phonemes with the + nasal feature less frequently than other phonemes. However, when this feature was produced, the infants imitated it a proportion of 1.00; therefore, it is reasoned that + nasal should appear at a higher rank, either before or after + oral.
The analysis of the subjects' speech was made by comparing the number of times the mother produced a phonetic sound and the number of times the infant imitated the sound at certain age levels expressed in weeks. The results of each phonetic sound were plotted on a graph. Each sound that occurred in the selected speech samples was grouped and compared according to place of articulation in the production of vowel and consonant sounds.

Comparisons of stress and intonation patterns, terminal junctures and distinctive feature content were made utilizing the value, proportion of imitation. This value was defined as the ratio of the number of times the infant imitated a speech pattern (stress, terminal juncture) to the number of times the mother produces that speech pattern.

Distinctive feature analysis was based upon results of phonetic transcriptions of the selected samples of speech. Each of the nine binary features was charted and the proportion of imitation was found. The value of proportion of imitation was defined and employed in the same manner as the data on stress and intonational patterns. All features were ranked according to the sum of their proportionate values.

The analysis and comparison of the vocalizations of the infants and their mothers were discussed according to imitation as a factor of developmental age. Individual results of the infants' imitations were fairly consistent in
that each infant increased in her imitation of the patterns of her mother's speech as she matured.

The results of analysis of the raw data indicated that

1. The front vowels were imitated at age forty-seven weeks with an increase in imitation as the infants matured. The [i] vowel was imitated more at forty-seven weeks of age and more frequently than the other front vowels.

2. The middle vowels were not imitated as frequently as the front or back vowels, but were substituted for other sounds.

3. The back vowels were imitated and produced more than the middle vowels and showed an increase in imitation with maturation.

4. The [aɪ] diphthong was produced and imitated as frequently as the [ɪ] sound and front vowel sounds from forty-seven to sixty-six weeks age level. The [ɔɪ] diphthong was produced less frequently than the [aɪ] sound; however, it was correctly imitated at age seventy-four weeks.

5. The bilabial [b] was produced and imitated earlier and more frequently than [m] and [p] sounds. The infants increased the frequency of imitations of the three labials as they matured.

6. Of the lingua-alveolar consonants produced by the mothers, the voiced and voiceless [d] and [t] and nasal [n] were the only sounds imitated. The [d] was imitated more
than the other lingua-alveolars at each age level; the imitation of both [d] and [t] sounds increased with maturation.

7. The lingua-velar [k] was imitated at ages sixty-eight and seventy-two weeks.

8. The labio-dental [v], lingua-palatals [r] and [d ʒ] and lingua-alveolars [s] and [ʃ] were not imitated at any age level.

9. The glottal fricative [ɾ] was imitated at the sixty-two weeks age level.

10. At each age level, both infants consistently imitated the stress patterns and terminal junctures of their mothers' speech.

11. All distinctive features were ranked according to the sum of their proportionate values. The rank order is as follows: grave, non-consonant, oral, nasal, lax, diffuse, interrupted, voiced, accute, compact, voiceless, consonant, plain, mellow, tense, flat, continuant and strident.

An interpretation of these results follows in Chapter IV.
CHAPTER BIBLIOGRAPHY


3. Irwin, Orvis C., "Infant Speech: Consonant Sounds According to Place of Articulation," Journal of Speech and Hearing Disorders, XII (Spring, 1947), 397-401.


CHAPTER IV

DISCUSSION, CONCLUSIONS, AND SUMMARY

Discussion

Discussion of the results that were obtained from analysis and comparison of the vocalizations of Infants I and II and their mothers will be presented in the same order in which the results were reported.

Phonetic Analysis

The infants presented a definite pattern in their imitation of the vowel sounds in their mothers' speech. The front vowels, the diphthong [aɪ], and back vowels were produced and imitated more often than the middle vowels, and were imitated more frequently at the younger age levels. These front vowels decreased in imitation as the infant matured; however, the back and middle vowels showed an increase in production and imitation with maturation. The results obtained on vowel production are in agreement with Irwin. His study reported that at the tenth through the eighteenth months age levels the infants in his study used a higher percentage of middle vowels (Irwin, p. 33).

In the analysis of the infants' productions of the consonant sounds, the infants produced and imitated the
bilabials $[b], [m], [p]$, the lingua-alveolars $[d], [t]$, and nasal $[n]$ earlier and more frequently than other consonants. Of the labials, the voiced $[b]$ and $[m]$ sounds and the voiced lingua-alveolar $[d]$ were imitated more frequently than their voiceless cognates. The infants increased their imitations of these sounds as they matured. It was observed that either the infants did not imitate the following consonants, or they imitated them less frequently than they did other consonant sounds: lingua-velars, labio-dentals, lingua palatals, glottal fricatives, and lingua-alveolar fricatives.

The results of this study on the imitation of consonant sounds agree in part with the investigation made by Irwin. Irwin's study reported that at age levels eleven through eighteen months, the infants showed the following rank order of percentage of productions of consonants by place of articulation: (1) glottals, (2) post-dentals, (3) labials, (4) velars, (5) lingua-dentals, and (6) combined (3, p. 399). The current study is more in accord with the study by Schultz. He stated that infants' phonetic utterances evolve from labial sounds by the law of the least physiological effort toward guttural sounds that require the greatest effort (12, pp. 30-31).

The present investigation is in agreement with Irwin's study of infants' production of consonant sounds according
to manner of articulation. Irwin's study of infants from ten to fifteen months presented the following rank order of percentage of production of consonants by manner of articulation: (1) voiced plosives, (2) voiceless fricatives, (3) voiced nasals, (4) voiceless plosives, (5) glides, and (6) voiced fricatives (2, p. 403).

**Analysis and Comparison of Intonation and Stress Patterns**

According to analysis and comparison of the speech of the subjects, it was observed that both infants were imitating the stress and intonational patterns, and terminal junctures of their mothers' speech at the initial tape recording sessions. Several studies have reported that the infant imitates the stress, intonational, and inflectional patterns of speech before actual phonetic imitations. Lewis considered intonation patterns to consist of syllables, stress patterns and pitch patterns. He stated that "...the infant is able to imitate the intonational form of others. In the imitation stage, the number of syllables, the stress patterns, and the pitch pattern are all imitated" (7, p. 94).

Lieberman's study of intonation used two subjects, ages ten months and thirteen months. He used quantitative acoustic measurements that were related to the imitation of intonation signals. The results showed that mimicry of the average fundamental frequency range occurred at about ten months (6).
Distinctive Feature Analysis

The results that were obtained on distinctive feature analysis indicated that the infants imitated the features of their mothers' speech according to a hierarchy of feature distinctions. Menyuk's study revealed that a hierarchy of feature distinctions may be a linguistic universal, which is probably dependent on the developing perceptive and productive capacities of the child (9, p. 142).

In the analysis of the features, all nine binary oppositions were treated individually which gave a total of eighteen features. The features were ranked according to the sum of their proportionate values. The rank order that evolved at ages forty-seven weeks to seventy-four weeks was (1) grave, (2) non-consonant (vowel), (3) oral, (4) nasal, (5) lax, (6) diffuse, (7) voiced and interrupted, (8) acute, (9) compact, (10) voiceless, (11) consonant, (12) plain, (13) mellow, (14) tense, (15) flat, (16) continuant, and (17) strident.

In keeping with the interpretations by Menyuk, it is apparent from the results of this study that the distinctive features of vowels and consonants that were acquired and imitated better than others seem to represent articulatory gestures which have on-off characteristics or maximal degree of difference. For example, the vocal cords vibrate or they do not (*voiced); the sound is emitted through the nasal
passages or it is not (nasal). The grave feature appears to represent a maximal degree of difference. If a consonant is marked +grave it is produced at the periphery of the vocal mechanism, whereas an +acute feature is produced somewhere other than the periphery of the vocal mechanism. The same interpretation is typical of the +continuant feature (9). Both the +acute and +continuant features ranked low in the infants' hierarchy of imitation of features.

In the production of the +non-consonant features (vowels) the vowels have no obstructive barrier along the median line of the mouth cavity, whereas consonants have a barrier sufficient to produce either complete occlusion or a turbulent noise source (5). The +interrupted feature (stops) have complete closure of the vocal folds followed by an opening. The infants in the present study imitated the +interrupted feature significantly more than its minimal pair, +continuant. The essential articulation difference between the +compact and +diffuse phonemes lies in the relation between the volume of the resonating cavities in front of the narrowest structure and those behind this structure. Hence, the consonants articulated against the hard or soft palate (velars and palatals) are more compact than the consonants articulated in the front part of the mouth. Open vowels are the most compact while close vowels are the most diffuse (5). This manner of production apparently accounts
for the reason the infants in the present study imitated the +diffuse feature proportionately more on consonants and varied their productions of the +diffuse and +compact features on vowel phonemes.

The +strident feature is characteristic of the labiodentals and sibilant sounds. Production of these sounds require more complex tongue movements than other consonant sounds. It was noted that the infants in the current study did not imitate these consonant sounds. The +flat and +plain features are characterized by a variation in lip orifice. The +flat phoneme requires a reduction (rounding) of the lips while the +plain feature requires a wider opening of the orifice; therefore, the plain feature is easier to produce (5). The +tense feature calls for articulation with greater distinctness and pressure than the corresponding lax phoneme (4). Perhaps this production accounts for the infants' producing the +lax feature more frequently than the +tense feature.

The results of distinctive feature analysis correlated closely with Menyuk's rank order of production and mastery of distinctive features of consonant sounds. The minor differences obtained between the two studies could be related to the number of features that were utilized. Menyuk also used older children, ages one to three years of age.
Conclusions

From the results obtained in this study it may be concluded that

1. The infants of this study vary somewhat in the age levels at which they begin to develop each pattern of their mother's speech (stress and intonation patterns, phonetic, phonemic and distinctive feature content).

2. The infants produced and imitated vowel and consonant sounds according to a developmental pattern which is related to place and manner of articulation; this hierarchy of production and imitation of sounds was acquired, maintained, increased and/or decreased as a function of maturation.

3. The infants began to imitate the intonation and stress patterns and terminal junctures of their mothers' speech before they imitated other qualities of speech.

4. The infants showed a rank order in production of the distinctive features of phonemes. The features were imitated according to the simplicity of production (manner and place of articulation). The ability to produce these phonemes increased with maturation.

5. The infants' imitated vocalizations of their mothers' speech contained the same distinctive feature analysis, yet a different phonetic content.
The infants in this study began to imitate more frequently the speech patterns (stress, intonation, phonetic, phonemic and distinctive feature content) of their mothers' speech between the ages forty-nine and sixty-two weeks.

Much research and numerous studies have been done on the development of speech in infants. The different results that were obtained from these studies make it apparent that vocal habits vary from infant to infant; therefore, it is impractical to assign a definite age level to the time at which infants commence or complete a certain stage of speech development.

The results of this study indicate that it is possible to determine the age range at which Infants I and II began to develop the speech patterns of their mothers' speech.

It is possible that these age ranges can be applied to infants who have normal physical and mental development; however, allowance should be made for individual differences of each infant, his environment, as well as the circumstances of the mother-infant relationship. In addition, it should be kept in mind that the infants in this study were selected according to certain criteria.

Although only two infants were used in the current study, the results concerning infant speech development could be applied to other infants according to Osgood's following statement: