PRE-LINGUISTIC BEHAVIOUR

A systematic Analysis and Comparison of Early Vocal and General Development

A.B. [illegible] (highest honors) 1961

Submitted by Thomas G. ordon Bever, to the Department of Linguistics
in partial fulfillment of the requirements for the degree with honors

March 31, 1961

Table of Contents

Introduction

Much has been written in the past twenty-five years on the development of language in children. Most of this work, however, has been concerned with the acquisition of language itself, of its phonemes and morphophonology. Investigation of what precedes the early linguistic period has been largely confined to cursory observation of vague and non-descript "periods".

Although early vocal behaviour may be pre-linguistic, it is still vocal, and a study of its development from birth until the first stage of language learning should be profitable just because of the psychological simplicity implied by the label "non-linguistic". A study of early vocal development in relation to other aspects of infant growth may provide information relevant to the relation between mature vocal activity and other aspects of mature behaviour.

Before vocal development and the development of other behaviour patterns can be compared, they must be made commensurable with one another. For example, an increase in vowel-sound activity cannot be directly related to an increase in the ratio of plantar/dorsal reflexes. Both items must first be interpreted in relation to other aspects of vocal and general development, respectively, and more general patterns abstracted in each case.

Thus this discussion is divided into three sections, a discussion of the patterns of vocal development, interpreted from raw data and theoretical literature, an investigation of the data on early general and neurological development, and a final brief comparison of these two aspects of the child's development.

The observation of processes as they emerge together can give otherwise unobtainable definition of the relation between those processes in the mature organism. Accordingly, this paper attempts to organize early vocal and general development in comparable terms, to define the relation of the emergence of the two activities, and to discuss the implications of that relation for general vocal activity.

Chapter 1. Data on Early Vocal Development

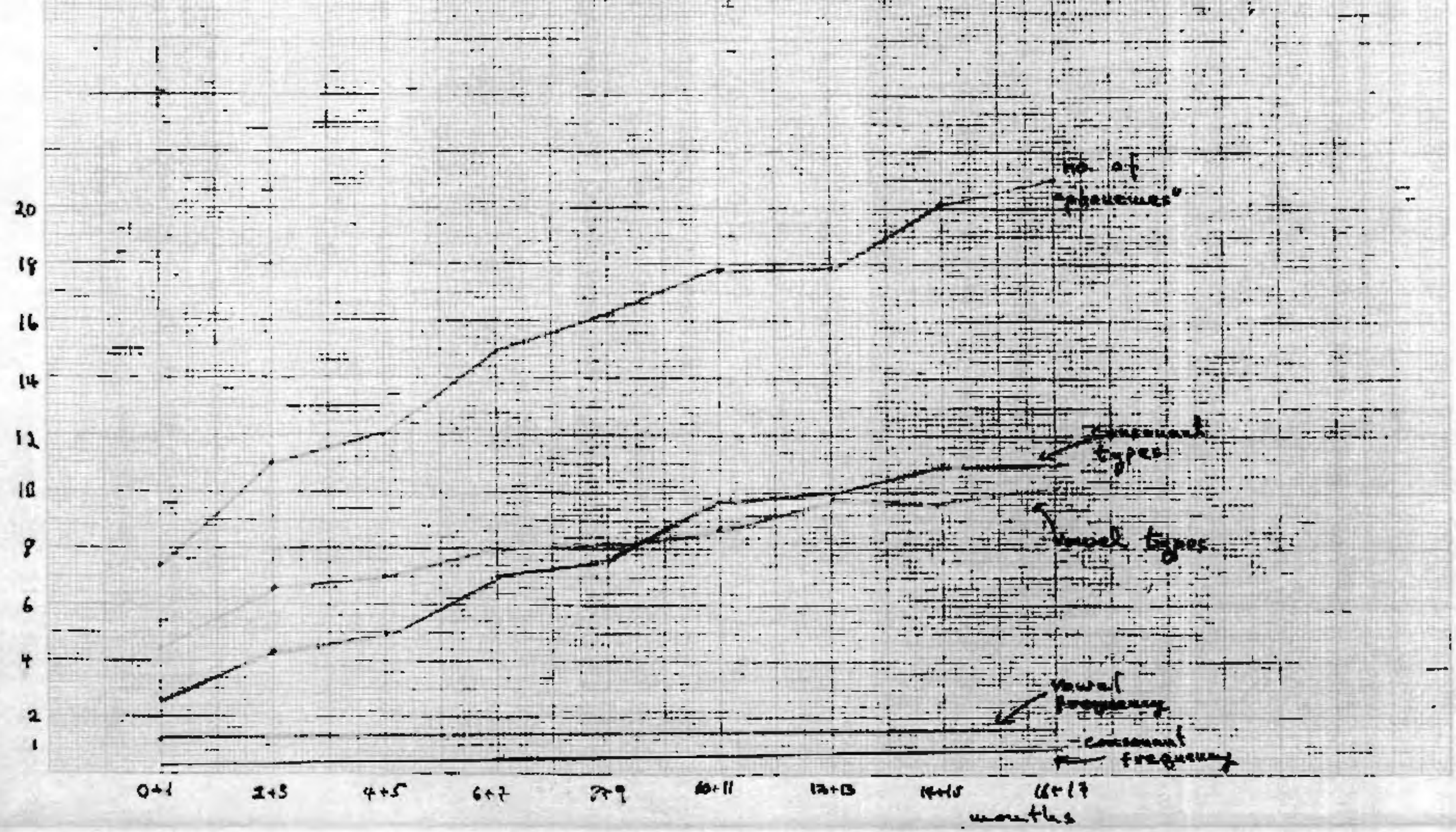
1.1. The Data of Irwin et. al.

Irwin and his associates worked together for many years, developing a consistent phonetic representation for the vocal productions of infants, and were eventually able to reach a high level of agreement on how to code most sounds (Irwin, 1945-1947).

There are many difficulties presented by Irwin's methods of collection and presentation of the data. (1) The analyses of different aspects of vocal development were carried out on different children and using different numbers of children, a procedure which has the unfortunate effect of smoothing over any detailed ontogenetic features of vocal development. Consequently, each set of data is an average which can be compared only with other averages and it is thus impossible to follow the details of individual development, which might be the most informative approach to this problem. (2) No distinction is made between sounds that are "used" and sounds which are "babbled"; it is simply stated that the sounds (confusingly referred to as "phonemes") are "produced". (3) The data are presented in the form of two-month averages. This smothers any possibility of determining developmental patterns or cycles, best measured in days rather than in months. (4) A chronological, rather than a developmental, time scale is used, making it even more difficult to assess the developmental significance of the data.

These objections pertain particularly to work on the period of early linguistic development (nine to eighteen months), but its value for the first months of life is not so seriously damaged. This paper attempts to organize the data on early "pre-linguistic" vocal deve-

Graph 1



no. of "phonemes"
consonant types
vowel types
vowel frequency
consonant frequency
20
18
16
14
12
10
8
6
4
2
1
0+1
2+3
4+5
6+7
8+9
10+11
12+13
14+15
16+17
months

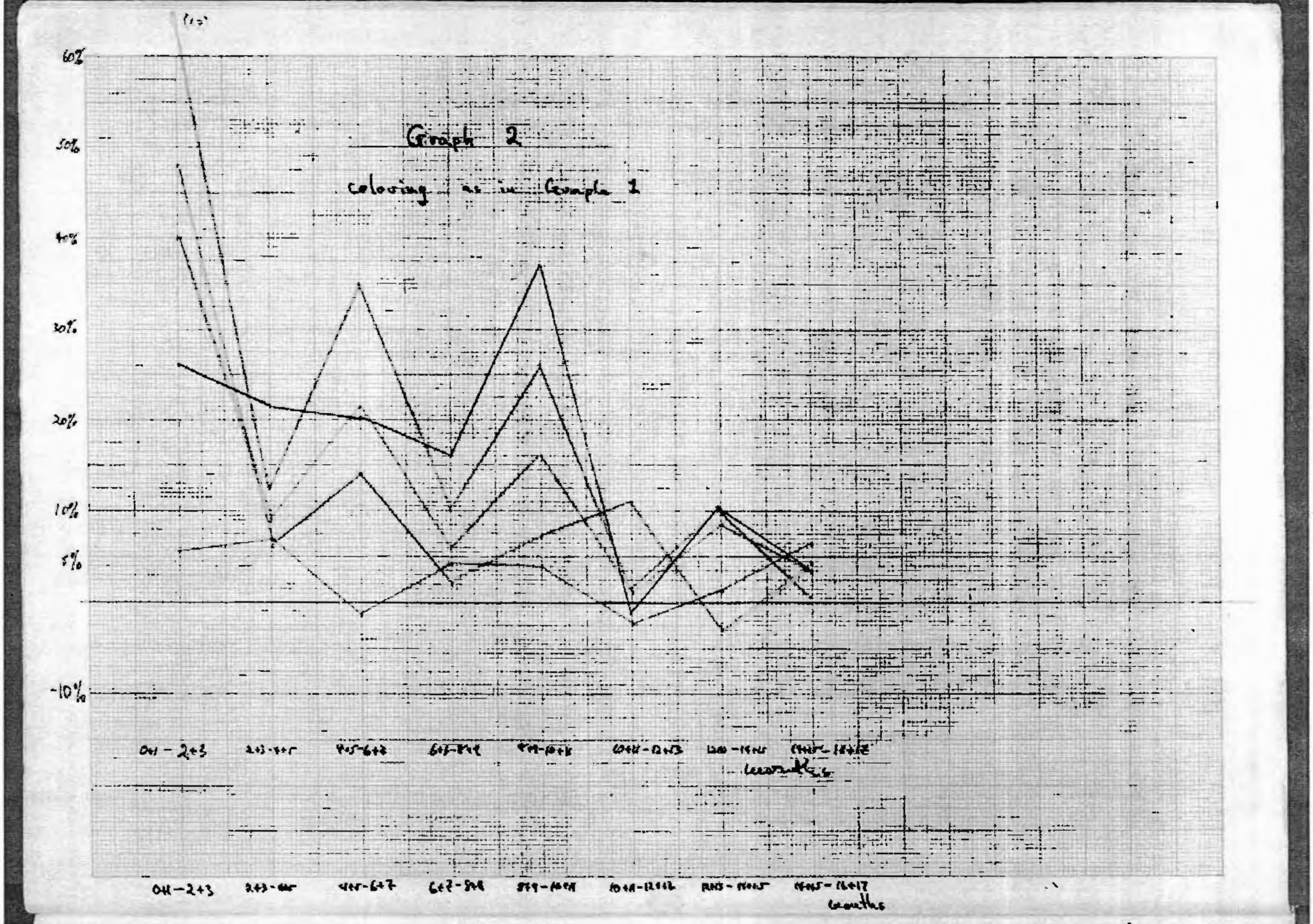
lopment so that it may be related to early behavioural and neurological development. It is impossible to consider vocal development at this early age as "linguistic" progress, but the fact that Irwin did so does not make it necessary to ignore his data. For a study such as this, knowledge of the development and changes in the sounds produced is valuable, aside from whether or not they are used phonemically or interpreted as "phonemes".

months

Early pre-linguistic vocal development shows strong patterns of relationship between the increase in number and frequency of vocalic and consonantal sounds and other aspects of the vocal data. Two major trends appear in the first eighteen months: (1) There are three periods, four through eleven months, and twelve through eighteen months.* Each period has a characteristic set of developmental patterns, and is set off from the other periods by unique and distinct changes in these patterns. (2) On the basis of the way these patterns develop and change, it is clear that consonantal sounds develop in a manner different from that of vocalic sounds during the first two periods, and that during the third (the first stage of language) their growth patterns are similar.

1.11 In the analysis of these data at least one stage of numerical reinterpretation is necessary before any trends can be isolated. The information as presented by Irwin is summarized in Graph 1. The most clear conclusion which may be drawn is that there is a general increase from two-month period to two-month period in the number of phoneme types produced, in the frequency of vocalic and consonantal sounds,

*The notation used in this paper is based on the conventional form: the first thirty days of life are referred to as "0 months: n days" when used cardinally, and as "the first month" when used ordinally. Thus, during the period 30-60 days, the child is "one month old" but enjoying his "second month".


Graph 2
colouring as in Graph 1
60%
50%
40%
30%
20%
10%
5%
-10%
months

and so on. But this absolute increase is neither linguistically nor psychologically significant, since it is obvious that the new-born's production of sounds has nowhere to go but up.

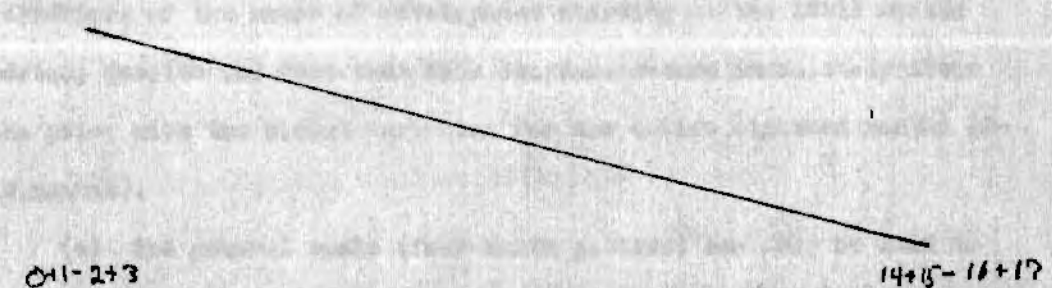
The measure which is useful in the evaluation of vocal development is how fast the various functions increase with respect to what they were. In other words, what is the percentage change (i.e., the rate of change) from one period to the next and how does this value compare with the percentage changes between other pairs of periods? This analytic interpretation of the data has more psychological validity than the data in raw form, since the psychologically significant question in quantitative behaviour change is not only the direction the change takes from one time to another and its absolute magnitude, but also the magnitude of the change with respect to other changes.

Graph 2 is derived from the same data as Graph 1, but here each figure represents the percentage change occurring between two-month periods. Graph 1 gave the impression that early vocal development is a gradual and steady process, but even a cursory examination of Graph 2 shows this to be misleading, since the actual rate of increase and decrease in the development of the various functions is subject to severe fluctuation. (It could be objected that these variations are artifacts of poor methodology or of statistically predictable variation, and thus are not significant records of the child's actual behaviour. These objections are discussed and met in Appendix IB.)

1.12 As mentioned above, it would be begging the question simply to state that, as the child grows older, his vocal diversification increases. The nature of this increase must be more accurately specified in order to have data which are comparable with data on the general development of the child.

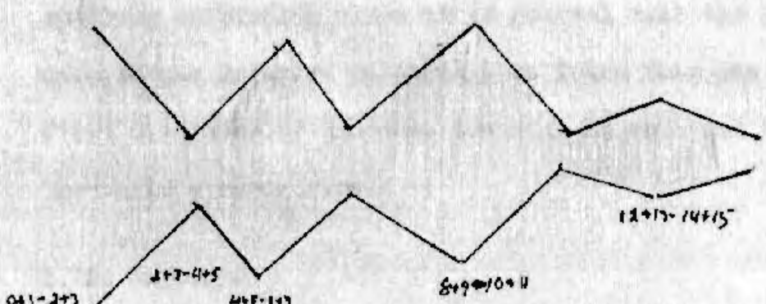
(1) The first observation is that there is a steady decline in the rate of change of the various components:

(Figure 1)



(2) This steady decline has superimposed upon it a four-month cycle, which is characterized by a sharp <u>increase</u> in the rates and ranges of the rates of change between the 0&1 and 2&3, 4&5 and 6&7, 8&9 and 10&11, and 12&13 and 14&15 months periods, and a sharp decrease in the rates and ranges of the rates of change between the 2&3 and 4&5, 6&7 and 8&9, 10&11 and 12&13 months* periods.

(Figure 2)



Thus, in the periods of birth through three months, four through seven months, eight through eleven months, and twelve through fifteen months, there is a cyclic pattern in the rate of change, with a peak rate at the

*Hereafter these transitions in the data from two-month period to two-month period are sometimes referred to as "1-2 months", "5-6 months", "9-10 months", etc., for convenience and clarity.

middle of each cycle. By inference, the 1-2, 5-6, 9-10, and 13-14 months transitions are the periods of greatest relative increase in vocal development.

(3) The third major feature is a sharp decrease in the range of variations of the rates of development starting at the 12&13 months period, despite the fact that this decrease occurs immediately after the point with the widest variation for the entire eighteen months (9-10 months).

(4) The general cycle (four-month pattern) can only be said to occur after the change from the 2&3 months to the 4&5 months period. The difference between those two periods is, in part, extremely high rates of change in the first, followed by a sharp drop, and subsequent clustering of the rates of change in the second. Nearly all the values less than ten percent likely to be a function of chance (assuming a linear increase to be the null hypothesis) occur in the first transition (0&1 - 2&3 months), for all aspects of vocal development. This is not entirely surprising since it is natural that the younger child has a much larger relative percentage to learn than the older, so that at first the rates of increase are high in relation to what is already in the child's repertoire.

1.13 Summary.

(1) The first change in the rates of increase, between the average of the first two months and the average of the next two (0&1 to 2&3 months), shows a much greater range and higher value than the change in the next transition (2&3 months to 4&5 months). In addition, the range of this transition is considerably more elevated (26-67%) than the ranges of any of the other transitions (-4 to 38% range for the 8&9 to

10-11 months transition is the next highest).

(2) There is a four-month cycle in the rate of change in vocal activity with a peak at the middle of the periods four through seven, eight through eleven, and twelve through fifteen months. There is also a peak during the birth through three months period, but it is not determinable from these data whether it is preceded by a period of low rate of vocal development. The periods of peak activity are accompanied by wider ranges of rates of change than the periods of low activity.

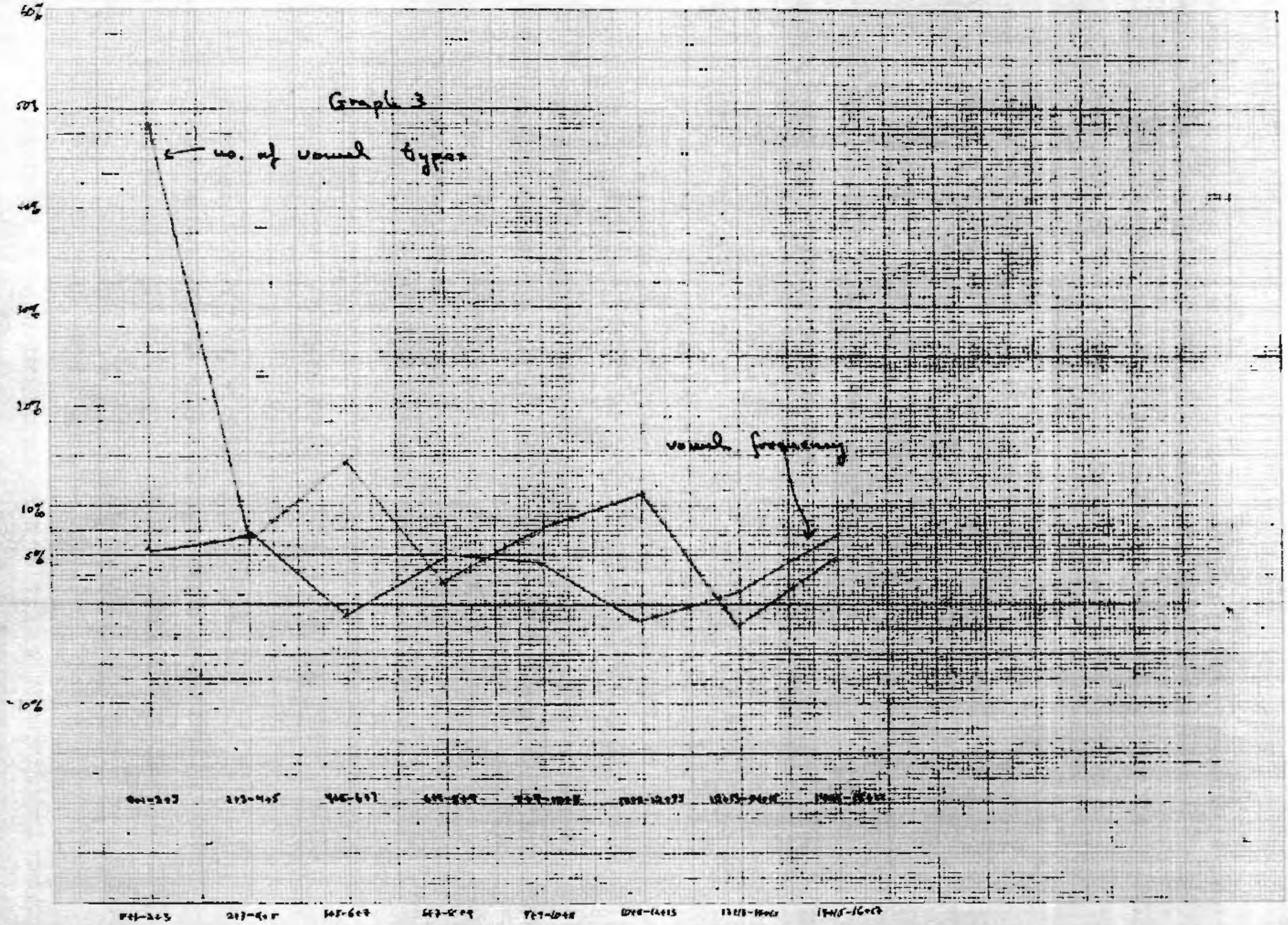
(3) After a period of extremely high activity in the 10-11 months period, the rates of change assume a lower and more stable range for the twelve to eighteen months period.

On the basis of these findings, the data fall into three chronological sections, birth through three months, four through eleven, and twelve through eighteen months. Alternatively, two periods of particular interest can be isolated in the development of vocal productions, around three and four months, and around ten and eleven months. Each of these critical points is followed by a sharp decrease to a more stable plateau in the rate of change in vocal behaviour.

1.14 Detailed Analyses.

1.141 Vowel-sounds

The frequency of vowel-sound activity is already high in the first month and does not increase sharply at any point in the next seventeen; indeed, the rate of change never goes above plus eight percent at any one transition, and at three transitions is less than minus one percent. The rate of increase in the number of vocalic types is never as high as the rate of increase in consonantal types, but the initial absolute number of types of vowel-sounds is much higher than the number of types

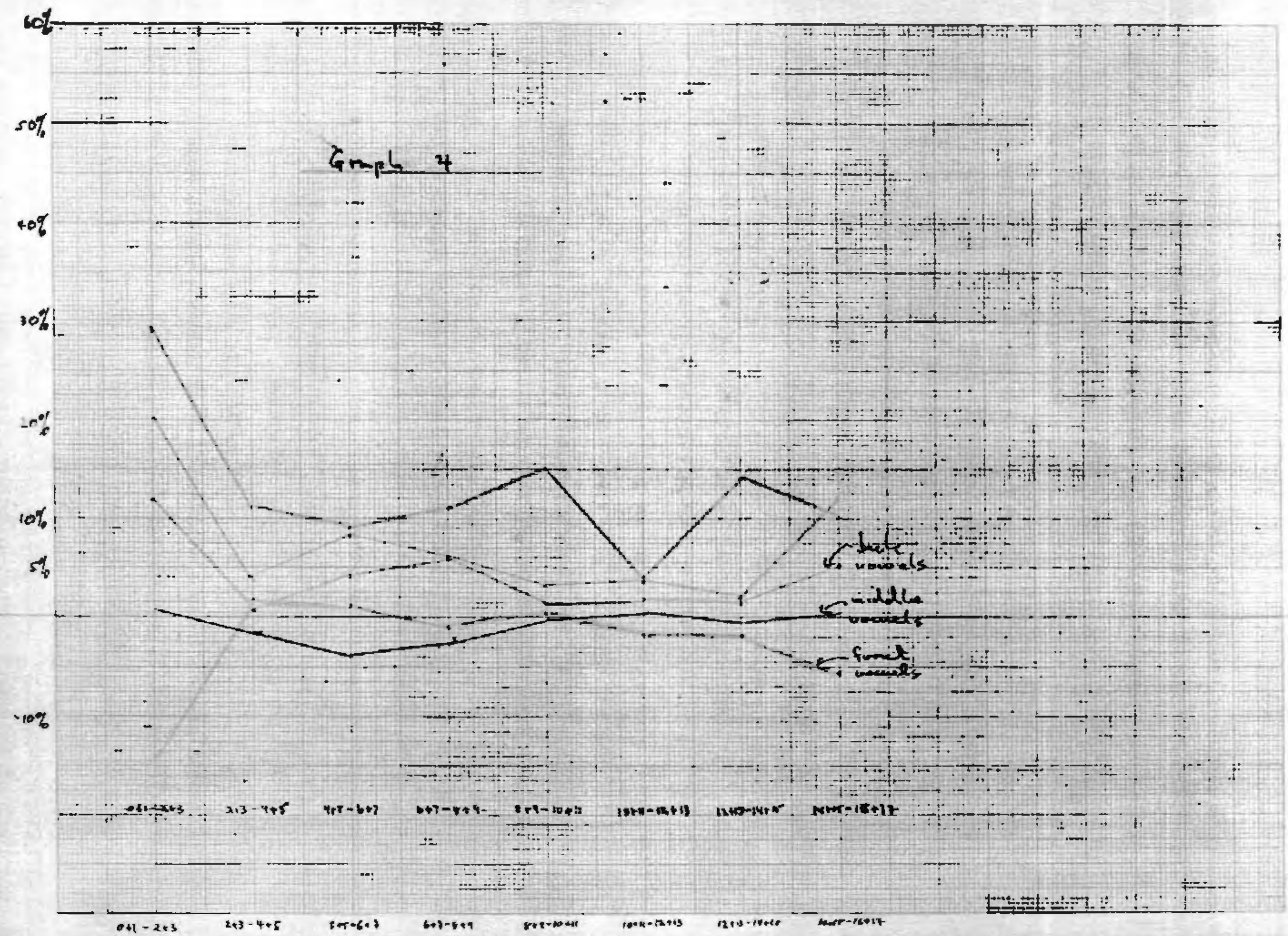

Graph 3
no. of vowel types
vowel frequency
60%
50%
40%
30%
20%
10%
5%
0%

of consonant-sounds. (Graph 1)

One would expect that an increase in the rate of change of vocalic types would be accompanied by an increase in the same direction in the rate of change of vowel-sound frequency; it seems natural to expect that greater frequency of vocalization would be accompanied by greater differentiation. These two functions are shown together on Graph 3, which demonstrates that the exact opposite occurs, until the transition from ~~10&11~~ 12 & 13 months to ~~12&13~~ 14 & 15 months when both functions increase. Up to this point, the rates of change of vowel-sound frequency and of the number of vocalic types are mirror images, the rate of increase falling in one and rising in the other. Hence, from birth to twelve months, the differentiation of new vocalic types is not a directly proportional function of vowel-sound frequency, but, on the contrary, is in inverse proportion to it. A relation may exist indirectly, however, since two months after the rate of increase of vocalic frequency has risen, the rate of increase in the number of vocalic types rises. After the ~~11-12~~ 13-14 months transition, there is no apparent binding relationship between the two functions.

Examining the kinds of activity which occur among the vowel-sounds gives a further indication of the patterns of early vocalic behaviour. Graph 4 shows the changes in the percent-frequency among three classes of vowel-sounds and a summary of the total percentage change occurring at each point in comparison with the preceding point. This summary is referred to as vowel-class "activity".

A general increase in the percentage of back vowels and a decrease in the percentage of front vowels has already been noted by McCarthy


Graph 4
60%
50%
40%
30%
20%
10%
5%
-10%
back vowels
middle vowels
front vowels

and others (McCarthy, 1956). During the first stage of development (0-3 months) this rule holds, but at the second transition (2&3 to 4&5 months) the percentage of front vowel-sounds actually increases more than that of back vowel-sounds, and then remains unchanged until 12&12 months, when it again falls sharply. From 2&3 months until 10&11 months the back vowel-sounds do continue to increase, which is compensated for by a decrease in the percentage of middle vowel-sounds. After the 10&11 months period, a decrease compensating for the continuing increase in back vowel-sounds is exhibited by the front vowel-sounds, while the percentage of middle vowel sounds now remains unchanged.

A general summary of the changes in total intra-vowel-sound activity is also shown on Graph 4. Each figure in the red line is the sum of the changes occurring among the percentage frequencies of twelve different vowel-sounds, and in the gray line, among the three vowel-sound classes. According to the summary of the activity of twelve vowel-sounds (which is the more complete measure), there are two points of interest, the 3-4 months transition and the 11-12 months transition. Both show a sharp drop in overall intra-vowel-sound activity.

These two indices of intra-vowel-sound activity are mirror images of each other after the first and second transitions, which implies that when the changes among the three classes of vowel-sounds are large, the changes among the individual vowel-sounds within the separate classes are small, and vice versa. Therefore, a large amount of activity within a class of vowel-sounds tends to be self-contained and precedes a change in the percent frequency of the whole class (after the first four months), i.e., the class as a whole does not change markedly even while some of its members are fluctuating, because the movements of the members are not uniform in direction and cancel each other out.

Another way of summarizing and depicting the overall rate of vowel-sound development is shown in Figure 3. Here each value is the sum of the rates of change in the number of vowel-sound types and in the frequency of vowel-sounds at each transition times the absolute number of vowel sounds. (Figure 3)

The first two periods of development are clearly delineated at the 3-4 months transition by a sharp drop in the rate of development. It is not clear whether the third cycle starts at eleven or at thirteen months. The previous summary of other detailed evaluations of vowel-sound activity has shown that the 3-4 months and the 11-13 months periods are important.

(Figure 4)

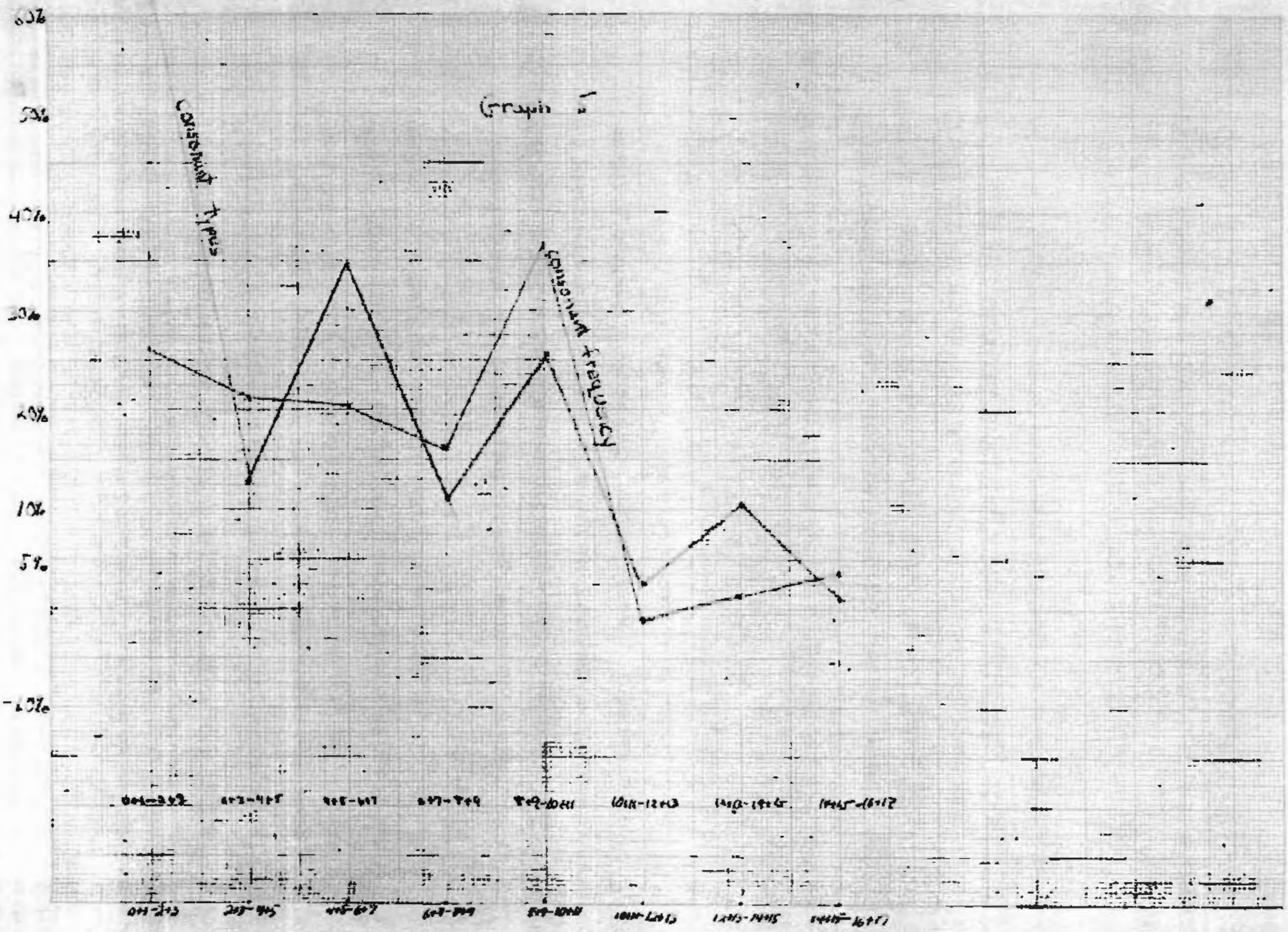
3-4
frequency/type increase

middle-vowel sounds
decrease

11-13
frequency/type indeterminate

front-vowel sounds decrease

low intra-vowel activity-high activity – low activity


Graph 5
Consonant types
Consonant frequency
60%
50%
40%
30%
20%
10%
5%
-10%

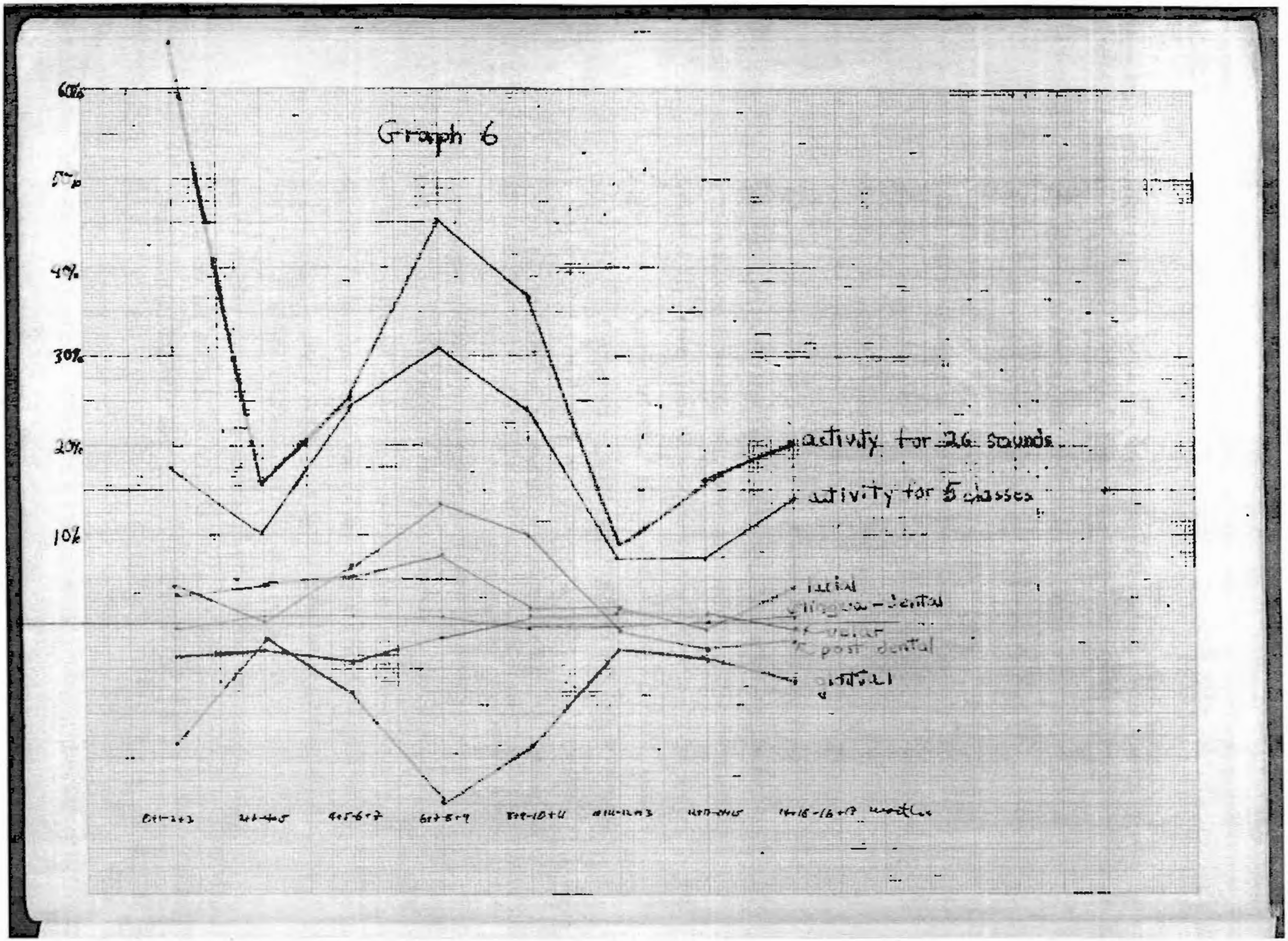
1.142 Consonant-sounds

The rate of increase of consonant-sound frequency decreases steadily until the 9-10 months transition, despite the wide fluctuation in the rate of growth of the number of consonant-sound types. After this transition, the rates of increase of both functions coincide, until the eighteenth months, indicating that an increase in the rate of change of consonant-sound frequency reflects a concurrent increase in the rate of growth in the number of consonantal types, or vice versa (Graph 5).

Graph 6 presents the percent frequency of five consonant-sound classes and two indices of intra-consonantal activity, i.e., the sums of the percent-frequency changes among five classes of consonant-sounds and of the percent-frequency changes among twenty-six consonant-sounds. These two indices have similar curves, which indicates that for consonantal vocalizations high activity among sound classes is a reflection of high activity among the individual consonant-sounds. In general consonantal sounds move forward in the mouth as the child grows older.

There are three periods of consonant sound activity, birth to three months, four to eleven, and twelve to eighteen months. The first is characterized by a sharp increase in activity, the second by an inverted parabolic curve with a peak at 8&9 months and lows at both ends, and the last by a gradually rising rate of activity.

It is interesting to note that the peak of activity in the middle period occurs two months before the point at which the pattern of consonantal frequency-growth begins to coincide with the pattern of growth in numbers of consonantal sound-types. Thus the activity peak comes


Graph 6
60%
50%
40%
30%
20%
10%
activity for 26 sounds
activity for 5 classes
labial
post dental

two months before a sharp burst in the rate of growth in both number and frequency of consonantal sounds; a coincidence of the peak rate of intra-consonantal sound activity with a peak rate of growth in consonantal frequency would have been expected.

A summary of the rate of consonantal sound development, similar to that abstracted from the development of vowel-sounds in section 1.141 (Figure 3), is presented below.

(Figure 5)

There are three periods of development, birth to three months, four to eleven, and twelve to eighteen months. The significance of these periods and the points which divide them is summarized below.

(Figure 6)

3-4 months

Peak frequency + type increase

11-12 months
reduction of rates of increase

Peak intra-consonental
Sound activity

1.15 Conclusions

1.151 A more detailed examination of the development of vowel- and consonant-sounds substantiates the preliminary conclusion that there are three periods of significantly varying patterns of vocal development to be found in the data recorded by Irwin for the first eighteen months. These periods are separated by two points of sharp change occurring around three and four months and around nine to twelve months, both characterized by a decided drop in the rate of vocal development. The birth to three months period is one of high rate of development; the four to eleven months period starts with a low general rate and has a peak in consonantal number and frequency increase just at the end, while the growth rate of vowel-sounds remains fairly constant; the twelve to eighteen months period is started by another drop in general vocal activity, followed by a gradual levelling.

1.152 The four-month cycle in the rate of "phoneme"-type increase seems to be a product of the changes in the rate of development of consonant-sounds more than of vowel-sounds, but vowel-sound development adheres to the pattern sufficiently closely for the observed series of peaks around 1-2, 5-6, and 9-10 months to remain significant (the initial peak at 1-2 months and the peak at 9-10 months are followed by sharp drops which set off the middle period of four to eleven months).

1.153 In the case of the intra-vocalic and intra-consonantal activity indices (based on all the vocalic and consonantal sounds rather than on sound classes), a peak of activity is reached two months before the peaks in the growth rate of the number of vocalic and consonantal types. In effect, large shifts in the relative frequency of specific sounds already existing in the child's repertoire precede the differentiation of new sounds.[1]

Furthermore, the activity index peaks occur two months before the points at which the rates of vocalic and consonantal sound frequency-growth change their pattern with respect to the rates of growth in the numbers of vocalic and consonantal sound types. It is concluded that change in the type/frequency pattern for either vocalic or consonantal sounds is heralded by high intra-vocalic or intra-consonantal activity.

1.154 The second major conclusion, which brings together some of these data and the preliminary conclusions drawn from them, is that vocalic sounds develop differently than consonantal sounds. After the second period in vocal development their patterns are more similar.

Vocalic sounds are much more developed than consonantal sounds in the first month. They do not have a sudden spurt in rate of increase around 10-11 months, as do consonantal sounds, nor is the beginning of their third period defined by a marked drop in the rate of development or by changes in other patterns.

Comparison of the curves for the development of different items in vocal behaviour shows that vocalic sounds do not have the same developmental patterns as consonantal sounds. The rate of growth of the number of consonantal types is positively correlated to the rate of increase in consonantal frequency, after 8-9 months. Prior to that time there is no consistent relation between the two functions. In contrast to this pattern, the rate of growth of the number of vocalic types is in inverse relation to the rate of increase in vocalic frequency, until after 11-13 months, when no definite relation can be isolated. The intra-consonantal and intra-vocalic curves are similar, but differ in the timing of the middle peak, and it is only in the birth to three months and twelve to eighteen months periods that the functions follow the same pattern.

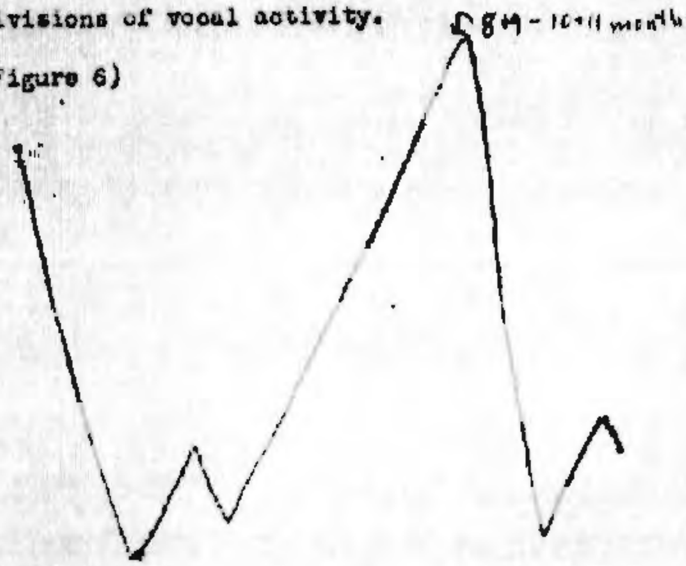
The rates of development of the numbers of vocalic and consonantal types follow the same pattern, the four-month cycle, until 12-13 months, when the patterns diverge, as the rate of increase of consonantal types rises and the vocalic increase rate falls.

The relation between the total percent-frequency changes among vocalic sound classes and the total percent-frequency changes among twelve separate vocalic sounds is inverse. In contrast, the two intra-consonantal sound activity curves, based on five classes and twenty-six consonantal sounds, are in a positive relation to each other.

The fact that vocalic sounds move backward in the mouth, while consonantal sounds move forward, as well as that the patterns in other aspects of their development are different, is evidence that at this early age vocalic activity does not emerge by the same process as consonantal activity.

Comparison of Figures 3 and 5, of the absolute values and the general rates of development of consonantal and vocalic activity, summarizes and delineates the developmental differences between these two divisions of vocal activity.

(Figure 6)



The conclusions that (1) there are three major periods in the infant's vocal development, and that (2) the patterns of consonant- and vowel-sound development differ, raise the question of the bases for these phenomena. An evaluation of additional data follows, in the hope that the relationships between the patterns distilled from the Irwin data and the patterns derived from other studies of the first stages of vocal behaviour will yield a more precise description of early vocal development.

1.2 Other Vocal Developmental Data

Although linguists generally provide little analysis of <u>pre</u>-linguistic utterance and comprehension, beyond discussion of the so-called "periods" (crying, babbling, imitating, and so on), some observers of child development have published detailed data on early active and passive vocal behaviour. Their varying emphases may be brought together through the application of certain uniform analytical criteria.

1.21 Data on Productive Vocal Behaviour

1.211 Stern, Preyer, Buhler, and Gesell and others concur in the observation that after a few weeks the cries of the infant differentiate between the cry of hunger and other cries. (Lewis, 1936, p.21ff; Gesell & Thompson 1934; Buhler, 1930, p.37) Lewis points out that the cries uttered in comfort must differ from those uttered in discomfort due to the position that the vocal organs assume when the child is in a state of comfort or discomfort. This natural organic differentiation of the sounds drops off around the third month, according to Lewis' data. (Lewis, pp.21-37)

1.212 Preyer is generally recognized as having produced the first nearly complete record of a child's development. He found that around the middle of the third month (2:14), his son's repertoire underwent a severe limitation. One sound was selected from the previously large store, and this sound was heard until the ninth month, while other sounds produced prior to the two and one-half month point were lost. (Lewis, pp.233-42)[2]

The Sterns noted that auto-repetitive chains started at the middle of the third month (2:14) in one child and at the end of the third month

(3:0) in the other. It was found that the child who produced the auto-repetitive chains earlier also imitated adult utterances of those sounds, but that there was a period from the third to the eighth month in which there were no imitative responses. They stated that this is a common phenomenon. (Lewis, p.235-6) (Stern p.137)

Meyer gives similar data on imitation. For the first three months his son imitated an adult who presented him with sounds from his own repertoire. There was then a period without imitative activity, lasting until the beginning of the ninth month (8:0). (Lewis, p.237, p.244)

At the middle of the fourth month Lewis' child "K" first produced "chains of 'babbling', often with variety of intonation". During the fourth and fifth months very few new sounds appeared. There were few attempts and no successes in imitative vocal response from the middle of the fourth month until the end of the first year. (There were, however, some other behavioural responses to adult vocalization, such as smiling or visual attentiveness.) Lewis develops a theory of three periods of imitation based on an analysis of nearly all but the most recent studies: 1) 2-3 months, approximate (2) 3-9 months, no imitation and (3) 9 months on, accurate imitation. (Lewis, pp. 70-102, 239-42, 249-52)

Leopold's intensive study of his own child found that her cries differentiated at the second month (1:21). "In the first days of the third month,....the production of articulated sounds increased" and she became attentive to adult vocalization. From this time until the ninth month, however, there was "little linguistic progress". "Linguistically the development seemed at a standstill if not in actual regression", although there was some babbling. After the ninth month the child began to learn and to use adult language. (Leopold, 1939, pp. 16-24)

According to Jakobson,

> A short period intervenes between the stage of spontaneous babbling and that of the advent of language, during which children are completely without speech. Generally, however, one stage moves without interruption into the next, so that the acquisition of the linguistic material and the death of the pre-linguistic run their course simultaneously.[5] (Jakobson, 1941)

Following Gregoire, Jakobson points out that it is necessary to consider the phineme, or linguistically "used" sounds, as distinct from the "babbled", or non-linguistic vocal productions. There are two periods of vocal development, the period of non-linguistic babbling, and that of linguistic development (starting around the ninth month). During the babbling period the child produces "all possible sounds" but is not able to make use of that "experience" when the time comes to learn the phonemes of the language. (Jakobson 1941)

The onset of the actual linguistic stage of vocal development may be determined according to various criteria, but for the purposes of this study the appearance of the first "word" will be taken as an indication that the linguistic process has begun. Bateman's summary of the literature of the nineteenth century found that the first word usually occurs at ten months, within a range of eight to fifteen months. A presentation of eight modern studies found a range of eight to thirteen months. Morley found that the mean age for the appearance of the first word was 10:4 months. (Bateman, 1917; McCarthy, 1954; Morley, 1957)

At this period the course of vocal development reaches a stage of particular interest. The child produces utterances which have the intonation patterns of adult speech, but which do not necessarily use words or phonemes of the language. Language therapists refer to this as "vocal play", linguists, as the final stage of "babbling".[4]

The complexity of this intonational production apparently is not linguistically significant, since the first sentence with intonation which is produced by the child is a question-like monosyllabic statement rather than an utterance with complex intonation. (Stern 1907) Chrelashvili considers this phenomenon in the child's linguistic development to be extremely significant for general psychological development; it signifies that the child has become aware of language as a tool at his command.
(Chrelashvili, 1959)[5]

1.213 Summary

A few weeks after birth the cries of the infant differentiate into those associated with hunger and those associated with discomfort. At about the second month the child responds to vocalizations with a somewhat similar vocalization. This behaviour pattern continues until the end of the second month when the child no longer responds to a vocalization with an approximate imitation. At this point several other changes occur in the production of sounds. Repetitive chains and babbling appear and the sounds produced may no longer be interpreted as organically influenced by the states of comfort or discomfort. During the babbling period the child may produce all possible sounds in any conceivable order and variation. After about the tenth month, when the child begins to learn the phonemes of his eventual mother tongue, babbling is no longer the only vocal activity, and it decreases in frequency as the child's linguistic ability develops.

Also around the ninth month the child again responds to adult vocalizations with imitative vocalizations, but this time with more apparent accuracy than during the early period of imitative activity. The period of linguistic development (perhaps preceded by a short period of silence) starts with the first stop-vowel contrast, around ten months. The first "word" appears around ten to eleven months, and at this time a period of intonational narrative without words also arises. Around the twelfth to thirteenth month the child acquires a one-word "sentence" with a characteristic interrogative rising-tone intonation.

1.214 Schultze states that in infants sounds are all learned and used according to the principle of least effort. (Schultze, 1880) But the division made by Grepoire and Jakobson between produced sounds and phonemically employed sounds shows that the ability to utter a sound does not necessarily imply the ability to employ that sound linguistically. Goldstein's refinement of the law of least effort, that the learning and use of sounds follow the principle of least physiological effort, allows Schultze's general principle to remain applicable in this instance. (Goldstein, 194~~9~~5 p.31) Since early vocal development and babbling do not specifically facilitate the subsequent acquisition of linguistic material, it is inferred that the physiological effort is of a different nature for the two kinds of vocal behavior.

1.22 Receptive Vocal Behaviour

Evaluation of the data on the infant's discrimination of sounds presents a more difficult problem than the treatment of sound production: how to determine whether or not the child is perceiving or discriminating a given auditory stimulus.

1.221 Bernard and Sontag found that human foetuses respond with sharp body movements and cardiac acceleration to a wide variety of tones, transmitted through the air to the mother's abdomen. (Bernard and Sontag, 1947)

Summarizing the data on early auditory discrimination, Karl Pratt states that "the neonate is not deaf but there is little evidence that it makes pitch discriminations". The type of response depends on the length of the stimulus. Short stimuli affect gross muscular patterns, of response, and when they are repeated, the gross muscular responses decline, leaving the palpebral, plantar, and other relatively invariant reflexes. Long stimuli have the effect of lessening activity. (Pratt, 1934)

A study by Lowenfeld shows a gradual differentiation of responses according to the quality of the stimulus sound. Initially the responses to all sounds are negative; the degree of response depends on the intensity of the stimulus. After the first month the response to "noises" remains negative, but pure tones elicit a neutral response. At the fourth month the child first shows a positive response (smile) to tones. At the fifth month responses begin to differentiate appropriate to the affective quality of the sounds.[6] (Lewis, p.44 ff)

Buhler and Hetzer ran a series of tests on children between the third and eleventh month, designed to bring out the responses to differing affective intonation patterns. They found that at the third month children respond positively to both "positive" and "negative" vocalizations. Immediately after the third month they begin to respond appropriately. At the fifth month they begin to respond neutrally to either vocalization, and at the ninth month respond positively to either vocalization. (Buhler and Hetzer, 1928)

Imitation in which the child repeats what is said to him provides another indication of the child's power of receptive discrimination. As the preceding section discussed, there are two periods of imitation, the first during the first three months, the second after nine to ten months. Responses in the first period are approximate, while the responses in the second are quite accurate.

According to McCarthy's tabulation of nine major studies, there are two periods of reaction to vocalization. At the second to fifth month (1:3-4:0) children attend adult vocalizations, or at least give some kind of response to them. At the eighth to tenth month children respond appropriately to some words (e.g., "bye-bye"), as well as again showing an overall attentiveness to speech. (McCarthy, pp. 409-502) This was also noted by Leopold. (Leopold pp. 21-23)

1.222 Summary

The foetus and neonate react markedly to tones and noises. The intensity of the reaction depends upon the intensity of the stimulus. Around the first month the responses differentiate so that tones now elicit a neutral response, although general "noises" are still reacted to negatively.

At the beginning of the fourth month the child responds positively to most sounds. At the fifth and sixth months the reactions become more appropriate to the stimuli, if they are non-vocal sounds, but there is an increase in neutral responses to affective vocalizations. Finally, at the ninth month, children show a positive response to both positive and negative vocalization, respond to familiar words, and pay attention to speech in general.

1.223 One problem which must be untangled is the confusion produced by the differences between the data on early responses to "noises" and "tones" and the data on responses to different types of vocalization. The response to "noises" is positive or negative, appropriate to the stimulus, at the same period that the response to vocalizations has become neutral, whatever the affect of the vocal stimulus.

The simplest explanation for this apparent anomaly is that the response to noises is not made to the same acoustic feature as ~~to that~~ in the human voice. The fact, that pure "tones" elicit a positive response at the same time as both positive and negative vocalizations elicit a positive response, provides a clue to what may distinguish the human voice from "noises". That is, a steady tone is the important feature in the human voice for the child at this early period.[7]

1.23 Summary

Lewis found three periods in the development of imitative behaviour, but other aspects of vocal development also conform to these divisions in the chronological emergence of vocal behaviour patterns.

The development of productive and receptive vocal behavious has three distinct phases: the early period of immature imitation and primary differentiation of the expression of emotions (birth to three months); the second of "little linguistic progress", few new sounds, and then the emergence of babbling (lasting from three to about nine or ten months); finally the onset of actual learning of the language, the first "linguistic" period.

Comparison of the characteristics of the first two stages (0-3, 4-10 months) reveals some striking similarities, especially between the features which occur just before the end of each period:

(Figure 7)

End of first period	End of second period
PRIMITIVE IMITATIVE ACTIVITY	IMITATION
ATTENTIVE TO VOCALIZATION	ATTENTIVE TO VOCALIZATION
LARGE REPERTOIRE	LARGE REPERTOIRE

The strong resemblance between the final phases of these periods stimulates comparison of the development of the characteristic features of each period.

(Figure 8)

Period 1 (0-3 months)

	1	2	3
a)	non-differentiated crying		differentiated crying
b)	few different sounds		many different sounds
c)	no imitation	no imitation	primitive imitative activity

d) Response to Noises, Tones and Voice
+ = "Pleasant noise", - = "Unpleasant noise", r = response)

1	2	3
tones - -r	tones - neutral r	tones - +r
+ noise - -r	+ noise - -r	+ noise - +r
- noise - -r	-,noise - -r	- noise - -r
		+ voice - +r
		- voice - +r

e) Attentiveness to human voice.

1	2	3
		attentive

Period 2 (4-9 months)

	1	2	3
A)			intonational differentiation
B)	few new sounds restriction of repertoire		new sounds babbled
C)	no imitation	no imitation	imitation

D) Response to voice

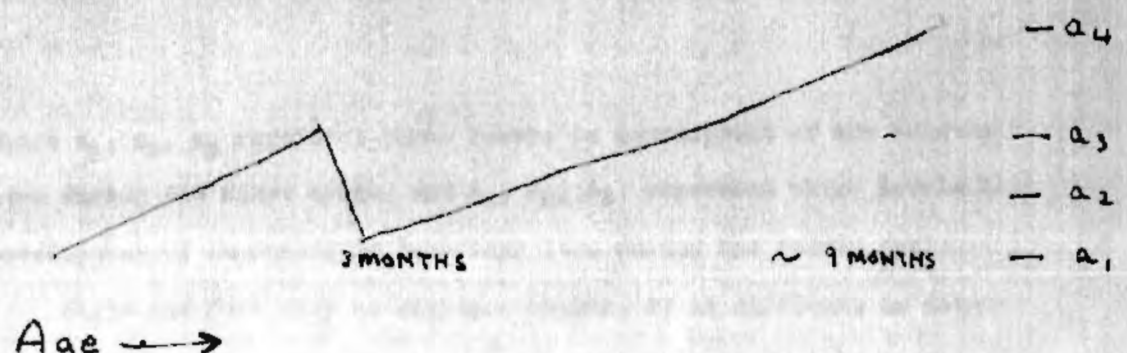
1	2	3
+ voice - +r	+ voice - neutral r	+ voice - +r
- voice - -r	- voice - neutral r	- voice - +r

E) Attentiveness to human voice

1	2	3
	relatively indifferent	attentive

It is clear that the emergence of behaviour patterns within one period is quite similar to the emergence of behaviour patterns within the next period. Thus division of vocal development into chronological stages is not a completely adequate interpretation. It would be more precise to say that vocal development emerges in two cycles. The curve of development for each item in vocal behaviour is:

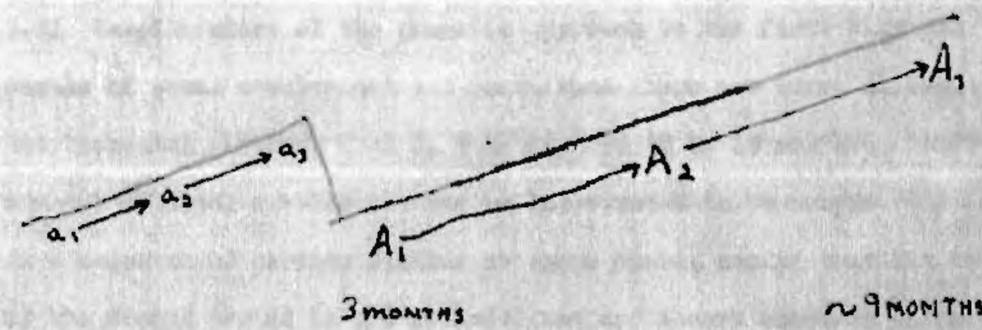
(Figure 9)



where a_1, a_2, a_3 represent three levels in the development of the item.

However, it is equally clear that, although the behaviour patterns and their developmental stages in the first cycle are undeniably similar to those in the second cycle, they are not identical. The early imitation is much rougher than the later, the early differentiation of crying intonation more basic than the babbled development of intonation patterns, and so on. Therefore a new curve is determined:

(Figure 10)



where a_1, a_2, a_3 represent three levels in development of the behaviour item during the first cycle, and A_1, A_2, A_3 represent three levels in development of an analogous behaviour item during the second cycle.

Since the data stop at eighteen months, it is difficult to determine a third cycle. The final characteristics of the second cycle do not undergo a complete loss, although the temporary "period of silence" may be analagous to the limitation of vocal activity around the third to fourth month and the "question-like" sentence similar to the development of earlier intonation patterns. Pending a more careful analysis of the later data it seems best to assume that the second cycle does not end at the tenth or eleventh month, but that it continues. It is at the tenth to eleventh month that it attains a point analagous to the end of the first cycle. The characteristics of the second cycle may develop beyond the stage represented by A_3 to A_4 ; the point here is that it is at this time that it reaches the A_3 phase, analagous to the a_3 of the first cycle.

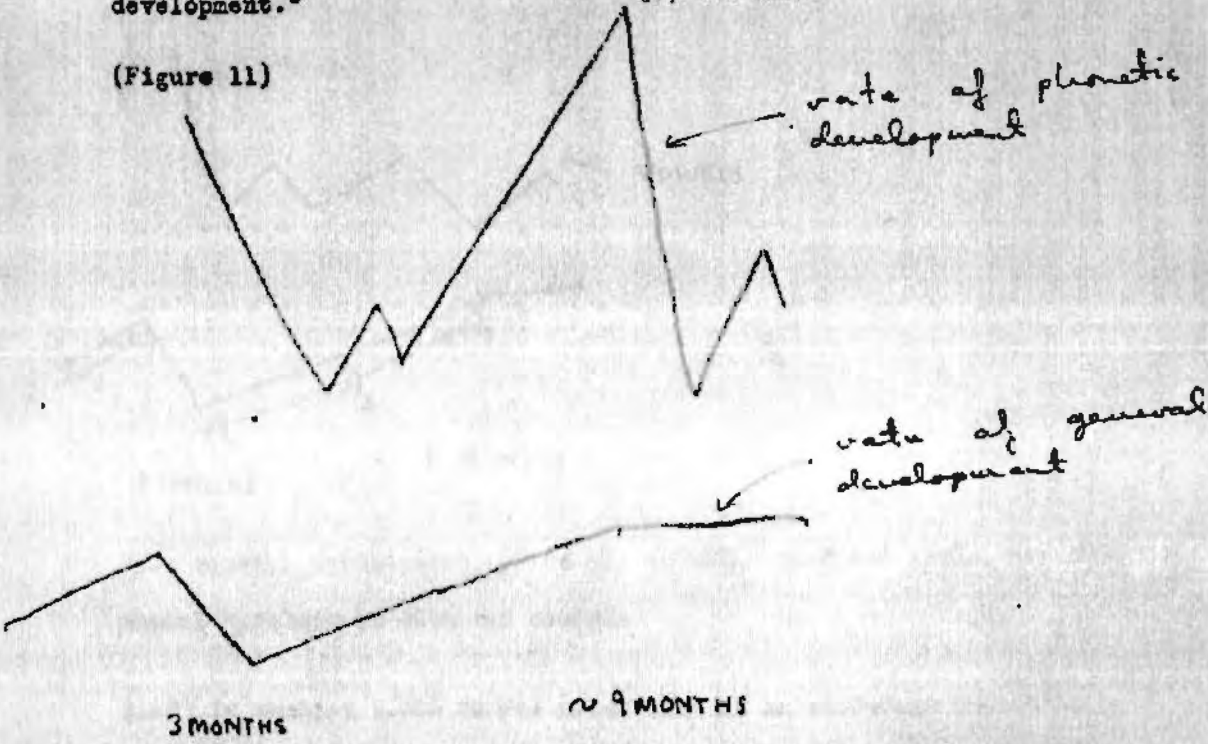
1.3 Conclusions

1.31 Consideration of the phonetic approach to the first eighteen months of vocal development has shown that there are three distinct developmental periods, 0 to 3, 4 to 11, and 12 to 18 months. Other aspects of vocal development may be interpreted in two ways: (1) As a sequence of periods similar to those above, except that the end of the second period is not well-defined and occurs somewhat earlier in the data. Those periods are 0 to 3, 4 to 9 or 10, and about 11 to 18 months. (2) As two developmental cycles which exhibit similar patterns in the emergence of vocal behaviour, the first running from birth to three months, the second, from four to about ten months. Whether a third cycle of similar pattern starts at this point or whether the second cycle now advances beyond a point analogous to the final stage of the first cycle cannot be stated conclusively from these data.

The interpretation of the phonetic data and both interpretations of the data on general vocal behaviour agree that the transition from three to four months is extremely significant in the vocal development of the child. The transition from the second period to the third is not so well-defined, and hence not so significant. It is not clear that there is a third cycle, since the exact date of the beginning of the third period varies between the phonetic and general developmental data, and even within the phonetic data itself there is some disparity between the beginning of the third period for vowel-sounds and for consonant-sounds. The vagueness of the division between the second and third periods makes the two-cycle interpretation seem the more adequate.

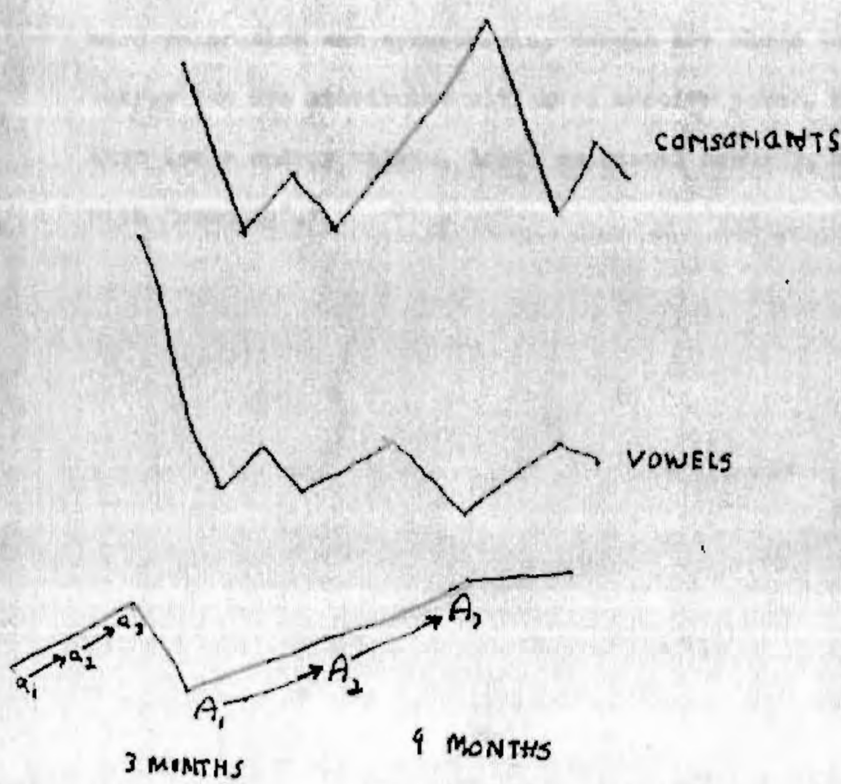
1.32 If the overall rate of phonetic development is considered in terms of this interpretation, it also appears to have developmental cycles which match with those found in the other aspects of vocal development.[8]

(Figure 11)



However, this overall rate has two components, vowel-sound maturation and consonant-sound maturation. The rate of vowel-sound development has its peak in the course of the first cycle, and the rate of consonant-sound development has its peak in the second cycle.

(Figure 12)



Thus vocalic development is associated with the first cycle, and consonantal development with the second.

1.33 In section 1.223 it was noted that at an early age the child is most receptive to the continued-tone characteristics of auditory stimuli. The peak rate of vowel-sound development occurs in the same period, and consequently it seems justified to interpret "vowel-Sounds" as "sounds which are made up of continuous bands of frequency".

Primary differentiation of emotional expressions also occurs in the earlier period. That the peak rate of consonant-sound development occurs at the end of the second cycle, the beginning of the "linguistic learning period", may indicate that consonants are more specifically linguistic than they are "expressive". Indeed, in many analyses of word coloration and synesthesia, vowels are shown to have more acoustic energy and are attributed with more emotive power, while consonants have lower energy values, lower emotional content, and are concerned with "meaning".[9]

Chapter 2. Data on Early General Development

To facilitate analysis of general developmental data in comparison with the information on vocal behaviour, general development is divided into two categories, maturation and development of overt behaviour patterns (2.1) and the neurological development implied by this behavioural development and by studies specifically designed to reveal neurological development. (2.2).

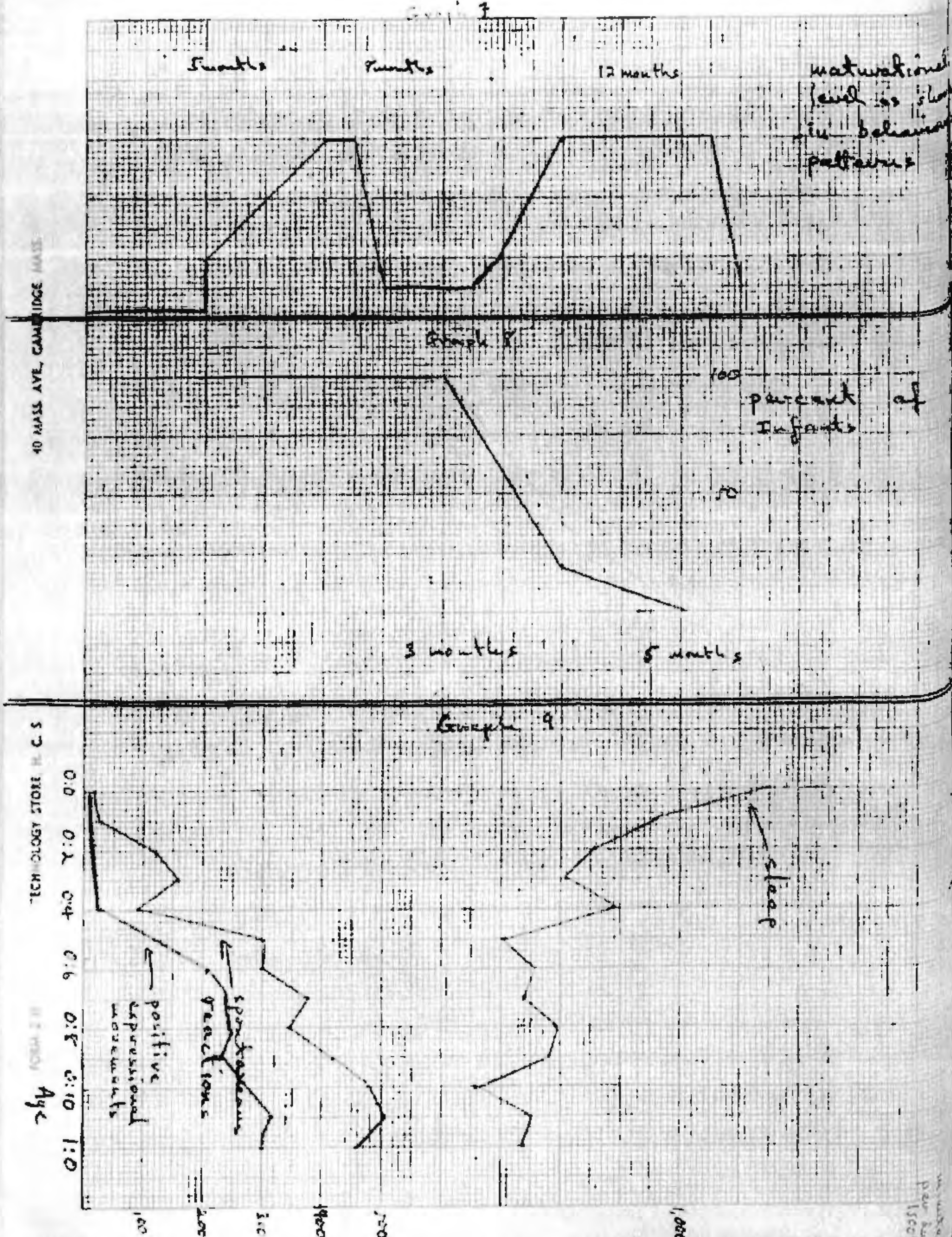
Unfortunately, there are fewer mutually-comparable data on general child development than on vocal development. It is not possible to present raw data and then to analyze it, since behavioural data is analyzed before it is discerned, in the sense that authors are oriented toward certain aspects of development before they begin, in contrast to observers of vocal development who can confine their analyses to the relatively straightforward phonetic facts.

The general method of presentation is a summary of the major studies and an attempt to distill the relevant and commensurable information from them.

2.1 Overt Maturation and Development.

Gesell has found that there are several cycles in the maturing motor patterns of the child (Graph 7). The major cycles run from five to seven and one-half months and from seven and one-half to ten months.

The tonic-neck-reflex predominates until the third month, when it declines sharply (Graph 8). By the fifth month it has disappeared completely. During the early period the child approaches a dangled ring with both hands; starting with the fifth month he transfers the ring



12 months
Graph 8
100
percent of Infants
50
3 months
5 months
Graph 9
sleep
spontaneous reactions
positive expressional movements
Age
40 MASS AVE, CAMBRIDGE MASS.
TECHNOLOGY STORE H.C.S

from hand to hand.

Gesell outlines four developmental stages, 1-4 months (control of the oculomotor muscles), 4-7 months (head-supporting and arm-moving muscles, the baby reaches for things), 7-10 months (sits, hand control), and 10-12 months (face, finger, and thumb control, stands).

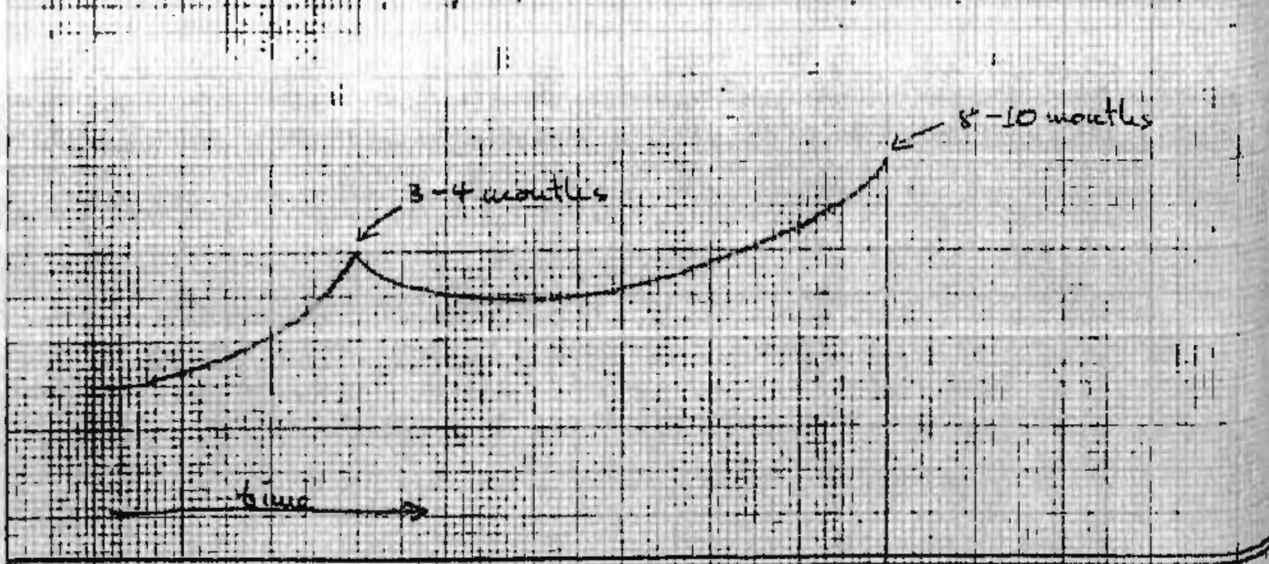
As is true in ontogenetic biology, the neuromotor organization of the maturing child "proceeds from head to foot in the direction of the longitudinal axis", according to Gesell and other students of child development. The corollary developmental principle is that the neuro-motor organization proceeds from central to peripheral segments. This has also been corroborated for child development by observation. (Gesell, 1938, 1954, Landreth, 1958)

In her classic studies of infant behaviour and its development, Buhler concentrated largely on the affects of behaviour ("positive and negative"), as well as studying more straightforward phenomena such as the amount of sleep per day. (Buhler 1930, Chapter X)

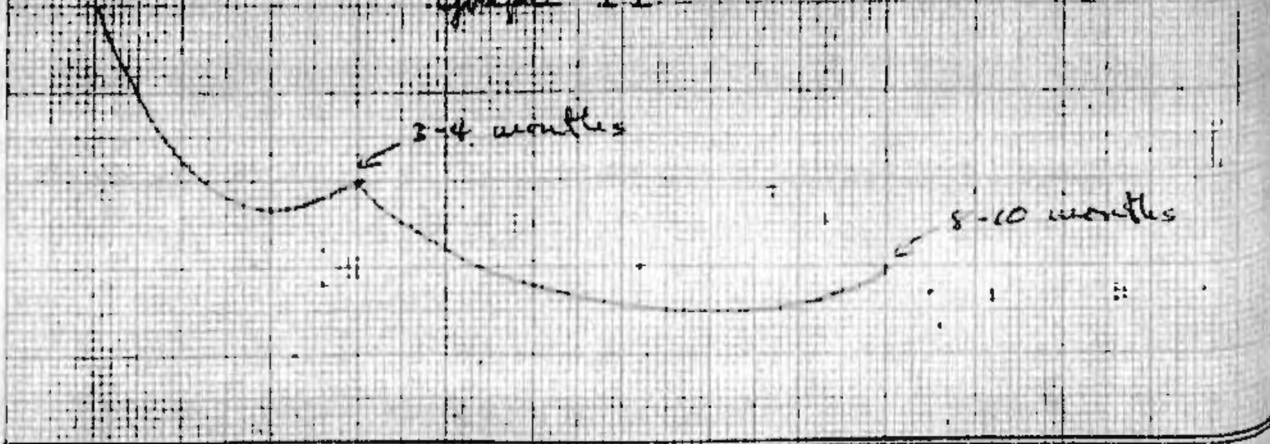
The amount of sleep per day drops steadily from birth until the fourth month, when it increases briefly and subsequently continues to fall, with a short period of increase around the eighth month (Graph 8)

At the fourth month several other behaviour items assessed by Buhler change significantly. (1) The amount of active waking time decreases in proportion to the amount of passive waking time. (2) Just prior to the fourth month, the daily amount of "positive quiet waking" and all positive reactions in general increase sharply. (3) The number of spontaneous (unstimulated) reactions decreases at four months and increases shortly thereafter. (4) The number of

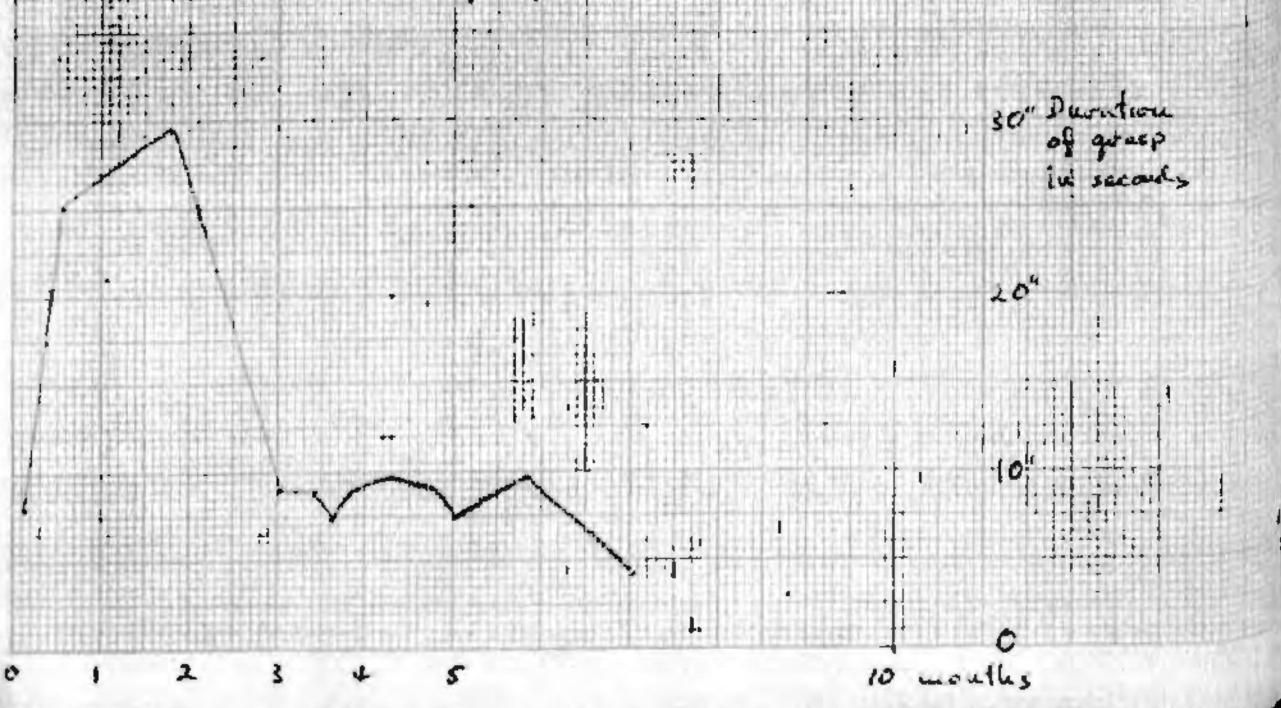
Graph 10



Graph 11



Graph 12



positive expressional movements (whether stimulated or spontaneous) increases markedly after a decrease at the fourth month (Graph 9).

2.12 Summary and Conclusions

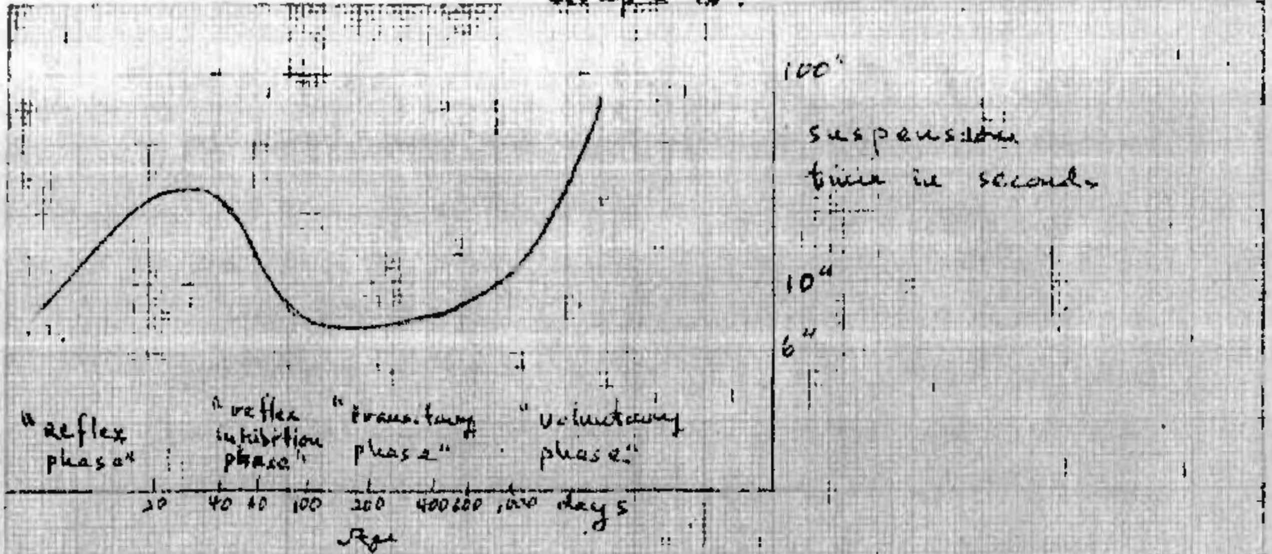
There is no obvious relation between Gesell's developmental cycles and Buhler's data. In general the information on affective states conforms to two developmental cycles (Graph 10, 11) in general activity, with low points at the third to fourth and ninth to tenth months.

2.2 Neurological Ontogenetics.

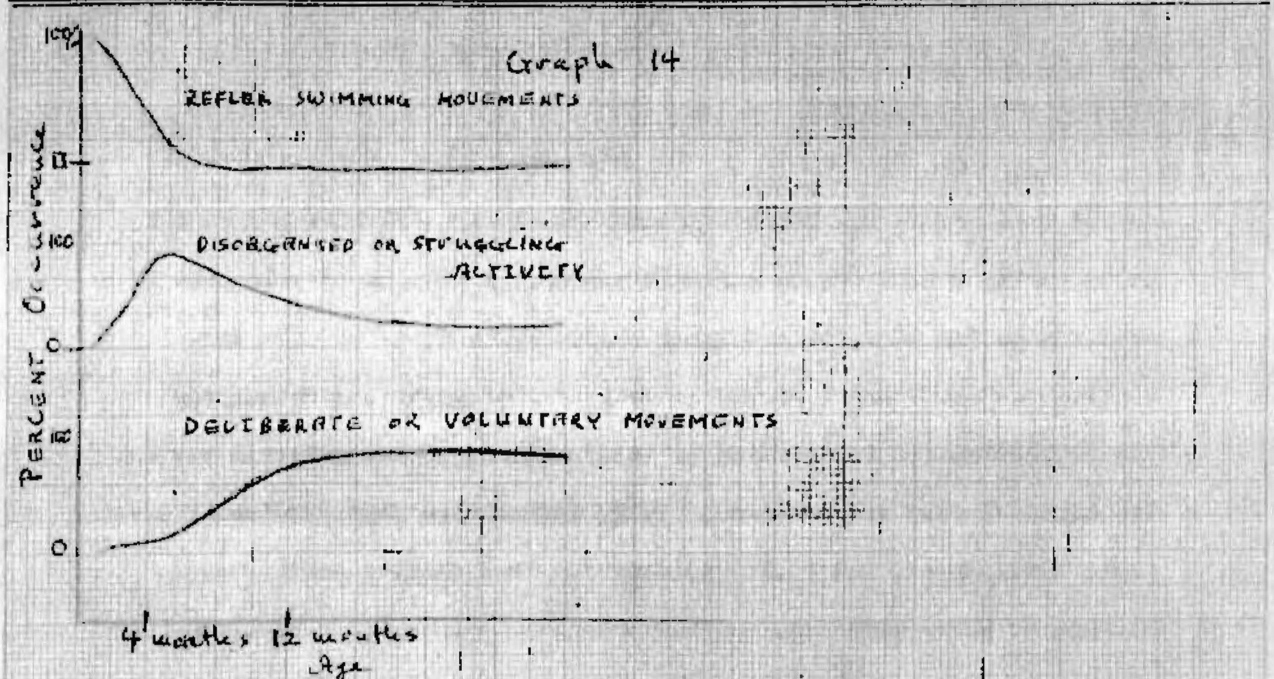
The general developmental data reviewed in the previous section showed that around the third to fourth month is a critical period for the maturing child. Since our main concern is with the development of language function, it now seems necessary to focus on data concerning the development of the central nervous system, particularly the maturation and integration of the functions of the cerebral cortex. Two kinds of data are reviewed, (2.21) information from studies of cortical development, and (2.22) information from studies on the conditioning of young children.

2.21 Landreth refers to data of Lindsley on the development of the occipital alpha rhythm in the encephalogram of children. The rhythm first appears around three to four months of age, at a frequency ca. 3-4 per second, and increases to ca. 5-6 per second at one year of age. From this and other evidence it is stated that "at birth the cortex may have little functioning capacity". (Landreth, pp. 33-6)[10]

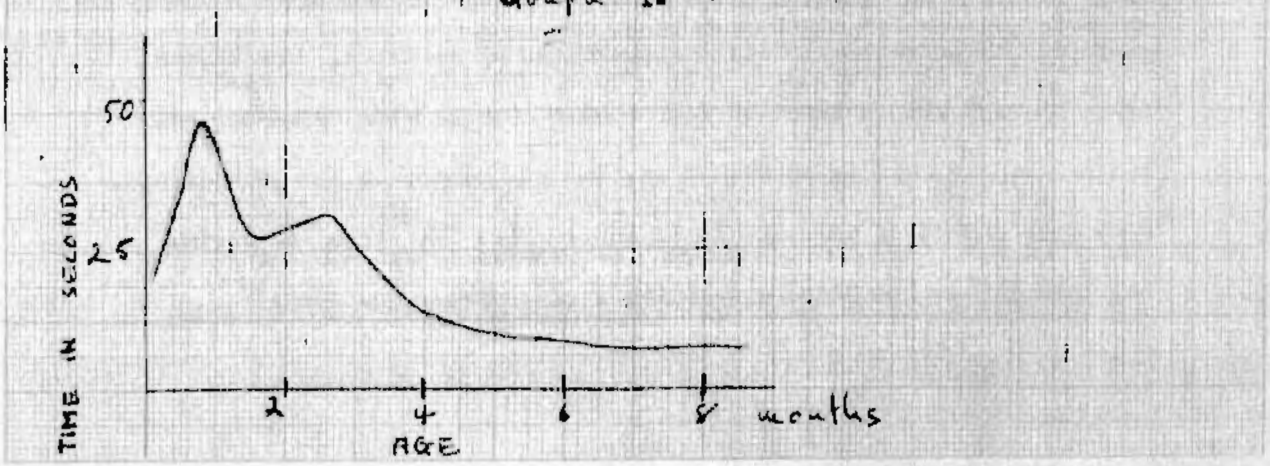
Graph 13.



Graph 14



Graph 15



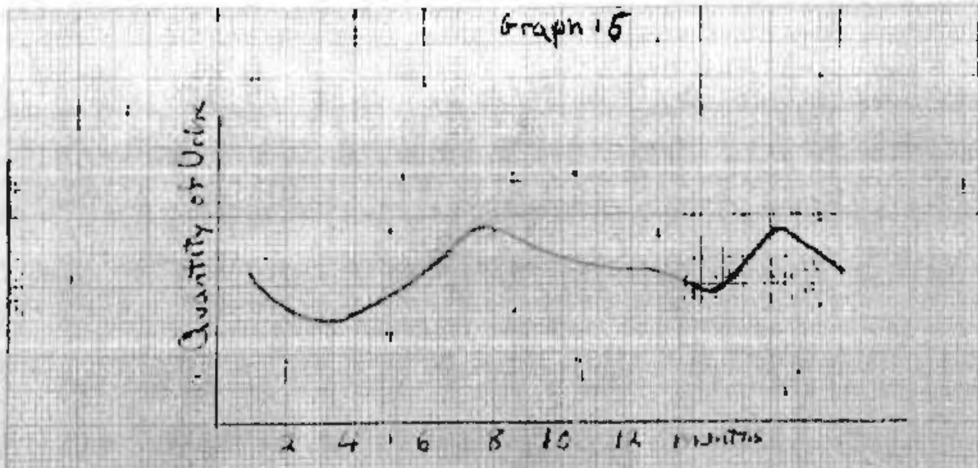
McGraw made an extensive survey of infant behaviour, with respect to cortical development. She studied the reflex ability to suspend body weight by gripping a suspended rod. Counting the number of seconds that the child could hold himself up as he grew older, she found that the data assumed the curve in Graph 12. The peak of success in the activity is reached at one and one-half months and then falls off rapidly. After the loss of this behaviour pattern at three months, it does not recurr appreciably until six years of age. McGraw states that the initial success is due to the development of "nuclear centers governing this function". "The subsequent decline probably corresponds to the onset of some inhibitory influence of the cortical centers upon the activity of the subcortical nuclei."

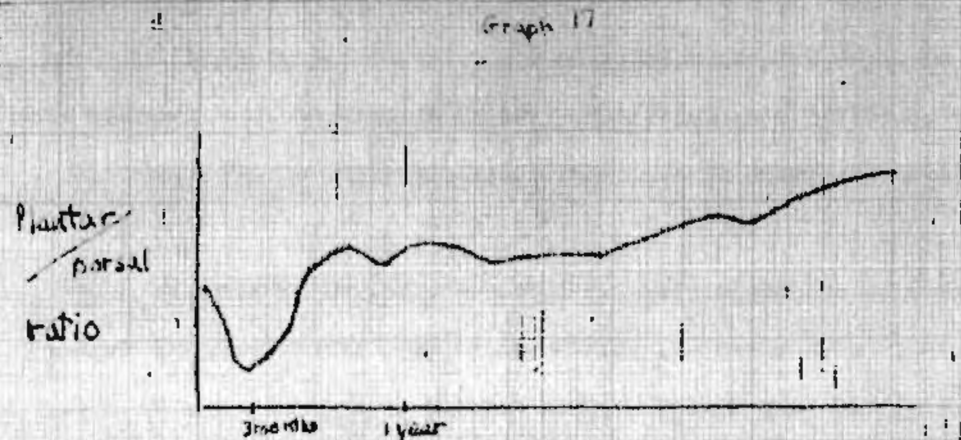
The data are explicitly interpreted by McGraw in terms of four behavioural phases; reflex, reflex inhibitory, transitory, and voluntary. Graph 13 is a direct copy of McGraw's.

Taking this investigation as a model, McGraw and her associates analyzed films and written protocols on other types of activity. She found that the reflex form of swimming movements declines sharply after three months, that "disorganized or struggling activity" reaches a peak at five months, and that voluntary movements first appear at five months and increase sharply at seven months (Graph 14).

Study of the voiding response to stimulation determined the phasic curve in Graph 15. Tracing the decline of the Moro reflex, McGraw found the curve in Graph 16. (McGraw, 1943)

Malakhovskaia made an intensive study of the normal, unconditioned, development of the plantar reflex, the flexion of the toes toward the sole of the foot in response to stimulation of the skin of the sole.


Graph 15
Quantity of Urine
2
4
6
8
10
12
months


Graph 17
Plantar/dorsal ratio
3 months
1 year

> Most investigators believe that plantar flexion of the toes is a cortical function, but that dorsal flexion (preceding the plantar and mixed in with it) is a function of the lower portions of the central nervous system. As the cortex develops it begins to inhibit and modify the activity of these lower centers. (Malakhovskaia, 1959)

In the first month of life, however, Malakhovskaia finds that the plantar reflex ~~appears also to be a lower reflex~~ appears also to be a lower reflex activity which drops off at the middle of the second month. He isolates three periods of plantar reflex development, 0-1, 2-9, and 10-36 months. During the first period the early plantar reflex is mixed with the dorsal, and falls off at the beginning of the second period, after which the plantar reflex increases until the eighth to tenth month. The third period is one of gradual solidification of the predominance of the plantar reflex over the dorsal. The general developmental curve for the plantar/dorsal ratio is in Graph 17.

As mentioned in the previous section, the movements associated with the tonic-neck-reflex disappear or are highly modified around the third to fourth month. Although Gesell's study was not directed primarily toward specification of the time of cortical development, it is possible that the time at which the t.n.r. begins to disappear may signify the development of cortical inhibition, since certain pathological recurrences of the t.n.r. in adults seem to be associated with damage to cortical functioning. On the basis of this evidence and evidence on baboons, Gesell states, "The submergence of the naive t.n.r. of early infancy is the result of the ascendancy of cortical controls. ..". (Gesell, 1954 pp. 352 ff) The time (four months) of the decline in the t.n.r. in normal infants may thus be the time at which cortical control and inhibition develop.

Babkin found, in a series of highly controlled and documented studies on reflex activity in children, that "the extinction of some rudimentary reflexes in the early post-natal period of development should be understood, not as a simple removal or destruction, but as a process of transformation".

"Searching" activity, at first carried out by the skin analyzers, becomes dependent on the visual analyzer at the third to fourth month. Head orientation reflexes to visual and auditory stimuli become extremely prominent around this time, replacing the rudimentary reflex head movements (mid-facial, cheek-turning). Babkin interprets this point, when the more developed head-orienting reflex supercedes the more primitive reflexes, as the point at which there is an inclusion of the efferent nerve system into the already present (and presumably ontogenetically more primitive) afferent system.

The congenital grasping reflex (best stimulated tactilely) begins to die out at the fourth to fifth month and is gradually replaced by the "voluntary" reflex (now dependent on visual stimuli). The primitive form of the hand-mouth reflex is suppressed by the third to fourth month. (Babkin,1957)

A feature common to the above studies is a stated or implied belief that behaviour does not develop along a rigid time scale. Different behaviour patterns do not "stop", but are modified; they do not progress in well-defined stages, but in phases. In all cases, early activities are assumed to be reflex, congenital, or primitive patterns; in all cases, the meaning is the same: the activity of the early neonate is in no sense "voluntary". Western workers state this in terms of "primary reflex" development, Russians, in terms of the "afferent analyzer" system.

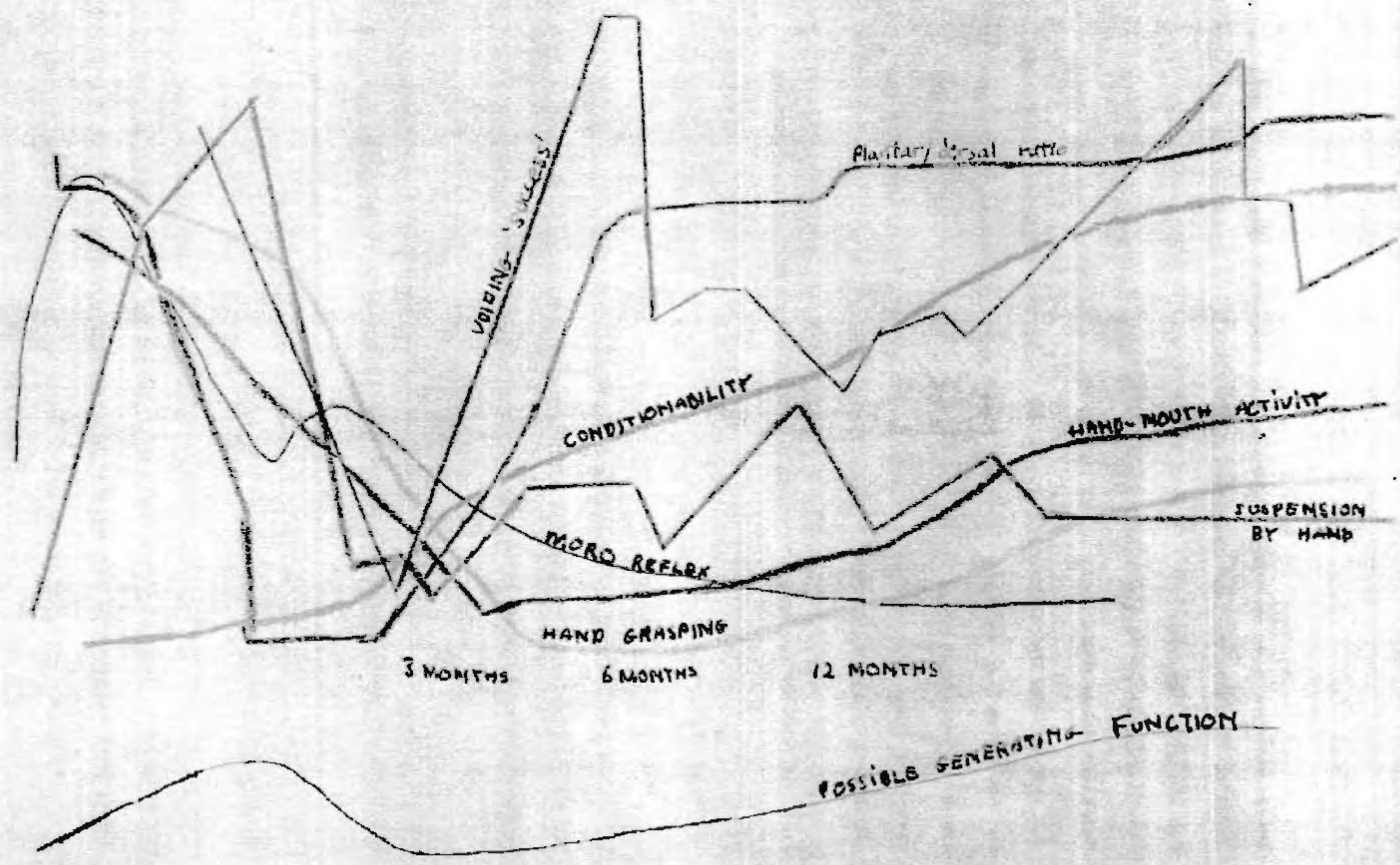
The onset of "voluntary" behaviour is described as process of "personality development", or as one of "the integration of the efferent system into the afferent", i.e., the inhibition of primary reflexes and the advent of cortical control. Behavioural processes, although somewhat similar to their early forms, are now "controlled" or organized by a "higher" neurological organ, the cortex, which inhibits the organizing activities of the "lower" organ.

2.22 As another approach to early neurological development, American and Russian researchers have devoted much time to studies of conditioning in young children.

Wenger found that the strongest response patterns are obtained "with the conditioned lid response to tactual vibration of the foot and with conditioned withdrawal and respiratory responses to auditory stimulation". (Wenger, 1936)

Dashkovskaya attempted to condition children in the first fourteen days of life. He discovered three stages in early response behaviour: 0-5 days, no conditioned reflex activity ("excessive stimulation is easily disseminated in the cortex and induces sleep"); 5-9 days, a new kind of inhibition, the external, arises; 9 days on, conditioned association forms, but is tenuous. Dashkovskaya noted that "the development of distinct conditioned reaction to a bell in newborn babies is preceded by a stage at which there is a cessation of all movements during each sounding of the bell". (Dashkovskaya, 1957)

GRAPH 18



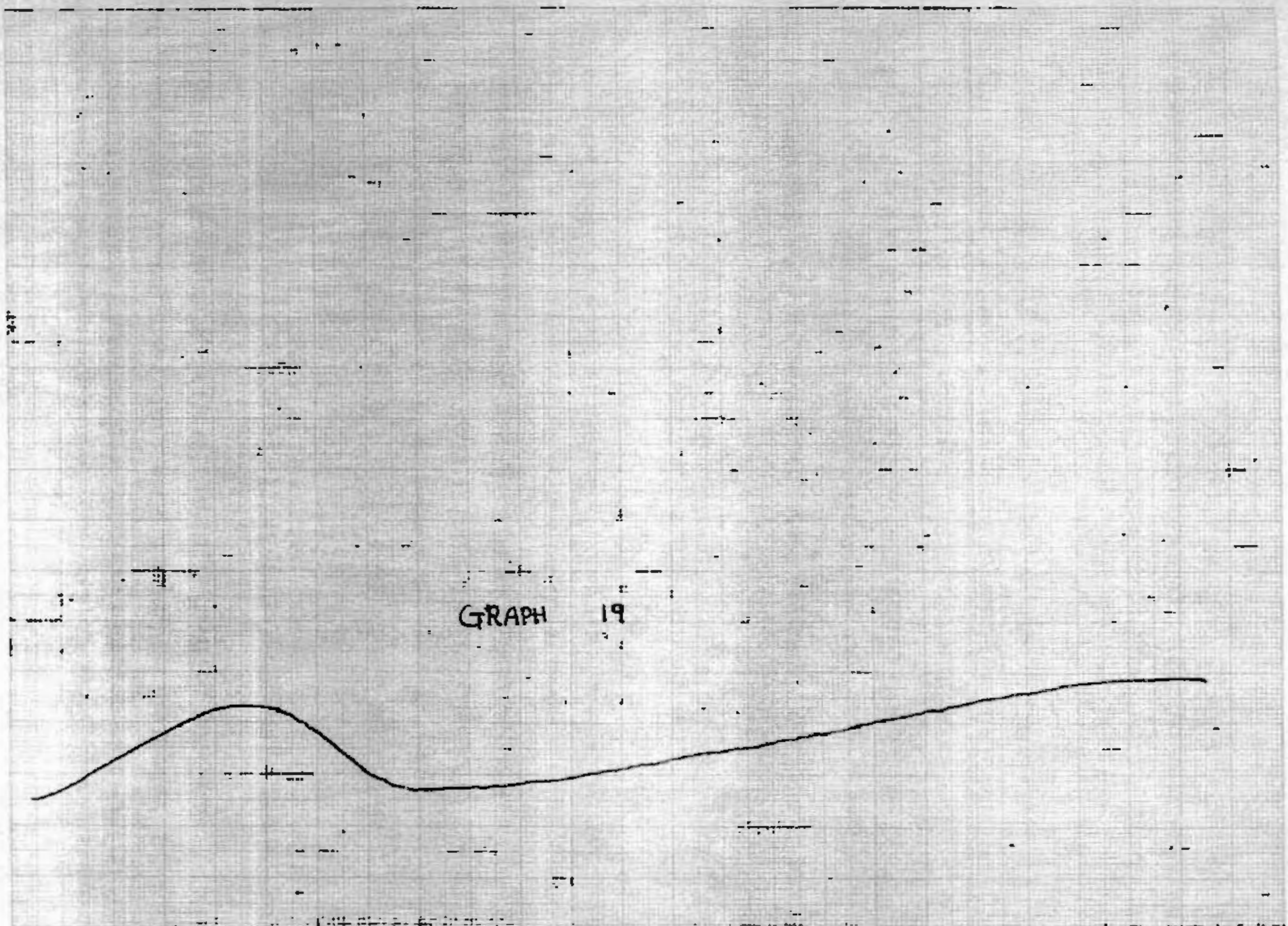
VOIDING 'SUCCESS'
Plantary dorsal ratio
CONDITIONABILITY
HAND-MOUTH ACTIVITY
SUSPENSION BY HAND
MORO REFLEX
HAND GRASPING
3 MONTHS
6 MONTHS
12 MONTHS
POSSIBLE GENERATING FUNCTION

Kasatkin, Mirzoyants, and Khokhitva found that an inconsistent, conditioned orientation reflex may be induced at two and one-half months and that after five to seven months a conditioned orientation reflex will develop in the child very rapidly. (Kasatkin, Mirzoyants and Khokhitva 1959)

2.23 Summary

A composite graph of the data in this section (Graph 18) compares the chronological development of the behavior patterns. The curve below it is an average of the curves of these various functions.[11] Examination shows immediately that the two to four months period is critical in the early neurological development of the child.

The data on neurological development may be interpreted cyclically. The first period is 0-3 months; the second starts at the third month, but its termination depends upon the particular behaviour item. A theoretical explanation for this cyclic pattern may be that the second cycle reflects a process of development of cortically controlled behaviour. The fact that all of these behaviour patterns lose their primitive, or reflex, form at two to four months, i.e., that the first cycle occurs at the same time in many different kinds of behaviour, is strong indication that at this time a general, cortically based, inhibition of all congenital activity takes place.



GRAPH 19

2.3 Conclusions

2.31 Considering the development of affective states, the development of congenital reflexes and their ultimate replacement by cortical behaviour, the development of susceptibility to conditioning, and the increase of electroencephalographic alpha rhythm, all chosen for their relevance to the development and activity of the cerebral cortex, one can say that the cerebral cortex reaches a state of maturation, sufficient to allow it to begin taking over the organization of behaviour from the reflex nuclei, at about the third month. At this time (1) certain reflex patterns fall off sharply (t.n.r., Moro reflex), (2) others fall off and are replaced by equivalents at a much later date (hand-grasping, hand-mouth reflex, plantar reflex), and (3) others (EEG alpha rhythm, conditionability) first start developing.

It seems clear that the two to four months period is the first stage in cortical control of behaviour. The decline in reflex activity patterns may be attributed to the appearance of cortical inhibition, which suppresses the organizing control of the lower centers even before the cortex is itself able to reorganize reflex behaviour patterns at the cortical level. A general developmental curve for all of these activities is presented in Graph 19.

2.32 It was stated above that the rate of development in the cortical phase varies with the kind of activity under scrutiny. There are behaviour patterns which develop along a time scale different from the 0-3, 4-9 months sequence found for vocal development. In general, these are the more physical aspects of behaviour, e.g., motor maturation, the t.n.r., urinary control, hand suspension, and swimming movements. These lose their primary reflex stage at 2-4 months, but the subsequent development of their counterparts in cortical behaviour follows developmental cycles of varying length and number.

The aspects of behaviour which have sequences most like the 0-3, 4-9 months pattern are those which could be considered "mental" or "cognitive", rather than physical, activities, such as Buhler's affective states and conditionability.

2.33 It has been concluded that the cerebral cortex inhibits the organizing influence of the reflex centers at about the third month. The functions and activities of the lower centers after cortical inhibition are still an open question. Clearly, they do not atrophy as a result of losing dominant control of behaviour. Electroencephalographic tests in Russia have shown that the lower nuclei continue to discharge, even when their effectiveness is inhibited by the cortex. (Palmer, 1959) In view of Babkin's statement that the disappearance of rudimentary reflexes should be understood as a process of transformation rather than one of loss, it is possible that cortical control does not by-pass the lower center, but incorporates it into a larger complex of neurological organization. Such a possibility is significant for the understanding of development in vocal behaviour, as will be discussed in the next chapter.

Chapter 3. General Comparison and Conclusions

Thus far each aspect of human development has been considered in a closed system. Reference to vocal development has not been used as an aid in the interpretation of neurological maturation, and vice-versa. This chapter presents a brief discussion of the relationships between these developmental patterns, and discussion of the implications of these relationships.

3.1 Comparison of Vocal and General Development.

Gesell's cycles of motor development, while lending validity to the general theory of cycles in human ontogenetics, do not coincide with the cycles found in the linguistic data and in the other types of general maturational data. This would seem to substantiate the oft-reiterated statement that vocal growth (and, in this case, psychological development) does not coincide with periods of general motor development, but that, on the contrary, it is in periods of low motor development rate that vocal development progresses.

Graph 8, measuring the sleep per day in the maturing child, yields evidence that the periods around the third to fourth month and around the eighth to ninth month are significant in the developmental sequence. Both these periods show large amounts of sleep and "quiet waking", which may indicate that the child is learning, or integrating a new process prior to the behavioural emergence of that process.

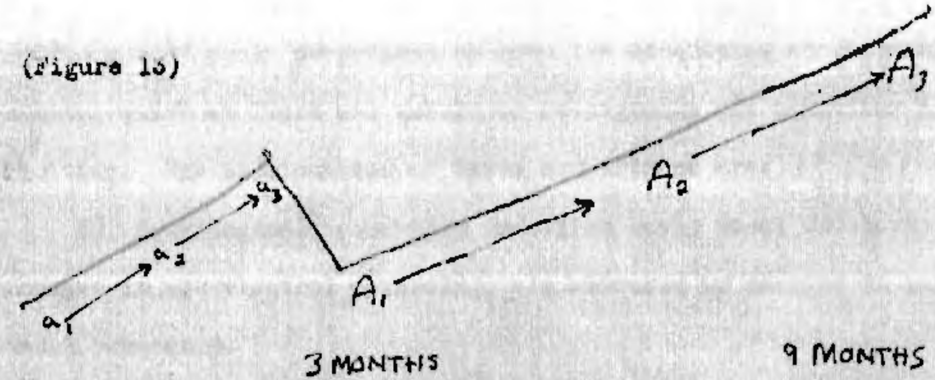
The Irwin data showed a four-month cycle in development. It is possible that those periods of high vocal change are related to periods of a large amount of waking time, so that it may simply be the awake time per day which superimposes a four-month cycle on the other patterns in vocal development. However, this possibility does not affect the interpretation of the vocal data as two major cycles, 0-3 and 4-10 months, since the four-month cycle occurs only in the rate of general development, and does not characterize changes in the patterns of development.

The principle of anterior-posterior and interior-exterior progression in neurological maturation must affect vocal development. The larynx and aesophagus are part of the digestive tract, and neurologically mature sooner than the mouth. Hence the copious early production of vowel-sounds may be predictable, since the only basic requirement for a vowel is an open chamber. Consonants require oral articulation, but according to the general ontogenetic principle, the oral articulators mature later than the pharyngeal exciters. The vowel, or "voiced tone", is the simplest of all vocalizations, and it is not surprising physiologically that early infant vocalization consists largely of such sounds.

3.2 Comparison of Vocal and Neurological Development

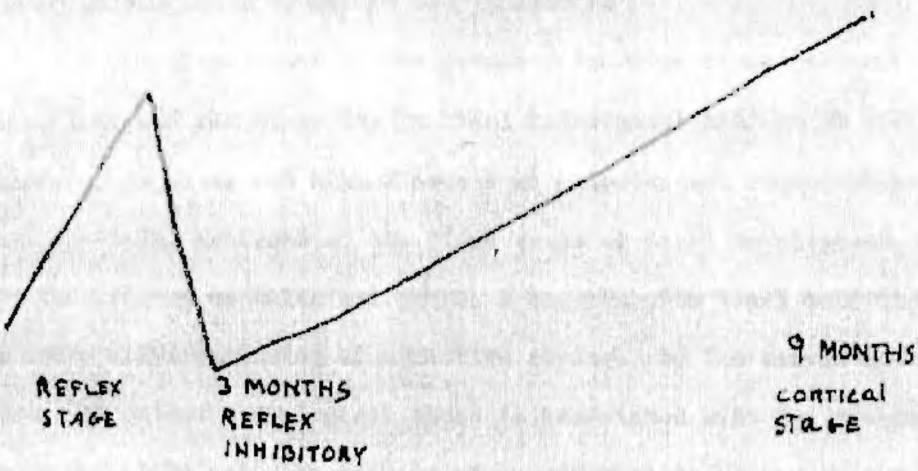
The analysis of phonetic and general vocal development has brought out an explanatory model based on two analogous cycles of development: the maturation from birth to three months is similar to the maturation from four months to about ten months.

(Figure 13)



Study of the neurological aspects of development yielded a general maturational curve.

(Figure 14)



The congruence of these curves leads to certain conclusions about the relationship between vocal and neurological development. The third month marks the end of the first cycle in vocal development and the end of the first cycle in vocal development and the end of the reflex phase in neurological behaviour. The beginning of the second cycle at the fourth month coincides with the marked onset of cortical inhibition.

As the second cycle progresses so does the maturation of cortical organization, which at first was unable to re-organize the behaviour it was inhibiting. The implications of these comparisons are:

1) Neurological maturation underlies early vocal development. Changes in neurological physiology are mirrored by changes in manifest vocal behaviour.

2) The cycles observed in vocal development are produced by phases of neurological maturation. a) The first cycle is concurrent with and presumably a manifestation of a primary level of neurological organization of vocal behaviour. b) The end of the first cycle is a result of the end of the reflex stage of behaviour due to cortical inhibition. c) The second vocal developmental cycle occurs as the cortex gradually re-organizes the activity it had inhibited.

3) The differences in the manifest behavioural characteristics of the first and second cycles in vocal development are due to differences between the lower and higher levels of neurological organization. a) There are two essential features of the first cycle of vocal development, and thus of the primary neurological phase, a concern with tonal activity and the primary differentiation of affective crying. b) The second cycle and thus the second neurological phase is associated with the development of consonant-like activity, and is often referred to as the period of "preparation" for the onset of language-learning proper. The babbling stage is presumably a reflection of the process of integrating vocal activity and cortical organization.

By comparing two kinds of behaviour patterns as they develop it is possible to observe, in a component form, the relationships between those patterns. Analysis and comparison of how each new level develops and how behavioural manifestations develop concurrently may better specify the relationship between those levels and those behaviour patterns in the adult. This process of physiology through ontogeny yields certain hypotheses about the neurological composition of vocal activity in adults. It would be impossible to elaborate these in sufficient detail to avoid mis-statement, but a preliminary formulation can be made.

(1) It is possible that in so far as the kind of vocal behaviour exhibited in the first cycle occurs in adults, it is neurologically organized by the "lower level". (2) It is possible that in so far as the kind of vocal behaviour exhibited in the second cycle occurs in adults, it is organised by the "higher level". (A detailed discussion of two approaches to the specification of the lower and higher levels is given in Appendix II.)

FOOTNOTES

1) This may be due simply to the fact that even with the phonetic alphabet, the sounds were coded into rigid classes, and thus differences could not be recorded until they were great enough to fall into a new sound class.

2) Lewis collated much of the important work of the past fifty years. Although the instances quoted have been checked in the original source, Lewis' organization is much easier to follow. Hence the reader is referred to his appendices.

3) Jakobson 1941; Chapter 23; the translation is my own.

4) See Morley and Leopold for bibliographies of the Linguistic and therapeutic approach.

5) This concept is especially important to the Russians, since they are concerned with the organising role of language in behaviour.

6) The reliability of these data is questionable because the definition of "pleasant" and "unpleasant" seems to have been decided <u>after</u> the child reacted to it, in order to provide a standard to compare with later observations.

7) Hence a young child (in the first month) may not react at all to a bell which sounds once, but shows a marked reaction to a rattle or other continuous sound.

8) This curve is derived from figures 3 and 5.

9) See Sapir, <u>Language</u> and Roger Brown <u>Words and Things</u>.

10) Sample EEG graphs are included on page 36 in Landreth.

11) Since this graph compares information which does not have commensurable data on the y-axis, it has been made only approximate.

APPENDIX I

I.A. Summaries of the Irwin Data

(1) Summary of Basic Data in Seven Irwin Studies (McCarthy)

Age in Months	Mean No. of Phonemes	Mean No. of Vowel Types	Mean No. of Consonant Types	Mean Vowel Frequency
0-1	7.2	4.5	2.7	49.0
2-3	11.1	6.6	4.5	52.8
4-5	12.3	7.1	5.2	56.3
6-7	15.1	8.1	7.0	55.2
8-9	16.0	8.3	7.7	56.4
10-11	18.6	8.9	9.7	58.0
12-13	18.8	10.0	9.8	56.6
14-15	20.4	9.7	10.8	56.5
16-17	21.0	10.1	10.9	60.0

Age in Months	Mean Consonant Frequency	Relative Frequency of Vowel Sounds Classified by Place of Articulation: % Front	% Middle	% Back
0-1	11.3	72.4	25.2	2.3
2-3	14.3	60.6	25.8	13.6
4-5	17.6	62.1	23.7	14.3
6-7	21.2	63.3	19.8	16.7
8-9	24.7	62.2	17.0	20.8
10-11	33.5	62.1	16.4	21.5
12-13	32.6	60.0	17.0	23.1
14-15	36.1	59.8	15.9	24.3
16-17	37.6	54.0	16.5	29.5

Relative Frequency of Consonant Sounds
Classified by Place of Articulation

Age in Months	% Labials and Labio Dentals	% Lingua-Dentals	% Post-Dentals	% Velars	% Glottals
0-1	0.6	—	0.7	11.6	87.1
2-3	3.7	0.8	5.4	14.7	75.4
4-5	8.1	0.7	4.5	12.6	74.3
6-7	13.3	0.8	11.3	8.3	66.3
8-9	20.8	1.6	24.3	6.1	47.1
10-11	22.9	1.2	34.9	6.7	34.3
12-13	25.4	1.1	33.9	7.6	32.0
14-15	25.3	0.7	36.6	8.6	28.8
16-17	29.6	0.7	39.7	8.1	21.9

I.B. The General Method of Analysis for Statistical Validity.

It might be argued that the apparently uneven distribution of values in the rates of change of phonetic development was caused by a random sample of a random process and that it is within the bounds of a random function. Since the children assessed always numbered at least fifty, it is unlikely that the sounds they produced were not average for any large number of children at any given age level. However, it is still possible that it might be invalid to compare one age level with another, since in some cases different children were studied. The first point also meets this objection, since if the number of children studied at each age level is large enough to be representative of all children at that age level then it is valid to compare one level with another as a sequence in general child development

There is, however, still the possibility that, although the distribution of variations is not a function of poorly-controlled data, it may be produced as a function of statistically allowable mathematical variation.. This possibility was tested by the use of a standard deviation analysis and found to be unlikely. (See Table of Standard Deviation Analyses) In other words, the variations may be taken to have been produced by corresponding behavioural variations among children rather than by poorly controlled data or statistical variation.

Before it is proved otherwise it must be assumed that a function has a set of values which are either at the average value or are statistically distributed about the average value. On this assumption eight values must be considered for each function in order to decide whether any one of these values is disproportionately far from the mean. The statistics, of course, state only how likely it is that a given value will be a given distance away from the mean, but it is fair to state that any value under 10% likely in a random distribution can be considered significant and an indication that the distribution in question is not actually random.

The method of standard deviation gives just this statistic: given a specific sample size and a mean for that sample, it is possible to find the value for one standard deviation, the distance within which c. 64% of the random values will fall; the chances that a randomly generated point would fall within two standard deviations is 96%, and the chance that it would fall within three standard deviations is 99.73%; hence, anything over two standard deviations, only 4% likely, is well within the bounds which have been set up.

However, given the fact that one number out of a given sample is being considered, the chances of that one number will be increased by the size of the sample: the larger the sample, the larger the chance that one of the values will be several standard deviations away from the mean, still as a random process.

In the case of these data the sample is always eight and hence the chances that a value would exceed two standard deviations from the mean is 8 x 4% = 32% likely in a random distribution. To maintain the requirement that only those values less than 10% likely will be considered significant, the sample size requires that any value over 2.50 standard deviations (1.25% likely in a single case) will be a sign of a non-random process.

The above process is valid for a whole function model, i.e., it passes judgement from the variation of one particular value on the randomness of the total function. If, however, only one number is considered at a time, in order to determine the chances that the whole null hypothesis model predicted that number, it is not necessary to multiply the chances by the sample size. Thus, to fit a 10% likely criterion, a single value would only have to be 1.65 standard deviations distant from the mean.

The null hypotheses used here are simply that the rates of change of the various functions are a random function with the mean as a generating model. In other words, the hypothesis is that the values are expected to cluster around the mean in a random fashion.

The formula used to calculate the standard deviations in the changes in the rates of growth was:

$$\sqrt{\frac{1}{8}\left(\sum_{i=1}^{8} \overline{x_i}\right)^2}$$

where $\overline{X_i}$ equals the absolute deviation of X_i from the mean.

STANDARD DEVIATION ANALYSES

Number of Phonemes:

	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	
α	40	9	23	6	16	1.1	8.5	3.5	μ=13.4
β	27	4	10	7	3	12	5	10	Sd=12
γ	+2.25					-1		-.8	

Number of Consonant Types:

	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	
α	67	15	35	10	26	1.2	10	.9	μ=20
β	47	5	15	10	6	19	10	19	Sd=19
γ	+2.4					-1		-1	

Number of Vowel Types:

	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	
α	48	7	14	2	7	12	-3	4.1	μ=16
β	32	9	2	14	9	4	19	12	Sd=15
γ	+2.1			+1			-1.3		

Frequency of Vowels:

	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	
α	5.7	6.6	-1.9	4	-4.3	-2.4	1.8	6.2	μ=3.0
β	2.7	8.6	4.9	1	6.3	5.4	1.2	3.2	Sd=2.8
γ	+1	+1.3	-1.6		-2.5	-2		+1.1	

Frequency of Consonants:

	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	
α	26	23	20	16	37	-1.2	10	4	μ=16
β	10	7	4	0	21	17	6	11	Sd=11
γ	+1				+2	+1.4			

An analysis of the mathematical statistical tests applied shows that the points at which the rates of change exceed even one standard deviation are those for the transition from the second to the third month and those around the ninth to twelfth month, indicating that something of particular interest occurs at these points.

Another interesting feature is that vowel-sounds exhibit a different pattern of variations than do consonants, until the last few values. The rate of increase in the frequency of consonantal types takes a sharp non-random rise, followed by a sharp decrease in the rate of vowel frequency growth.

This necessitates an explanation of the use of the term "patterns of variation". By this is meant the relationship between the various functions, referring purely to vowel-sounds or purely to consonant-sounds. The statement that the patterns of variation for consonant-sounds and vowel-sounds were different prior to the ninth to twelfth month simply means that the frequency of the consonant-sounds in relation to the number of consonantal types did not develop in the same manner as the frequency of vowel-sounds in relation to the number of vocalic types. The growth in the numbers of consonantal and vocalic types, however, did resemble each other during this period.

Key to the table of standard deviation analyses:

α = the actual percentage changes in th raw data; each value represents one transition (from 0-1 to 2-3 months, etc.).

β = the numerical deviation of that value from the mean for the eight values.

γ = the number of standard deviations by which that value departs from the mean.

μ = the mean for the eight percentage changes.

S_d = the calculated standard deviation value.

From this table it is clear that many of the values are significant on their own merits. In addition, comparison of one graph with another is the main analytical device used in this paper. The chance that two independent functions would show a consistent pattern with respect to each other is 50% for two values, 25% for three values, 12.5% for four, and 6.25% for five values. Thus the conclusions about the patterns (especially for the second period) are quite significant.

APPENDIX II

A Discussion of Neurological Possibilities

On the basis of many and varied data, vocal development has been interpreted as a reflection of neurological development. A brief consideration follows of the implications of this hypothesis for theoretical models of the neurological bases of vocal activity in general. Unfortunately, theories concerning the activity and physiology of the human nervous system, and particularly of the brain, are undergoing a revolution against classical concepts. Thus it is impossible to state that a given concept is "known" or "accepted by experts"; it is much clearer what is not known and what is not accepted.

Behavioural evidence has indicated that at least the early developmental stages of vocal activity are reflections of transitions between neurological levels of organization. Therefore an examination of the stages in manifest behaviour should reveal the characteristics of the different neurological matrices which underly them. This method of physiology through ontogeny is useful since, as a level first emerges developmentally, it reveals itself and its characteristics untainted by the influence of another level, and consequently gives rise to distilled examples of the kinds of manifest behaviour properly interpreted as an effect of this particular level.

According to the developmental hypothesis presented in this paper, the first cycle of vocal development is associated with the lower neurological level. Therefore the manifest behavioural characteristics of that level are a concern (receptive and expressive) with tonal activity and primary emotional differentiation of vocalization. For the purposes of argument, the primary, or more primitive, level of neurological organization will be referred to as a "primary center". Whether or not this center actually exists anatomically is not proven, but it is used as an explanatory concept.

(Although the usefulness of the concept is somewhat vitiated by its ambiguity with respect to receptive <u>and</u> productive behaviour. The concept of a receptive center would be easily acceptable as a useful notion, but ascribing both aspects to one center stretches the conceptual imagination. Speaking of a lower neurological "level" with both functions is valid by definition, since a lower "level" is defined as that level which manifests primary receptive and productive behaviour. However, there are several hypotheses which justify referring to a primary afferent and efferent "center". (1) Although not anatomically or physiologically the same, there are two centers which are connected, or are related so that their activities are interdependent (which is equivalent to saying that together they comprise a conceptual "level").

(2) The organizing center for receptive activity limits and governs productive activity by a cybernetic action. In this case, receptive and productive vocal behaviour would be functions of receptive processes.

Whatever the case, since there is a consistently similar pattern in both productive and receptive behaviour in early vocal development, the "primary center" will be considered as referring to both afferent and efferent organization, unless otherwise stated.)

The search for further information on the postulated primary center necessitates a consideration of data on the neurological composition of vocal activity in adults. If (1) evidence independent of the developmental data suggests that a given anatomically specified area of the brain is likely to serve as a primary center, and if (2) investigation shows that the behavioural manifestations of that area are similar to the observable characteristics of the inferred primary brain center, then the statement that the independently found area is a possible location of the postulated center will be justified. Conversely, if (1) characteristics which are similar to those manifested by the postulated primary center can be independently isolated in adult vocal behaviour, and if (2) investigation shows that the neurological organization of these characteristics is likely to have specific anatomical and physiological properties, then the statement that these anatomical and physiological properties may be true of the postulated primary center will be justified.

In the first case, the unknown factor is the characteristics of the primary center and the known is the location; in the second case, the unknown is the location and the known is the characteristics. Both approaches are used in this discussion.

II.A. The Neurological Basis of Speech

The localization of brain cortex function has been a controversial subject since the beginning of systematic investigation of the brain. Although an answer to the problem would be extremely relevant to the topic of this paper, the intensity and diversity of views held by respected researchers makes it advisable to sidestep this issue. "Levels" of speech activity organization, and the statement that the "higher" organization is cortical, are terms which remain comfortably ambiguous about whether the organization is total cortex activity or only in specific cortical areas.

In their treatment of the afferent auditory system, Krieg and Ranson and Clark note that the auditory nerve runs through the medial geniculate body of the thalamus, and it is believed that at this point the nerve becomes de-myelinated. (Krieg, 1942; Ranson and Clark, 1959) There is general agreement that the medial geniculate body contains synapses of the auditory nerves, and it has been shown that it is tono-topic in the cat, i.e., that specific areas of the medial geniculate nucleus receive nerves carrying specific frequency bands.

Penfield and his collaborators are clearly committed to the concept of cortical localization, and incident to their major argument is a thorough investigation of the most likely lower brain center organization for speech. "It is proposed, as a speech hypothesis, that the functions of all three cortical speech areas in man are coordinated by projections of each to parts of the thalamus and that by means of these circuits the elaboration of speech is somehow carried out." (Penfield and Jasper, 1959, p.207) According to Penfield and Jasper, the pulvinar is the center for afferent-efferent links concerned with speech activity.

The possible neurological relationships between Penfield's lower center and the auditory nucleus discussed above are clear. It is believed that there are connecting fibers between the pulvinar and the medial geniculate nucleus. (Rasmussen, 1957; Krieg; Ranson and Clark) Thus the pulvinar and medial geniculate bodies of the thalamus seem to provide a likely lower neurological center for speech.

The postulated primary center is associated with tonal activity and primary differentiation of affective crying. Vowel and tonal activity are thought to contain more emotive content and affective colour than consonants (strongly emotive sound gestures are generally vocalic, and it is known that for most languages vowels are less linguistically necessary than consonants). The tentative location of the lower organization of speech in the thalamus fits this manifest characteristic of concern with tonal and vocalic activity, and is equally in agreement with the other characteristic of the postulated center's activity, the early differentiation of affective crying, since the thalamus is generally considered to be the center for the transmission of emotional activity.

II.B. Synesthesia

The present problem is to examine, in mature vocal activity, instances of behaviour similar to that of the postulated primary center, in the hope that these characteristics have a discoverable neurological basis which may be identical with or related to the postulated center of speech activity. Neurological colour-synesthesia is a phenomenon which may be used to separate tonal from non-tonal activity in mature speech. Although the phenomenon is extremely confused and masses of inconclusive literature have been written about it, a study of synesthesia may yield extremely useful information. Apparently, the major difficulty encountered in such a study is classification and subsequent interpretation of the various types of colour-synesthesia. This paper follows Ulich's and Mauce's distinction between psychological and neurological synesthesia.

In all cases of visual synesthesia to speech sounds (whether neurologically or psychologically based), coloration is associated primarily with vowels, while consonantal responses run on a black-white scale. It has also been discovered that pure tones elicit associative coloration. Since concern with vowels and tones is a characteristic of the postulated primary center, an examination of the possible neurological bases of synesthesia should aid the location of the postulated primary speech center.

Both Langenbeck and Bos published studies on subjects who had coloration associated to vowel-sounds, and agreed in general on the types of colors associated with particular sounds:

a - red, ae - pink, o - blue, u - dark brown,
ø - light blue, y - gray, e - yellow,
i - silver-white. (Langenbeck,1913; Bos,1929)

Jakobson presented another case, including slight coloration for consonants:

a - red, o - red-blue, u - dark blue,
e - light green, i - canary yellow.

(Jakobson, 1941) Reichard and Jakobson quote an Hungarian informant:

i - white, é - yellow, e - darker yellow,
a - tan, á - dark tan, o - dark blue,
ó - black, u,ú - red. (Reichard and Jakobson, 1949)

Argelander found for many subjects:

i - white, e - yellow, a - around red,
o - brown, u - black. (Argelander, 1927)

One could hope that in all cases there would be one colour per phoneme, but this is not quite the case. In general, /i/ is white or bright yellow, /a/ is red, and /u/ is dark-coloured, but there are some exceptions.

Argelander also found that synesthetic color-hearing is occasioned by pure tones as well in most of the people who had synesthesia at all. In these cases high tones were associated with yellow and orange, middle tones with red, and low tones with blue and violet. Thus vowel coloration would seem to be associated with the position of the second formant.

i	e	a	o	u
yellow	green	red	red blue	blue
high tones	medium tones		low tones	

The relation of the cardinal vowels /i/, /a/, /u/ to classical colour theory is obvious: they stand at the corners of Goethe's colour triangle. There are two contrasting axes:

yellow
↑
green ⟶ red
↓
blue

The redness of the association of a colour to a vowel is determined by the height of the first formant, the yellowness by the height of the second formant.

The most important point is that synesthesic coloration occurs almost exclusively for vowels and tones. The data on consonantal coloration presented by Jakobson shows that the colours associated with consonants are very dim and also fall into colour classes which bring the consonants into the same linguistic classes as the similarly coloured vowels (e.g., /s, z, ʃ, ž/ are all light-coloured and share the linguistic features of diffuseness and acuteness with the bright yellow /i/.).

Is synesthesia a neurological process? That is, is this phenomenon based on neurological composition or on psychological association? Is red seen with the sound /ae/ simply because the subject, when he was young, associated this sound with a red truck? This possibility seems obviated simply because of the remarkable agreement among the reports of synesthesics. Although they do not all agree on the exact particulars of the coloration of a given sound, there is a general agreement, even cross-lingually and cross-culturally, on a general conformation to a continuous spectrum (i.e., progressing from /i/ to /u/ usually indicates a colour progression in one direction on Goethe's colour triangle).

The fact that these agreements exist casts doubt on the view that synesthesia is completely dependent on individual psychology or cultural milieu. The phenomenon must be due, at least to a large degree, to some kind of neurological cross-over between the auditory and visual systems.

The Neurological Possibilities:

Unfortunately, little is known about the neurological particulars of either colour vision or vowel discrimination, but an investigation of the anatomy of the visual and auditory systems gives some indication of the ways in which the synesthesic cross-over could occur neurologically.

A cursory examination of the anatomy of the two systems does not reveal any given point at which the auditory and visual signals could become confused with one another. Although the major nerves come into near-contact at several points, they are protected from cross-stimulation by the non-conductive myelin sheath. (Gardner, 1959; Krieg; Ranson and Clark)

In fact, the only point where it is likely that the neural connections become de-myelinated near each other is in the lateral and medial geniculate bodies of the thalamus. This possibility is strengthened by Bauce's statement that the thalamus plays a primary role in neurological synesthesia. (Bauce, 1947)

There is not a great deal of information about these two nuclei. Rasmussen points out that specific areas of the latero-geniculate body are associated with specific areas of the retina and of the cerebral cortex. Ranson and Clark state that it has alternate layers of fibers and cells and that its general function is as a relgy station for visual impulses.

The medial geniculate body may be the auditory equivalent of the latero-geniculate body. According to Morgan and Stellar, lesions of this nucleus in cats results in apperception of specific aural frequency ranges.

These two organs are synaptic relay points for afferent auditory and visual stimuli, specific areas of them are associated with specific receptive ranges, and the two bodies are adjacent to each other and are both "lobes" on the pulvinar. (Rasmussen, Ranson and Clark)

Consequently, it is hypothesized that the synesthesic cross-over occurs between these two nuclei. There are two possible routes which the receptive cross-over could follow, a direct connection or a common connection with some third body of the thalamus.

There is little or no published evidence for or against a direct pathway between the two nuclei. In the normal mature brain such connections seem unlikely, and the bodies are somewhat distinct from one another. But synesthesia is not normal in adults, and this fact and the belief that synesthesia is more common in children could be explained by the possibility that in the immature, or abnormal adult, brain the lateral and medial geniculate bodies are neurologically connected, either due to the temporary de-myelinization of nerves passing through both bodies or due to the lack of sufficiently developed insulation between them.

There is some evidence for an indirect connection between the two nuclei, in that it is believed that there are connecting fibers between the lateral and medial geniculate bodies and the pulvinar, and it is here that a connection between the bodies could take place. (Rasmussen, Krieg, Ranson and Clark)

In either case, the general area for the neurological transfer of receptive impulses is the region occupied by the pulvinar and the two adjacent geniculate bodies, and it is a possible area of synesthesic cross-over. This area is, of course, coincident with that discussed in the preceding section. Not only are the characteristics of an independently located possible lower speech center similar to the characteristics of the speech center postulated on the basis of developmental data, but also characteristics independently isolated, but similar to the characteristics of the postulated center, may be organized neurologically by an area of the brain coincident with that found by the converse procedure.

BIBLIOGRAPHY TO APPENDIX II

1. Gardner, E.: Neurology (Philadelphia, 1959)
2. Harris, J. D.: Some Relations between Vision and Audition (Springfield Ill. 1950)
3. Krieg, W. J.: Functional Neuroanatomy (Philadelphia, 1942)
4. Penfield and Roberts: Speech and Brain-Mechanisms (Princeton 1959)
5. Ranson, S. and Clark S.: The Anatomy of the Nervous System (Philadelphia 1959)
6. Rasmussen A.T. The Principle Nervous Pathways (New York 1957)
7. Ulich, E. : Synästhesie und Geschlecht (Munich 1954). A thesis presented to Munich University.

BIBLIOGRAPHY

Babkin, P.S., "The Establishment of Reflex Activity in Early Postnatal Life," The Central Nervous System and Behavior, Bethesda, 1959.

Bateman, W.G., "Papers on language development: I. The first word," Ped.Sem., 24, 391-398, 1917.

Bernard, J., and L.W. Sontag, "Fetal reactivity to tonal stimulation: A preliminary report," J.Genet. Psychol., 70, 205-210, 1947.

Buhler, C., The First Year of Life, New York, 1930.

Buhler, C., and H. Hetzer, "Das erste Verstandnis fur Ansdrucke im ersten Lebensjahr," Z. fur Psych., 1928.

Carmichael, L., ed., Manual of Child Psychology, New York, 1954.

Chrelashvili, N.V., "Critical Moment in the Psychic Development of the Child," The Central Nervous System and Behavior, Bethesda, 1959.

Dashkovskaya, V.S., "The First Conditioned Reactions in Newborn Infants Under Normal and in Certain Pathological Conditions," The Central Nervous System and Behavior, Bethesda, 1959.

Gesell, A., "The Ontogenesis of Infant Behavior," Chapter 6, Manual of Child Psychology, L. Carmichael, ed., New York, 1954.

Gesell, A., and H. Thompson, The Psychology of Early Growth, New York, 1938.

Goldstein, K., Language and Language Disorders, New York, 1948.

Irwin, O.C., "Reliability of infant speech sound data," J. Speech Disorders, 10, 227-235, 1945.

______, "Infant Speech: Variability and the problem of diagnosis," J. Speech Disorders, 12, 287-289, 1947.

______, "Infant Speech: Consonantal sounds according to place of articulation," J. Speech Disorders, 12, 397-401, 1947.

Irwin, O.C., "Infant Speech: Consonant sounds according to manner of articulation," J. Speech Disorders, 12, 402-404, 1947.

_____, "Infant Speech: Development of vowel sounds," J. Speech Hearing Disorders, 13, 31-34, 1948.

_____, "Infant Speech," Sci. Amer., 18, 22-24, 1949.

Irwin, O.C., and H.P. Chen, "Infant Speech: Vowel and consonant frequency," J. Speech Disorders, 11, 123-125, 1946.

Jakobson, R., "Kindersprache, Aphasie und allgemeine Lantgesetze," Uppsala Universitets Arsskrift, 1942.

Kasatkin, N.I., N.S. Mirzoyants, and Khokhitva, "Oriented Conditioned Reflexes in Infants During the First Year of Life," The Central Nervous System and Behavior, Bethesda, 1959.

Landreth, C., The Psychology of Early Childhood, New York, 1958.

Leopold, W.F., Speech Development of a Bilingual Child, Vol. I, Evanston and Chicago, 1939.

Lewis, M.M., Infant Speech, London, 1936.

Malakhovskaia, D.V., "The effect of conditioning on the development of the unconditioned plantar reflex in young children," Pavlov, v.9, no.2,1959.

McCarthy, D., "Language Development in Children," Chapter 9, Manual of Child Psychology, L. Carmichael, ed., New York, 1954.

McGraw, M.B., The Neuromuscular Maturation of the Human Infant, New York, 1943.

Miller, G.A., Language and Communication, New York, 1951.

Morley, M.E., The Development and Disorders of Speech in Childhood, Edinburgh and London, 1957.

Pratt, K.C., "The effects of repeated auditory stimuli upon the general activity of newborn infants," J. Genet. Psychol., 44, 96-116, 1934.

Schultze, F., Die Sprache des Kindes: Eine Anregung zur Erforschung des Gegenstandes, Leipzig, 1880.

Stern, C., and W. Stern, Die Kindersprache: Eine psychologische und sprachtheoretische Untersuchung, Leipzig, 1907.

Wenger, M. A., "An investigation of conditioned responses in human infants," Univ. Iowa Stud. Child Welfare, 12, 1-90, 1936.