DE GRUYTER

D. L. Olmsted

OUT OF THE MOUTH OF BABES

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OUT OF THE MOUTH OF BABES

EARLIEST STAGES IN LANGUAGE LEARNING

by

D. L. OLMSTED

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FOREWORD

"It is foolish to think that, just because we must abstract a phonologic system from the articulatory-acoustic substance in which it is made manifest, therefore the former is our sole object of interest and the latter is beneath our dignity. The analyst is not the only person who must *start*, at least, with the overtly observable speech signal and motions of articulation. A child has this same point of departure in learning a language; an adult has this same point of departure in learning a new language."

Charles F. Hockett

PREFACE

A study on the scale of this one would not have been possible without the cooperation of many co-workers. An essential contribution was made by Carol Wall and Julianne Dusel (now Mrs. Bernard Young) who arranged for the recording sessions with children, gathered the data in those sessions, interviewed the mothers to gather information about the parents, and — in about ninety percent of the cases — made the original phonetic transcriptions from the tape. Any contributions this study makes will be founded on their careful phonetic identifications, their patience and rapport with the children, their constant concern for accuracy and replicability. A fuller account of their activities is given in Chapter 2; here I can only record my enduring gratitude to them.

Analysis of the data and most of the writing were carried out at the Center for the Advanced Study of the Behavioral Sciences where I held a Fellowship during 1966-67. In one way or another the entire staff of the Center contributed to an atmosphere that made sustained work possible. I extend thanks to all of them. Some assisted more directly: David Peizer, statistical consultant to the Center, made a number of methodological contributions, which are credited and discussed in detail later in the text. In addition, he read parts of the manuscript and offered sound advice on all phases of the project. I am greatly in his debt, as will be evident. At the same time, he should not be held responsible for the statistical naiveté of Chapters 3 and 7, which were done at the end of my fellowship, while he was on vacation.

My appreciation also goes to Ted Cooper and Katharine

Holbrook, who, under Peizer's direction, punched and verified the cards whereby the data were conveyed into the computer, and to Elaine Olmsted, who assisted with the computations upon which the conclusions of Chapter 7 are based. Parts of the manuscript were typed at the Center by Irene Bickenbach, Jane Kielsmeyer, and Helena Smith, whose prompt and accurate work smoothed the way during the period of writing. My thanks also go to Betty Calloway and her staff at the library of the Center for their cheerful help in obtaining needed reference materials from other libraries. During the period at the Center, Stanford University allowed use of its libraries and computer facility.

Finally, for the privilege of the Fellowship at the Center, I extend gratitude to the Board of Trustees and to Director Ralph Tyler, Associate Director Preston Cutler, and Assistant Director Jane Kielsmeyer, whose many kindnesses made our stay there an idyll.

I profited from discussions with other Fellows at the Center, who read parts of the manuscript and offered helpful suggestions. In this connection, the collaboration of Justin Aronfreed, Calvert Watkins, Thomas A. Sebeok, Robert Singer, Glenorchy Mc Bride, Winfred Hill, Albert S. Cook, I. Charles Kaufman, and Arthur Jensen is gratefully acknowledged.

My colleagues at the University of California, Davis, have also helped in numerous ways. The Department of Anthropology supplied a tape recorder for the collection of the data; Brenda Ferns, Patricia Rademaker and Sheila Stiles, have typed portions of the manuscript. The project was supported, in the initial stages, by grants from the campus Committee on Research. I am grateful to Louise Tanous and Charles Plopper, who assisted in the scoring of errors; their contributions are discussed in Chapter 2.

Several of my colleagues have given me the benefit of their advice after reading sections of the manuscript. Among them are Martin A. Baumhoff and Benjamin E. Wallacker. I am especially indebted to Kelvin Deming for valuable editorial suggestions.

Special mention should be made of Professor Roman Jakobson,

who took time out of a busy schedule to check and approve translations of passages taken from his *Kindersprache, Aphasie und allgemeine Lautgesetze*. Most important, of course, has been the influence he has had on linguistic investigations of child language-acquisition. Though my approach has differed from his, the general aim — the eventual discovery of general laws concerning such acquisition — remains the same.

Finally, I wish to thank the parents of the children involved in this project for their intelligent cooperation and assistance. Without their help, the work would have been difficult if not impossible.

This book is dedicated to the one hundred children whose utterances form the basis of the study.

CONTENTS

LIST OF TABLES

1

INTRODUCTION

"language was at its beginning merely oral"
Samuel Johnson

When the Psalmist wrote (8.2): "out of the mouth of babes and sucklings hast thou ordained strength...", he did not specify what kind of strength he had in mind. To anyone who compares the life of man with that of the other animals, the answer must be obvious. Though the horse outruns him, the whale outswims him and the lemur outbrachiates him, though the tiger is fiercer, the elephant stronger, the bird more mobile, man has maximum adaptability. He has spread over the entire earth, from the deserts and jungles to the ice-caps of the Arctic, because of the strength derived from his life in society. The social adaptability of man, in turn, is traceable to his possession of culture (socially learned behavior), in contrast to the relatively rigid societies of ants and bees, whose behavior is, for the most part, innately acquired and thus not subject to major adaptive changes in short spans of time. Anthropologists have long agreed that a major aspect of man's sociocultural adaptability is his possession of a system of symbolic communication, i.e., language.

In this sense, language is a major source of strength to man; it is one of his most characteristic possessions and enables him, indirectly, to erect a technology that equals or exceeds the abilities of his animal competitors: a car is faster than a horse, a steel crane stronger than an elephant, an airplane faster than a bird, and so on. All these human products are results of cooperation made possible by swift and flexible communication. Human languages permit such communication, whereas the rudimentary signals of other species, without exception so far as we know, do not. The difference, despite the impressive signal-patterns of the bees, dolphins, etc., is qualitative, not merely quantitative.

Along with the great strength provided by possession of language, there can also be commensurate weakness: only men can be fools or liars or foreigners. That is because members of other species simply by virtue of such membership, are in what might be called STANDARD COMMUNICATION with other members of that species, whereas men, because their communication systems are learned, find it possible to be in states of subnormal communication with their fellows, as a result of imperfect mastery of symbols or 'improper' use of them.

Although much is known about how the developing infant gains his physical strength, we know less about how he acquires his social strength, and, in particular, his language. All languages so far investigated are based upon vocal-auditory behavior (speech); there is no reason why this should be so in logic, but it seems to be so in fact. The units of speech — UTTERANCES — may be defined as stretches of articulatory activity bounded by silence. Utterances may be divided into parts, each of which is identifiable with some part of the meaning of the whole utterance. Such parts — MORPHS — are governed by rules of combination, traditionally set forth in the parts of the GRAMMAR headed MORPHOLOGY and SYNTAX. Each morph is made up of one or more segments of articulatory activity known as PHONES.

These segments of articulatory activity constitute the basic stuff of speech and, thus, of languages. While human beings engage in other kinds of communicatory behavior, some of it directly related to language (e.g., reading, writing) and some not (e.g., kissing), the sound-making activity of the vocal apparatus is basic for two reasons. First, it is earliest ontogenetically: normal children always learn to speak several years before learning to read or write. Second, it is ubiquitous: every normal human being speaks, but at least half of all the human beings who ever existed, lived and died without knowing how to read or write.

ANY ATTEMPT AT A DEVELOPMENTAL PSYCHOLOGY OF LANGUAGE MUST BE BASED UPON THE FACTS OF SPEECH: THE CHILD'S RESPONSES ARE MOVEMENTS OF THE ARTICULATORY ORGANS AND THE (LINGUISTIC) STIMULI THAT COME TO HIM ARE THE AUDITORY PRODUCTS OF ARTICULATORY BEHAVIOR, EITHER BY HIMSELF OR OTHER SPEAKERS. Much recent work in linguistics has been concerned with aggregations of phones such as morphs, classes of morphs (morphemes). phrases, and sentences, and with the task of specifying rules of formation and combination of such aggregations. Such work has pointed the way to many important findings. Sometimes, however, neglect of the behavioral basis of the data has given rise to odd speculations. Consider, for example, the following passage from Chomsky (1965):

A theory meeting these conditions would attempt TO ACCOUNT FOR language learning in the following way. Consider first the nature of primary linguistic data. This consists of a finite amount of INFORMATION ABOUT sentences... ...For example, certain signals might be ACCEPTED AS PROPERLY FORMED SENTENCES, while others are classed as nonsentences... (31) (Emphases mine in all three cases.)

There are three difficulties with the quoted passage; they have been underlined in the above quotation. First, it is not clear what is meant by "to account for"; the topic is too extensive to go into here, except to record my own preference for SUCCESSFUL PREDICTION as the one really satisfactory confirmation of theories purporting to be about the data of science, as opposed to ones about logic and mathematics.

The second difficulty is of more immediate relevance. It should be apparent from the behavioral basis of language that primary linguistic data are not "information about sentences" but rather utterances themselves; one might perhaps call their perceptual effects secondary linguistic data. On the other hand, "information about sentences" appears to be a candidate for a place in a theory about the learning of metalanguage. In any event, "information about sentences" is very difficult to find, let alone study, particularly in the infant. What we get from him are cries and squalls and other articulatory products; if we infer from his speech that he possesses such and such "information about sentences", without wallowing in the data provided by his actual utterances, we risk suppressing much interesting information, and, in fact, the enterprise becomes an outline of the analyst's preferences in inferring "information" rather than a study of the child's behavior. And so in fact, runs the argument provided by Chomsky in the pages that follow: e.g., "A language-acquisition device that meets conditions (i)-(iv) is capable of utilizing such primary linguistic data as the empirical basis for language learning". (1965, p. 32)

The child seems to be viewed as if he were a computer judging the grammaticalness of sentences, instead of an immature, dependent human trying to survive. If we must attribute motives to the infant we are on biologically firmer ground in attributing to him a motivation to survive than we are if we attribute to him a motivation to make grammatical analyses.

From the point of view adopted here, the child's earliest linguistic efforts (— and they now appear to begin much earlier than formerly supposed, cf., the discussion below) are best seen as contributing to his survival, by means of their indirect contribution to his welfare, through reinforcement, or the avoidance of noxious stimuli; they thus function like his other classes of behavior at this period, and are strengthened (made more frequent) insofar as they are associated with desirable states of the infant organism. Such a view does not preclude the postulation of a later stage during which the child works out the rules of the grammar for himself; indeed it is difficult to imagine how else he might acquire them, since, as Chomsky rightly remarks, most children learn language without conscious teaching by others. What needs to be stressed is that, by the time he reaches the stage in which a cognitive, information-processing activity is usefully attributed to him, he has ALREADY LEARNED, BY MORE PRIMITIVE METHODS, A FIRM FOUNDATION FOR THE LANGUAGE, in the form of a set of utterances and, consequently, a set of phones of which the utterances are composed. Far from giving any evidence that he is concerned with whether an utterance is well-formed or not, the child (from the evidence of the 100 recorded field sessions used as the basis for this study) appears to react to any part of utterance he has previously experienced and to ignore the rest, unless situational or other cues provide a basis for this guessing at it. In short, the one thing that appears to have been left out of Chomsky's discussion of child learning is the child.

McNeill (1966) goes farther than Chomsky in attributing an analytical urge to the child:

> Suppose that a child has these basic concepts as part of his biological endowment. Suppose that he knows, for example, what the relation is between main verb and object. (46)
> By assigning the basic grammatical relations a place in the child's innate linguistic endowment, we assume them to be universal... Thus a child who knew them could commence acquiring any natural language by striving to discover how each of these relations is expressed locally. (47)

These formulations of McNeill's are difficult to test, since the task of examining an infant to see if he "knows" the relation between verb and object will strike anyone who has ever worked with babies as, at least, unprecedented. Such an assumption — however silly it may seem — would do no harm were it not for two consequences: first, it tends to turn attention away from the problem of studying the child's learning of basic grammatical relations by assuming that they are innate; secondly, it results in the attribution to the child of a "striving to discover" how these relations are "expressed locally". The latter attribution not only introduces non-parsimoniously, cognitive motivation for which there is no other evidence aside from the data it is supposed to explain, but it also helps prepare the way for consideration of the child as a kind of data-processing mechanism, rather than an organism. McNeill borrowed from Chomsky the notion of the LAD (Language Acquisition Device), and his discussion revolves around the efforts of the LAD to acquire language, though parallels are frequently drawn between the LAD and the child. Consider the following passage:

> ...the internal structure of LAD consists of the various linguistic universals, both substantive and formal. We pointed out that the hierarchy of categories is a substantive universal. So now are the basic grammatical relations. Undoubtedly, more universals than these two make up

the internal structure of LAD; however, we can be most clear about the two that have been discussed, and attention will be restricted to them.

We can imagine LAD going about its assigned task roughly as follows. Two things are done simultaneously, both of which make possible the remarkable "induction of latent structure" that numerous psycholinguists have observed on children. LAD receives a certain amount of preliminary linguistic data which it scans for distinctions that match the distinctions drawn in the universal hierarchy of categories. Because LAD is exposed to a natural language, some of the universal distinctions are bound to be present. Thus, we can imagine that whenever LAD observes such a distinction in the preliminary linguistic data, it is incorporated into LAD's own version of the underlying grammar. The function of the preliminary data, therefore is to give LAD a basis for selecting among various universal distinctions. The function of the universal heirarchy of categories is to organize the preliminary linguistic data. Moreover, because it is a hierarchy of categories, distinctions can be drawn successively, and LAD embarks upon its career by differentiating gross categories to obtain refined ones.

At the same time, LAD searches the preliminary linguistic data for sentence patterns that correspond to the basic grammatical relations. Presumably LAD recognizes them within limits set by the grammatical categories it has differentiated, so LAD's activity here is not independent of what it does with the universal hierarchy of categories. Each pattern in the preliminary linguistic data that corresponds to a basic grammatical relation will suggest one or another hierarchical structure to LAD. (1966, p. 49)

The effect of this passage is to view the child as a kind of cryptanalyst (or grammarian) searching an input text for regularities and matching them, when found, to rules drawn from a stock transmitted through the germ plasm. This view is discussed more thoroughly and counterproposals are offered, in Peizer and Olmsted (1969); I will therefore not pursue the matter here, except to note that the McNeill formulation appears to be a natural result of excessive preoccupation with the structure of the adult language, so that the problem of acquisition is seen almost exclusively in terms of linguistic analysis, rather than as a case of learning in the context of child development. It is thus doubly surprising to find such a proposal coming from one with fine training in psychology, which McNeill undoubtedly possesses.

The above problem is connected with another theoretical distinction that has proved productive in modern linguistics, but which may be a liability in the study of child development. That is the insistence upon differentiating competence from performance. To quote McNeill (1966): "Competence is an abstraction away from performance...". (17) However, "if we wish to explain performance, we must show how it derives from competence; that is, how the regularities in a child's grammatical knowledge produce regularities in his overt linguistic behavior." (17) If the evidence for competence consists of inferences from performance, then "explaining" the latter from the former would seem to be unproductively circular. The way out of this dilemma is apparently sought in the equation of competence with 'a native speaker's intuitions'. The use of intuition is controversial in linguistics itself, partly because intuitions differ from one speaker to another. However that may be, the use of intuition in "explaining" child language would appear to be doubly dangerous, since there is no known way to tap the linguistic intuition OF THE CHILD. For while no one would deny that the adult linguist has intuition about his language, it would be rash indeed to assert that he has the linguistic intuition of a eighteen-month old infant. Without it, we return to the circle of inferring *A* from *B* and then explaining *B* from *A*.

These questions are not likely to be quickly answered to universal satisfaction, since Chomsky, in a closely reasoned argument (Chomsky 1965, P. 47 ff.) has twined the various threads into two opposing bundles: taxonomic linguistics, learning theory, and empiricism make up the first, while generative grammar, innate schemata, and rationalism comprise the second. He suggests (54) that the issue can be resolved in one or both of two ways: testing either the adequacy "in principle" or the "feasibility" of the alternative approaches. This seems quite reasonable, until we learn that the test is to be whether the bundle of approaches can deliver a GRAMMAR that is "all close to those which we in fact discover when we investigate real languages". It is not surprising that he finds the advantage to be with rationalism, since the grammar he constructs (as opposed to discovers) is a generative one based on rationalist principles. If, however, one regards the lack of concern with replicable data-collection procedures to be a major shortcoming of much recent rationalist grammatical activity, then the advantage is not so clearly perceived. In fact, it appears that a better test of the claims of the two schools would be their ability to "explain", i.e., predict, the facts of language acquisition. After all, the child is not writing a grammar; he is producing utterances.

In summary, Chomsky proposes to decide a psychological issue (innate vs. learned) by tests based on intuitive linguistics or even on philosophy. My view is that, while each can play a role, neither can, by itself, be decisive concerning such a question.

The alternative is to study the early communicatory behavior of the infant as carefully as we would study any other sub-system of his behavior, using whatever is serviceable in the methods and approaches of the various sciences concerned. While we may not be able, within the near future, to get general agreement about what Chomsky sees as an opposition of empiricist and rationalist philosophies, we ought, at the minimum, to obtain good descriptions of the facts of children's progress in language acquisition. In that event we should be much better off than we are now, when, though every linguist has an anecdote about his own child's first morphs and phones and transformations, we are very short of materials representative enough to support some of the grand generalizations presently being offered.

The task of studying all aspects of child language acquisition would be of tremendous proportions; the present study attempts to approach only one small corner of that enterprise: the learning of phones. Phones, of course, are not learned by themselves, but as parts of morphs which in turn are parts of utterances. Ideally, the acquisition of all these elements would be best accounted for by a description that specified the conditions for acquisition of all of the systems simultaneously; it is in order to make a small contribution toward such an overall treatment that the present study aims at clarification of some of the conditions that influence the learning of phones. Although we explicitly recognize that intonational, morphological and syntactic factors play a role in the acquisition of phones, we think it interesting to discover what can be learned about the phones as a separate system.

The decision to study the acquisition of phones, instead of phonemes, rests upon two considerations: the chaotic state and uncertain status of phonemics in present-day linguistics, and the fact that, whatever the type of phonemic analysis, the child has to learn to pronounce some phones before he can be said to have a phonemic system. We discuss these points below.

Phonemics, once the favorite area in which fledgling linguistic analysts tried their wings, has fallen toward desuetude. The two decades between Bloomfield's *Language* (1933) and Bernard Bloch's "Contrast" (1953) saw vigorous attempts to develop a universally accepted method of analysis that would confer comparability among the results of various investigators, thus opening the way to the study of phonemic universals. There are several systems, such as those of Bloch and Pike, which, if followed consistently, would grant a large measure of such comparability, but, for one reason or another, they are not generally followed, even by those who regard phonemics as worth doing. The result is a melange of different analyses: both with and without consideration of acoustic data, both with and without the use of 'patterning' as a criterion, assuming phonemes to be FEATURES shared by phones or assuming phonemes to be CLASSES of phones, etc. etc. Clearly, the utility of any child language study based on one of these combinations of characteristics would be lessened in the eyes of devotees of other combinations. Moreover, the comparability of *any* study based on phonemes must be seriously questioned; the same is true, *a fortiori*, of studies based of morphophonemes, the theoretical foundations of which are also not subjects of general agreement. In short, the hopes we once entertained of a widely-accepted method which, when applied to the different languages of the world, would yield a set of basic phonological elements have come to naught; the wine of phonemics has soured. There are some who do not even bother to drink it any more: some of the rationalist linguists apparently see no need for a phonemic level in their system, but prefer to connect the morphemic level directly with the phonetic or componential level.

The ontogenetic priority of phones over phonemes seems obvious enough. Before the child can be said to have any kind of rudimentary system of distinctions between sounds, he must have some sounds, i.e., he must be able to pronounce some phones with reasonable consistency. If the child's acquisition of phonology were studied using phonemes as the units (even assuming we had an accepted algorithm for determining them), much interesting information would still be lost in the neglect of the earlier task of acquiring the necessary phones.

The present study grew out of an attempt to test a theory concerning the role of the discriminability of phones in their acquisition. That theory, in turn, was set in the context of a more general set of assumptions about language acquisition, which may be outlined as follows.

At birth, the human being has at his disposal a considerable repertory of behavior, some of which occurs during sleep and some while awake. Wolff (1966) found, for example, that three day old neonates display, DURING SLEEP, behavior that includes startles (brief, massive jerks, involving most of the muscles of the body), sobbing inspirations, facial twitches, rhythmical mouthings and erections of the penis. The rhythmical mouthing consists of bursts of eight to twelve lip movements separated by intervals of total inactivity lasting four to ten seconds. While awake, the newborn infant can make a variety of flexing and clenching uses of the arms, legs, hands and feet and twitching and smiling behaviors of the face. More important, with respect to his language-learning, is his ability to cry and to suck. Crying, being voiced, contrasts with (voiceless) normal breathing and shows that the distinction between voiced (i.e., with vocal folds set in vibration by the moving column of air) and voiceless (i.e., with vocal folds open, not impeding the moving column of air) is already possible for the newborn infant. Sucking shows an even more complicated set of behavioral possibilities. For one thing, it requires of the lips that they be under good enough control to tighten around the nipple; otherwise, no vacuum and therefore no milk. For another, sucking depends on the ability of the tongue to move backward and downward in the mouth, thus decreasing the amount of space taken up by the tongue in the mouth. If the lips have sealed off the front of the mouth and the passage to the nose is closed, then the tongue's progress backward in the mouth will create a partial vacuum. If the breast or bottle has milk in it, the liquid rushes into the infant's mouth. The ability of the lips, tongue and soft palate to perform the behaviors which, taken together, we call sucking, shows that a number of the more important motor patterns involved in speech are already present in the neonate. The fact that these behaviors are present in the newborn does not mean that their use in speech is thereby assured. Since their PRIMARY functions relate to respiration and ingestion, their SECONDARY functions as parts of a communicatory system have to be learned. What this seems to amount to is the RELEARNING of these responses or parts of them as elements in a new situation.

In addition to the impressive behavioral repertory of the neonate, he has a perceptual apparatus that is soon in operation. Wolff and White (1965) have found that visual pursuit and attention in three and four-day-old infants varied according to four states of the neonate: (1) alert and inactive, (2) waking and active, (3) vigorous pacifier sucking and (4) satiated pacifier sucking. They state (among other things) that: infants pursue with their eyes as well or better while sucking on a pacifier than during alert inactivity, and consistently better than during waking activity; and that after sucking the pacifier for at least three minutes, infants pursue a moving object with their eyes more consistently than right after they begin to suck. We have no comparable data for auditory stimuli (the ones most important for any theory of language learning) since we can judge the infant's attention by watching his eyes, whereas there seems to be no analogous method for judging his auditory attention. There is some experimental work to suggest (Birns 1965) that two-to-five-day-old babies reveal considerable individual differences in reaction to external stimuli and, important in the present discussion, that their REACTIVITY TO STIMULI WAS CONSISTENT, i.e., a baby who reacts vigorously to some stimulus tends to react vigorously to all, and vice versa. These findings do not suggest that we ought to extrapolate from visual to auditory modes of perception but, on the other hand, they do not suggest that we should not. If the main differences seem to be between children rather than between modes of perception, we may be justified in making such an extrapolation, provided we keep in mind that similarity between the visual and auditory modes of perception and attention is only a working hypothesis and not an established fact. Some recent work (e.g. Lewis 1965) suggest that cardiac deceleration (slowing of the heart beat) accompanies attention to visual and auditory stimulation; thus, there is a possibility that heart-rate measurements may afford an index of (otherwise unobservable) auditory attention. We shall return to this question when we consider theories of language-learning in the child.

The newborn infant spends most of his time sleeping; his waking hours are largely devoted to being changed, fed, bathed and clothed — the details that will be with him until death. Under normal circumstances, the baby gets to hear a fair amount of his mother's (or mother-surrogate's) language during his waking hours. This chatter will either be directed at another adult or at the baby himself. The infant is in a position to hear much of this talk (of course, we are unable to tell whether he is 'paying attention'). Some of it he doesn't hear, because it is masked out by other, competing noises, e.g., his own cries or those of brothers or sisters in the throes of sibling rivalry, the ring of a telephone or a tropical bird, the roar of a lion or a T.V., the keening at wailing wall or wake, the groans of the sick and the tears of the woebegone, the music of the dancers, the banging of utensils and the barking of dogs. All of these masking noises come and go relatively randomly with respect to what is being said in the child's vicinity. That is to say that no sound or word is more likely to be masked out than any other; the disadvantage is thus equal for the various elements of the language. In any event, it is unlikely that at this stage the child can distinguish any of the elements of the language. The first thing he probably learns is to distinguish his mother's voice from those of others. The odds to favor this, since, as we have seen, the child's most attentive period seems to be a few minutes after beginning to suck; in most cases this means while being held in his mother's arms and fed. Thus, to the advantage of being the most frequent locutor in the child's presence, the mother can add the possession of the most attentive period of his day. Wolff (n.d.) finds that the sound of the human voice will arrest the infant's crying by the end of the second week.

Certain needs of the organism, such as for food and drink, are called primary drives because, unless they are satisfied, the organism ceases to live. There is a voluminous literature (for example Logan *et al.*, 1955) supporting the assertion that the act of reducing a primary drive (say, by eating or drinking) tends to make the behavior that immediately preceded more likely to occur whenever the same stimulus situation arises. We say that such behavior has been LEARNED: the rat is more likely to turn to the right at the end of his T-maze if he is hungry and has found a pellet of food in the right-hand arm of the maze in the past; the horse is more likely to return to the barn if he has found a peck of oats awaiting him there in the past, and so on. The oats (the reward, or instrument of reduction of a primary drive) we call a primary reinforcement of the behavior learned. Drive-reduction is not the only way to learn, but it is a way that cannot be ignored, since it is characteristic of many species and important, among the 'higher' animals and man, particularly in the period of infancy. Thus, our neonate, cradled in his mother's arms and placidly taking his nourishment, is learning how to suck and to swallow (these were mostly innately present but he is overlearning them anyhow). More important, he is learning anything else he is doing at the moment or was doing just preceding his feeding. What is that? Before the feeding it may well have been crying, one of his principal forms of exercise at this stage. During feeding, since crying is obviously incompatible with feeding, he may well be observing by eye and ear. That is, his earliest feedings, in addition to keeping him alive, are reinforcing (and thus helping him learn) the behavior of paying attention and observing visual and auditory stimuli in his environment. What he can see, as a result of his largely supine position, is mostly trivial (with all due respect to his mother's shining face, beaming maternally down). On the other hand, what he can hear, right from the first few days of life (presumably), will be of enormous value to him throughout the rest of his life: his mother tongue.

In the earlier formulation of the theory that gave rise to this investigation, it was assumed that the child learns to distinguish cries of distress (made by himself or others) from the general impression made by the vocal activity involved in ordinary speech by about the age of six months. Recent impressive studies by Peter H. Wolff (Wolff, n.d.) strongly suggest that such differentiation takes place much earlier, and that the crying pattern is subject to modification as early as the third week of life. To quote from Wolff's summary:

> By at least the third week the STATE OF THE ORGANISM had become an important mediating factor between psychologically relevant stimuli and the infant's affective responses, so that it was no longer possible to speak of a one-to-one cause-effect relation between a fixed "stimulus" and a specific affective "response".
>
> The direct observation and spectrographic analysis of crying brought circumstantial evidence for the proposition that neonatal crying patterns are not entirely random expressions of distress; in selected instances one can infer the provoking cause from the morphological characteristics of the cry, and the mother is guided to some degree by these characteristics when she responds to her baby's cry. Direct observations combined with the analysis of sound spectrograms also gave some substance to the speculation that crying is functionally and morphologically related to the earliest non-crying vocalizations (Lewis 1951); and cast some doubt on the supposition that crying and early speech acquisitions are entirely unrelated, or that the first non-cry vocalizations (generally viewed as the global "precursors" of speech) begin *de novo* at one month, and then differentiate into refined lallation, babbling, and speech sounds, while crying follows its independent path.

In this connection we need to introduce at this point another psychological term: SECONDARY REINFORCEMENT. If, when the rat receives his pellet of food at the end of his maze, we turn a light on him as he eats, the light will come to assume some of the reinforcing properties of the food itself. Even though the light has nothing to do with reducing the hunger drive, it will, for a while and with reduced power, have the possibility of reinforcing other behavior. Thus, a rat who learned to obtain food paired with a light can be taught to do something else using ONLY THE LIGHT as a reinforcement, without the food. True, the effect is lost after a while, but it can be reinstated by again pairing the experience with a primary reinforcement. The infant feeding in his mother's arms is getting primary reinforcement for feeding behavior and for certain orienting behavior important to his perceptual development; in addition, he is attaching secondary reinforcing power to other constant stimuli in the situation. One of the most pervasive of these other stimuli is the sound of his mother's voice.

This is a point of great significance, since it asserts that (1) the child's language learning begins, in some sense, almost immediately after birth and (2) that his attitudes towards his mother as a reinforcing agent (and hence as an agent of enculturation) begin to be formed in the first few days of life. It is worth remembering that these two types of learning are taking place at a time when the child has no language at his own command; he cannot attach labels to objects and experiences. It follows that the learning of these early days is UNCONSCIOUS, by which we simply mean that the child cannot verbalize about it.

If the sound of the mother's voice acquires secondary reinforcing properties, it is reasonable to ask whether these powers decline as does the power of the light as a reinforcement for the rat. The chances are that they do not, since the child at this point is not learning anything new for which the sound of the mother's voice is being used as a reinforcement and, most important, since the sound of the mother's voice is constantly being re-paired with the primary reinforcement of food (and relief from discomfort, and pleasure of being held, etc.). Thus, by the time the child is old enough for the mother to have to use the sound of her voice as a reinforcement, its secondary reinforcing power should have built up to a high level.

While there is no DIRECT evidence that secondary reinforcement is a powerful factor in language development in the infant, there are many studies whose results give general support to that postulate. Some of these concern the effects of early maternal deprivation upon the development of various childhood skills. Bowlby (1951), in a review of the literature, concludes that "the least affected is neuromuscular development, including walking, other locomotive activities and manual dexterity. The most affected is speech, the ability to express being more retarded than the ability to understand". Gatewood and Weiss (1930) found that vocalization in neonates was correlated with the presence of environment stimulation of a benign sort. Brodbeck and Irwin (1946) found that the frequency and variety of vocalizations were significantly greater in family-living children than in orphanage children; this effect was noticed as early as two months of age. Similar effects of maternal deprivation on language retardation in infants and young children have been reported by Pringle and Tanner (1958), Burlingham and Freud (1954), Williams and McFarland (1937), Moore (1947), Goldfarb (1943a and 1945), Little and Williams (1937), McCarthy (1930), Smith (1935), Skeels *et al.* (1938). The importance of the mother or mother-substitute has been emphasized, though sometimes in different theoretical terms, by Dawe (1942), McCarthy (1952) and Pringle and Tanner (1958).

From the standpoint of language learning, the secondary reinforcing power acquired by the sound of the mother's voice is important in that it apparently (Miller and Dollar 1941, Mowrer 1960, Olmsted 1966) helps to guide the child's own production of vocal sounds.

As early as the second month of life, when the child is beginning to spend more time awake, so that all his waking moments are not occupied with crying, feeding, being changed, etc., he has time to exercise his developing muscles, including his vocal apparatus. Among other things, he usually continues the kind of feeding-rehearsal that Wolff (1966) noted as rhythmical mouthing and sucking. If there is no food present, one of the results may be sound. In fact the combinations of sounds produced at this period — ku, gu, and so on — are closely related to the movements of sucking and have given their name to the period — 'cooing'. If the vocal folds are not vibrating, the same motions may be gone through voicelessly, in which case they are not so likely to be noticed by adults in the vicinity, but they are nonetheless useful steps toward the acquisition of language.

When the child makes sounds at this period, he hears himself doing so. In order to evaluate what he hears, we need to consider yet another psychological finding: when an organism has learned something in one set of stimulus conditions, it will tend to perform similarly in some other set of conditions to the extent that the stimuli present are similar to those in the original situation. Thus, a rat who has learned to run maze *A* will do almost as well in maze *B* if *B* is practically identical with *A*. The more different *B* is, the more poorly we will expect the rat to 'transfer' his training. Similarly an organism trained to perform some act to the stimulus tone at middle *C* will do better to *D* (the next higher note) than he will to *A*, several tones higher. This phenomenon is known as STIMULUS GENERALIZATION.

When the infant hears himself making sounds, the stimuli most similar are the sounds made by the mother. As we have seen, these already have acquired secondary reinforcing properties. Thus, the more similar the child's voice is to the mother's, the more secondary reinforcement he can supply for himself. The more his sounds deviate from the mother's the less reinforcement, so he has a constant incentive to imitate his mother's locutions. Of course, at first his attempts are more or less random, except as they are subject to the conditions that produce cooing; however, we would expect that they would gradually tend toward greater similarity with the mother's sounds, since the latter's voice has its secondary reinforcing power constantly renewed by re-pairing with primary reinforcement. All this is long before the child is attempting to produce regular utterances of the language and long before anyone in the family thinks he is learning anything about language. Now, as probably later, his parents will teach him many important things without knowing it and will fail in their attempts to teach him other, incompatible things, without understanding why.

From the cooing period the child gradually grows into the babbling period; it is a time when he displays many different (some have said 'all possible' but this seems unlikely) responses of the vocal apparatus. From the diaphragm to the lips, the child exercises the vocal organs (we should remember that all these organs have primary functions in ingestion and respiration; the communicatory behavior is only grafted onto them — e.g. using the respiratory column of air as a medium for producing sound). This period of exercise represents only a gradual increase from the 'accidental' sounds of the cooing period and apparently has little to do with communication at first. At least, communication WITH OTHERS seems not to be involved. However, it is likely that the delivering of secondary reinforcement to oneself is a kind of communication, analogous to daydreaming in the older person. The babbling period needs thorough study; e.g., it would be interesting to know whether the sounds produced during this period change in the direction of those later to be employed in the child's native language. It is clear that most children so far studied reveal a much greater repertory of sounds during babbling (c.f. the summary of previous research in Jakobson 1941) than occurs in any of their native languages. As Jakobson points out, the children are unable to use in meaningful speech many of the sounds they have been babbling a month or two before, so that evidently the two tasks are different enough to block an easy transfer of response. More recent work (e.g. Weir 1963) suggests that the period of babbling may overlap long into the period when the child is also producing meaningful utterances; that those utterances may be repeated over-and-over, abbreviated or lengthened in ways unknown to the adult standard — in short made the object of verbal play or rehearsal that seems very analogous, on a different level, to babbling.

Between the babbling period and the later speaking period there seems to be one difference of crucial importance: THE ROLE OF AUDITORY FEEDBACK CUES FROM THE INFANT'S OWN BEHAVIOR. During babbling, under our assumptions about secondary reinforcement, the baby's main object is to obtain secondary reinforcement by sounding like the mother. Most of his sound-production probably meets this standard fairly easily, since it doesn't have to make up meaningful utterances; he therefore gains no particular advantage from paying especial attention to how he sounds. However, when he begins, toward the end of this period (at about one-year of age, give or take a few months) to try to say something he has heard said, such as "Mama", "ball", "milk" or "blanket", he soon finds that just any old motions of the vocal apparatus will not do. Some of his productions get better results than others. These results (reinforcement) come in the form of maternal smiles, cries of delight, and increased attention generally, to say nothing of the possession of the thing (e.g., the ball) for which he asked or was thought to ask. In other words, for the first time, the child finds that he must LISTEN to what he is saying with the object of matching it to what someone else has said. The closer the match, the better the results. The reinforcement is not now secondary pleasure in the sound of one's own voice, but much more direct in the form of food, attention and relief from frustration (e.g., getting the ball which has fallen from the crib).

It is thus possible that the most difficult task facing the infant beginning to speak (as opposed to babbling) is PERCEPTUAL AND IMITATIVE, rather than articulatory, as has been previously thought. For while many of these same sounds have been in the child's repertory, there is no evidence that they were under 'conscious control' or that the child had any reason to 'know' what he was doing. In the new period, his attempts to speak have to be evaluated by himself and others as good or bad matches against the model performances of those around him. Of course, he frequently gets help in the form of repetitions by adults or siblings of the utterance they think he is attempting to say.

Another new task for the infant at this period is the necessity to articulate sounds in a specific order. This is more troublesome than might at first appear, since the various articulatory movements that go to produce speech sounds tend to overlap considerably. For example, during the production of "Mama", the tongue remains in the position for /a/ during the pronunciation of both of the /m/'s, since it is not needed for /m/. However, when pronouncing "me", the tongue is in a different (higher and fronter) position during the production of the /m/. The /m/ of 'Mama' and the /m/ of 'me' may thus be seen as somewhat different articulatory problems, about which, in a sense, a decision has to be made some time before the overt occurence of the vowel that seems to make the difference. Thus, to say that 'm' occurred freely during babbling, and that therefore the child ought to be able to carry it over into the speaking period without great difficulty, is possibly to overlook many complexities of the learning situation. These articulatory problems have to be met by the infant at a time when he is just learning to pay attention to the perceptual match-ups between cues from his own utterances and those from the utterances of others. Small wonder, then, that he apparently is unable to produce sounds that he formerly 'had at his command' during the babbling period. The point is that he DIDN'T have them at his command in any testable sense. That is, we have no way of knowing what he intended to utter when he was babbling or indeed if he can be said to have intended anything at all: the sounds he produced may have been mistakes (i.e., not what he 'wanted' to say) or they may have been mostly random 'unintended' productions. The beginner at golf may get off a lucky drive the first time on the tee, but it would be a grave mistake to assume that he therefore has a good drive in his repertory since he may be unable to replicate the performance until he has practiced for many a frustrating hour. By the same token, a baby who has produced a Hottentot click during the eighth month of life presents no mystery in having to learn it again when he is two years old. (Of course, he will need to learn it only if he is a Hottentot; if he is Chinese, Greek or Navaho he will have no model and hence no need for it and it will be lost forever from his repertory unless, at some later date, he tries to learn Hottentot or one of its close relatives.)

It should be emphasized that the learning of the sounds of the language proceeds at the time as the learning of the higher-order units. At first the only higher-order unit learned is the utterance: a stretch of meaningful speech bounded at both ends by pause. It seems clear that each utterance (usually about one word long at this stage) is learned as a unit at first. The process seems to be approximately as follows: the first utterances learned seem almost always to be ones that have been heard by the child many times before he has tried to imitate them (e.g. milk, chair, ball, Mama, eat, wet, spoon, dog, cat, kitty — these are in fact words of very high frequency in recordings of English-learning infants); thus the child has had an opportunity for considerable LATENT LEARNING of these items.[1] The child's own vocal productions may include sequences somewhat similar to some of these words. We cannot tell — and it matters little — whether he 'intends' to say 'Mama' when he says something like [ma], but the important element in the learning situation is that someone else finally comes to think that he is trying to say something in the adult language, perhaps 'Mama'. Some recent statements about language acquisition have tended to give the impression that much of the structure of the grammar internalized by the learner is a reflection of his learning capacity (i.e. innate) rather than the particular course of his experience. It is questionable whether such a statement is testable at all; in any event, it does not seem to reflect much acquaintance with young children learning language. For the child utters many a sequence of sounds that is 'something like' the desired target utterance before he gets it right and he frequently does this for a long time before anyone perceives him as making the attempt. The evidence for these statements comes from the tape-recordings which were made of the 100 children of this study in their home environments, with home noises, mothers' comments, interruptions by siblings, etc., as part of the record. The tape recordings reveal what even the trained phonetician cannot always catch (and what the ordinary parent or sibling almost always misses): the unsuccessful attempts of the baby. When his productions are not close enough to some target to be understandable, the reaction of adults is to ignore them or to consider them holdovers from the babbling stage, which of course, they may be, since we have no way of learning the baby's intentions in most instances. Previous studies of language-learning have recorded a progression of SUCCESSES, which are, naturally,

[1] Latent learning can be demonstrated even in the rat: rats allowed to explore a maze without reinforcement learned to run it faster then others who had never been in it before.

of great interest to all students of the subject. There seemed to be no point in making records of all the unintelligible noises (failures ?) made by the infant between his few recognizable utterances. In this, the linguists were acting like ordinary adults, animated by the same circumstance that makes language learning much more efficient than it otherwise might be, viz. the fact that the adults and older children NOTICE and therefore REINFORCE only those utterances of the child that are close enough to the adult language to be taken to be attempts to say something. This results in rapid improvement in performance.

Having been noticed by the mother, the utterance (e.g. 'Mama') may be repeated by her (with suitable corrections). Now the child may or may not have intended saying 'Mama' when he produced something that sounded like it to her; however her performance — her saying 'Mama', her increased attention to the infant, her receptive attitude toward any attempts at speaking he might make — all these have changed the situation. Whether he originally meant to say 'Mama' cannot be discovered, but if he makes a fair approximation of that word now, he will be rewarded by the mother's smile and other indications of delight (acting as direct reinforcements) plus, very probably, another repetition of 'Mama'. Thus he has another chance to match his behavior to hers by trying to match the auditory cues from his own speech to the sound of what she said. Both the tape-recordings and common observation reveal that this process is repeated over and over again and there is evidence to suggest that language-learning is markedly slower in children who do not have such help from a normal mother or mother-surrogate (Pringle and Bossio 1958). A good model is essential; for example, twins, who spend much of their language learning years in each other's company, tend to learn more slowly than other children, because each gets less of the mother's attention and because they serve, to some extent, as (incorrect) models for each other. They thus learn more slowly and more of what they learn is incorrect (Day 1932, Davis 1937).

Having learned one articulatory-auditory match-up, the infant is usually presented with another model utterance soon, if not immediately. Whether or not he is successful in his second attempt, he has to begin to learn that a certain word is appropriate to some situations but not to others. If, after he says 'Mama' (or something his mother accepts as an understandable version of it), she then says 'ball' and holds up a ball, he may again say 'Mama', She may laugh, or say "no, ball!", or may simply repeat "ball", showing it to him again. A bit later, she may point to herself and say "Mama", then show him the ball and say "ball". The possibilities are many, and they may sometimes be misleading. If his mother enters the room carrying the ball, the infant may say (after much hard learning) "ball", whereas a sibling (who has been trying to get her attention away from baby) may say "Mama!" Such an incident may be a temporary setback in the semantic education of the baby, though it contributes once again, in a mild way, to his latent learning of the perceptual system of the phonology of the language. Thus his generally forward progress may be interspersed with temporary setbacks and with situations which are advances in one area of learning and reverses in another.

We may pause for a moment to take stock at this level of infant language-learning; his utterances are, from the adult point of view, one word long and, from his own, not divisible into smaller units. While it is clear that only human beings have the brains to learn and use language, with all its wonderful complexity, there is nothing in these early stages of language acquisition that is not explicable in terms of the learning theory that serves so well for research into non-linguistic human learning and animal behavior. In point of fact, it appears to be a more parsimonious and more powerful research tool than theories of child-language acquisition devised by extrapolating youthward from the linguistic behavior of adults.

This project began with the formulation of a theory about the prediction of errors in children's attempts to pronounce utterances modeled for them by adults. It started when, in preparing for lectures in a course in psycholinguistics given during the Linguistic Institute of 1962 at Seattle, I came simultaneously across Mowrer's suggestion of the role of secondary reinforcement, and Miller and Nicely's (1955) experiment on the effects of phonetic components on discriminability.

On the assumption that secondary reinforcement served to promote learning of certain aspects of language during a period in which the child had traditionally been supposed to be engaging in pre-linguistic articulatory exercise making no lasting contribution to language learning, it appeared that the findings of Miller and Nicely would provide a basis for differential predictions relative to the acquistion of various phonological elements. This approach involved a number of assumptions, set forth as postulates in Olmsted (1966). They may be summarized as follows.

As the child is exposed to the sound of the mother's voice, the occurrence of the phones of the language is in about the same proportions as it is in normal adult speech. The masking noises that interrupt the child's perception of what he hears do so randomly with respect to the various phones, i.e., their chances of being masked out are strictly in accordance with their frequency in the stream of speech. In this situation, an advantage in acquisition accrues to those phones which contain more discriminable components, since, unless the masking is total (which it presumably sometimes is), the more discriminable phones have more chance of 'coming through'.

Insofar as the more discriminable phones (those with more discriminable components) have an advantage, they contribute both to clearer perception of segments of the mother's stream of speech and to perception of the child's own utterances during cooing, babbling etc. Central to this argument is, of course, the further assumption that the components that are more discriminable to the adults in Miller and Nicely's group of subjects are likewise more discriminable to the child. If that is so, then the phones containing the more discriminable components discovered by Miller and Nicely ought, frequencies being equal, to be more familiar to the child (as the result both of his 'latent' perceptual learning, and of his articulatory experiments and their auditory feedback cues) at any point in his progress than the correspondingly less discriminable ones.

Since the components identified as differential in discriminability were (in descending order of resistance to error) nasality and voicing, friction and place of articulation, it was predicted that children would make most errors with respect to place, next most with respect to friction, and least — about equal numbers — with respect to nasality and voicing. The results of these predictions are set forth in Chapter 3. In addition, certain hypotheses were advanced with respect to successful pronunciations (hereafter called successes); the results from this sample are presented and discussed in Chapters 5 through 8. Chapter 2 outlines the methods used in the collection and preliminary analysis of the data, and Chapter 4 reviews some of the literature that deals with children's acquisition of phonology. Chapter 9 sets forth and discusses the conclusions of the study and points to a number of errors in research strategy that should be corrected in future studies.

The investigation has proceeded for the most part under the assumptions concerning scientific work that are briefly outlined in Logan, Olmsted, Rosner, Schwartz and Stevens (1955). These emphasize the desirability of prediction of previously unstudied events from assumptions set forth as clearly as possible so as to permit checking the consistency of the logico-deductive chain; specification in full of the methods of data-collection and analysis so as to permit full replicability; and the recording of instances of non-confirmation of predictions as well as the more satisfying outcomes.

Though the postulates of this study will not be equally acceptable to everyone interested in child language acquisition, it is hoped that the data presented will be found useful by workers of all theoretical persuasions.[2]

[2] Chomsky's view of linguistics does not meet with the approval of Lamb (1967), who makes it clear that profound differences still exist among linguists of various schools. Lamb is especially critical of Chomsky's efforts to deal with (or, as Lamb suggests, to avoid dealing with) performance (as opposed to competence). Lamb's point is not ill-chosen, since Chomsky and some of his followers have brushed aside the attempts of others to handle performance in terms of various psychological theories; not untypical is Postal (1968:295), who chides Hockett for regarding a language as a "set of habits" rather than as an "abstract object". When the tensions of debate get high, it is always nice to be able to count on comic relief.

2

PROCEDURES

"Quand on étudie l'apprentissage du language, le premier souci que l'on doit avoir est de connaître le parler des personnes entourant le nouveau-né."
Antoine Grégoire

2.1. CHOOSING A SAMPLE

Most previous studies of child phonology have fallen into one of three groups: (1) strictly theoretical studies devoid of new data; (2) phonetically sophisticated longitudinal studies of small numbers (usually only one or two) of children; and (3) statistically sophisticated studies of larger samples (sometimes hundreds or thousands) of children; these latter accounts are often suspect on phonological grounds, e.g., they often use as a unit the PHONEME without suggesting that they have actually done phonemic analyses of the idiolects of the hundred of thousands of children in the sample. Those who have carried out research of type (3) are usually cautious about stating their results and hesitate to make claims that their findings are representative of childkind as a whole. Those who have carried out, or who have depended on, research of type (2) have sometimes stated their results as if they indeed represented universal laws of child language development. The result is that our knowledge, both of genuine universals and of individual differences, is far from adequate.

The choice of sample is of course dependent upon the form of the theory it is designed to help test. In the present case, the influence of secondary reinforcement on language learning is assumed to be universal. However, the data concerning discriminability (derived from the experiment by Miller and Nicely (1955)) are derived from a study of English-speakers and are, at least until further evidence is in, presumed to be limited to English. Therefore, it followed that, for this first test at least, the children should be learning English as a first language. Since the theory made so bold as to state that its predictions ought to hold good at any point between the time the child began to say something identifiable as an attempt at English and the time he came to speak the language without any phonological errors, any child in that age-range was a proper subject for the sample. The age-range was, in point of fact, from 15 months to 54 months.

Since the theory had nothing to say concerning the effects of such variables as race or social class on language learning during infancy and early childhood, no attempt was made to select either for or against a particular caste or class. No record was kept of what appeared to be the caste membership of the parents; the social class membership of the parents is perhaps roughly reflected in the data concerning occupations and educational attainments of the pair.

Inasmuch as the two field-workers were students, it was perhaps not unexpected that they should begin by seeking permission to make recordings from those faculty members and graduate students with young children. These groups had the advantages of being close at hand and known to the investigators, at least in the case of the first few families. Moreover, they were well acquainted with the notion of research into various aspects of child development and tended to be not only sympathetic and cordial to the investigators (who usually invaded their homes for the recording sessions) but also genuinely interested in the outcome of the research. The result was that, without exception, they were intelligently cooperative during the interviews and elicitation sessions. The sample was, for the most part, extended by social agglutination; i.e., having recorded the utterances of a child, the investigator asked the mother to suggest other likely candidates. By this time the mother had a good idea of what was involved and generally had a sizable group of acquaintances with children of about the right age. In this way, the investigators moved through sub-groups of the university community; these sub-groups had the characteristic that they were connected by having as members mothers with young children of language-learning age. In addition, the sample was extended by the inclusion of some non-university families from a nearby town; these, by the usual leapfrogging procedure, brought in what proved to be about one-fifth of the sample. Again, the interviews and recording sessions presented no difficulties; this part of the sample contains the few working-class families. In general, there are no significant differences between the results from the children of university and non-university families.

In fact, the occupations of the parents are as follows:

TABLE 1

Fathers' Occupations

Graduate Student	24	Small Businessman	3
Professor	8	High School Teacher	2
Associate Professor	6	Rancher	4
Assistant Professor	15	Laborer	3
Other Faculty	11	Professional	2
Engineer	5	Librarian	1
Bureaucrat (medium-grade administrator)	5	Artist	1
		Truck Driver	1
		Clergyman	1
Laboratory Technician	5		

TABLE 2

Mothers' Occupations (Includes Part-Time Jobs)

Housewife	74	Librarian	1
Registered Nurse	3	Receptionist	1
Secretary	6	Social Worker	1
School Teacher	4	Medical Technologist	1
Nutritionist	2	Artist	1
Student	2	Bacteriologist	1
Seamstress	1		

The educational levels attained by the parents were as follows:

TABLE 3

Educational levels of the Parents

	Fathers	Mothers
Finished junior high school		2
High school graduate	5	16
One or more years of college	21	58
One or more years of graduate work	39	19
Ph. D.	32	

If one takes graduate work as evidence sufficient, but not necessary, of an intellectual life-style, one is forced to the conclusion that the families in this sample are rather atypical in this respect. Almost three-quarters of the fathers can be considered intellectuals by that criterion, and the fact that more than three-quarters of the mothers had had some college training suggests that the families as a whole are well-educated relative to the general population. Whether they raise their children any differently from the rest of the population has yet to be shown; indeed, it is not even the subject of this study. The educational attainments of the parents in this sample are given here to facilitate replication and to permit systematic extension of the method to other samples whose characteristics may be fit subjects for comparison with the data given here.

The sample is not in any sense representative of the population of the United States. Since the principal requirement was that the child be learning English (i.e., that the language customarily spoken to and around him be English and not some other language or a mixture of English and some other language), the parents were not necessarily natives of the United States, or even native-speakers of English. Two were native speakers of Norwegian, one of Dutch and two of Chinese. The dialects of English represented among the parents included varieties from the British Isles, New Zealand and Australia, as well as Canada and a full panoply of dialects of American English, both rural and urban and representing all major dialect areas of the United States so far identified. Clearly, it would be valuable to replicate the study with a sample better representative of the racial, ethnic, and class diversity of the society. Traditionally, studies of attitudes have suffered from having subjects drawn predominantly from populations of college sophomores; the present effort might almost have been titled 'Son of College Sophomore'. Not quite; 'Daughter of Ph.D. Candidate' might have been more like it.

The sample contained 58 girls and 42 boys, distributed according to age as follows:

TABLE 4

Age in months	Boys	Girls	Age in months	Boys	Girls
15		1	31	1	3
16		1	32	5	3
17	1	1	33	2	3
18	1	2	35	2	3
19		1	36	1	1
20	1	1	37		3
21	1	1	38	1	
22		2	39	3	1
23	2	1	40		3
24	1	6	41		1
25	2	3	42	2	3
26	5	4	45	1	
27	4		48	2	
28	1	3	51		3
29	2	1	54		1
30	1	2			

Thus, it may be seen that 17% of the children were less than two years old, 57% were between two and three years old, 22% were between three and four years old and 4% were between four and four-and-a-half years old; all ages are those as of the date of recording. Mean age is a little over 30 months; 52% of the children were 30 months of age or less and 48% were aged 31 months or more.

The sibling-position of the children was recorded, with the following results:

TABLE 5

Age rank in sibling group	Boys	Girls
Only child	12	12
Oldest	10	10
Second	8	14
Third	7	14
Fourth	5	4
Fifth		3
Eighth		1

Thus, it may be seen that 22 boys and 22 girls fall into the group encompassing first-borns (only children and oldest children); the 16 extra girls in the sample are all drawn from the 2nd, 3rd, 5th and 8th positions in large families. These data take their importance from the fact that some investigators (cf. McCarthy 1954) have found that girls appear to progress faster in some respects than boys, while others have reported no differences (e.g., Berko 1958). On the other hand, first-born children have been reported as progressing faster in some respects than younger siblings (McCarthy 1954). It seems clear from the table above that the present sample is not well suited to test these notions, since the group of girls has a larger proportion of younger siblings in it; thus the factors thought to make for faster progress tend to cancel each other out; one can of course correct for this by considering the effect of sex, holding sibling position constant, and vice versa.

Consideration of the place of birth of the children in the sample gives evidence concerning the amount of geographical mobility of their families during the three or four years preceding the time of recording. 54 of the children were born locally (defined as in Davis itself, or in Woodland or Sacramento, the two nearby cities whose hospitals serve Davis maternity patients) and 22 were born elsewhere in California, mostly in northern California. New York and Utah (with two each) are the only other states represented by more than one; other states on the list are: Maine and Massachusetts from New England; Indiana, Illinois and Michigan from the Midwest; Maryland from the Mid-Atlantic group; Texas and Florida from the South; and Wyoming, Nevada, Colorado and Oklahoma from the West. Three children were born in England, two in Australia and one each in Norway, France, and Canada.

In addition to keeping records of the childs' age, sex, sibling position, and place of birth, attempts were made to specify the dialects of the parents and the educational attainment of the mother, since it was thought that these would be factors contributing to the development of the model of English presented to the child.

Seventeen of the children had mothers who had not attended college; these were distributed as follows.

TABLE 6

Children of Non-College Mothers

	Boys	Girls
Age 30 or less	4	5
31 or more	4	4

The dialects of the parents were approached by way of a detailed residential history, covering the years from birth to age ten, for each parent. In the case of the mother, direct evidence was usually obtained on the same tape with the child's speech, in the form of explanations to the interviewer, glosses on the child's speech, etc. The data for the fathers are obviously less than ideal, but it was hoped that they would be adequate to indicate whether, in case the child produced some phone or combination not characteristic of the mother's phonological system, a possible model could be found in the father's dialect.

Data were not obtained on four fathers since their absence from the household made it seem unlikely that they serve as models for language development. The other 96 (a father is counted once for each child of his represented in the sample) fell into two groups: those whose boyhood to age ten was spent in one place and those who made at least one major dialect-move during that period. Of the first group, the following states and countries were the places of origin.

TABLE 7

Dialects Represented by Fathers who Spent Boyhood in One Place

California	34	Wyoming	1
New York	11	Pennsylvania	1
Utah	6	New Hampshire	1
Illinois	3	Hawaii	1
England	3	Michigan	1
Iowa	2	New Jersey	1
Connecticut	2	Ohio	1
Colorado	2	Texas	1
Kansas	2	North Dakota	1
Georgia	2	The Netherlands	1
Australia	2	Brazil	1
		Hong Kong	1
		Norway	1

Fathers whose boyhood was characterized by at least one major move are listed below, regardless of whether the move represented a major dialect change or not. When two places are listed, the first is the area where the father lived first, usually for about the first five years of life, with the second indicating where he lived roughly during the years five to ten. In case more than one move was indicated for either five year period, the term 'Mixed' is applied, on the theory that the dialects represented are likely to show effects of more than one area.

TABLE 8

North Dakota-California	1	North Dakota-Oregon	1
Arkansas-Oregon	1	Oklahoma-California	1
New York-Pennsylvania	1	Louisiana-Arkansas	1
Idaho-Montana	1	Minnesota-California	1
Washington-California	1	Connecticut-New Jersey	1
California-Mixed	2	Texas-Mixed	2

TABLE 9

Dialects Represented by Mothers Who Spent Girlhood in One Place

California	37	Connecticut	1
New York	9	Pennsylvania	1
Colorado	5	New Mexico	1
Utah	5	Indiana	1
Illinois	4	Maine	1
Wisconsin	3	Hawaii	1
Massachusetts	3	Montana	1
Ohio	2	Iowa	1
Michigan	2	West Virginia	1
England	2	Missouri	1
Australia	2	Scotland	1
Texas	2	New Zealand	1
		Norway	1

TABLE 10

Areas Represented in Major Moves During Girlhood of Mothers

Texas-California	2	Missouri-Arizona	1
Netherlands-U.S.	1	Connecticut-California	1
Arizona-Texas	1	North Carolina-Ohio	1
Arizona-California	1	New York-Mixed	1
Michigan-California	1	California-Mixed	1

We do not demonstrate the relevance of these classifications here; they served the investigators in the description of the model available to the child and in scoring errors. Thus, if the child's pronunciation differed from the mother's, it was, provisionally at least, an error. If the child's version agreed with the usage of any known dialect legitimately attributable to the father, it was not scored as an error. In practice, these calculations were seldom undertaken, because in a number of cases both father and mother had the same dialect history anyway, and in the overwhelming majority of cases, the child's errors were not ones attributable to any dialect of English. In such a case, there was no point in looking up the father's residential history.

While the above sample is unrepresentative in various ways, notably in its high educational attainment, its residential history is not entirely atypical considering the settlement patterns of California. More than a third of the parents were raised in California; half were raised in some other one place, and the remainder, say fifteen per cent, ended up in California after a series of moves. The states of the mountain West are represented in the sample out of proportion to their population; this exemplifies a trend prevalent for decades in the migration to California.

2.2. CONDUCTING THE INTERVIEW

Recording sessions were usually held in the home of the child with the mother present. The intention was to disturb the household routines as little as possible. The mother was informed about the purposes of the recording and was instructed not to prompt the child, since our primary interest was in utterances produced by the child in the absence of any immediately preceding model. Since the theory concerns attempts by the child to say something (as opposed to babbling), the cooperation and attention of the mother were essential, since she was more likely than anyone else to be able to identify vocal productions as attempts to say something. In case the investigator could not identify the target utterance, the mother was asked to say what the child's utterance meant (i.e., was an attempt to say). It sometimes happened that children would then respond to the mother's utterance with another attempt of their own, oftentimes showing startling improvement; such imitations of 'expansions' were ignored for the purposes of this study since they would tend to reveal the child's ability to imitate rather than his phonological competence as displayed in unprompted utterances.

After a period in which the investigator explained the procedures to the mother and attempted to gain rapport with the child, the tape recorder was turned on and usually left to turn through one 1200 foot tape at seven and-one-half without interruption. The sample from each child was typically the corpus consisting of his unprompted utterances that were judged (by the investigator and the mother) to be attempts to say something in English. A few of the samples were much shorter; these usually came from tapes that recorded a play session with two or three children at a time. In such sessions one or two children may dominate the conversation and the others may not get the floor often enough to build up much of a corpus. Fontunately, children recorded in this way were always old enough so that their utterances were recognizable by the investigator alone; otherwise, it would have been difficult to get the mothers to provide the translations without disrupting the record or the play session or both.

Where only one child was involved, utterances might be slow in appearing at first. Then the investigator might elicit them by asking "What's that?" and pointing to things visible in the room. Good results were frequently obtained by allowing the child to go through the contents of the investigator's handbag, naming the items as they appeared. It is interesting evidence of the early appearance of sex-typed roles that the little girls seldom lost a chance to go through the investigator's handbag, while the boys were more likely to express an interest in the tape recorder and a desire to stop it, take it apart, or learn how it operated.

Before long, children tended to find themselves sitting on the investigator's lap, 'reading' one of their own books to her. She, evidently ignorant of the names of the animals and people to be found in children's books, had to be told their names. Some children who had toy telephones, were induced to put in a call to a (real or imagined) playmate; such monologues were splendid, lengthy stretches of spontaneous speech. In younger children, they tended to relapse toward babbling on occasion, possibly since the imaginary phone call set up a situation in which there were no punishments for unintelligibility; verisimilitude demands only a flow of vocalization with appropriate changes in pitch and stress levels. The result was often regarded by the mother as an acute parody of her own telephone calls to friends.

Corpus length varied somewhat with the date of the recording session. As the investigators became more skilled, they eliminated many stratagems which gave poor results and developed some that seemed to work. For example, they learned that usually more time and emotion are spent trying to ban older siblings from the recording session than are lost by allowing them to participate under controlled conditions. The investigators also came to have an excellent idea of what kinds of topics were productive at various ages and what kinds not. The result of the increased skill of the investigators was smoother handling of the children and more corpus per unit of tape.

Sometime during the recording session, usually at the beginning, the investigator filled out the data sheet for each child which listed age; sex; number, age and sex of siblings; place of birth; parents' places of birth; parents' locations during childhood; parents' education; parents' occupations.

2.3. SCORING THE DATA

The raw data of each interview consisted of information concerning the personal history of the child and its parents, plus one side (rarely more than one side) of a roll of magnetic tape recorded at the home of the child. On this tape were a sample of utterances made by the child and, in addition, usually some utterances made by the mother.

The first step in handling these data was to transfer them from the tapes to a visual record made in a modification of the International Phonetic Alphabet. The variety used was largely adapted from that taught to graduate students by Bernard Bloch, who began his career in linguistics as a highly successful field worker in dialect geography. In my own courses in linguistics I had, over the years, added and substituted a bit as experience seemed to dictate.

The phonetic work of this study is in the tradition of Pike (1943) and Hockett (1955), though with differences at various points, doubtless to the disadvantage of the present undertaking. We differ from Hockett principally in doing phonetics and not phonemics. Moreover, no use has been made of the syllable as a unit of analysis because of the difficulty in deciding whether e.g., the /n/ of 'many', belongs to the first or second 'syllable'. Hockett says (p. 64) that "structurally, the point of syllable division in an interlude is irrelevant". For some purposes it may well be so, but, if we were to use the syllable as a unit within which phones would be handled differently depending on whether they were deemed to be onset vs. coda, it would obviously be of crucial importance to be able to define the syllable unambiguously. Since the presence or absence of microjunctures is said (Hockett 1955: 63) to vary even within the utterances of single adult speakers, we shrank from the task of attempting to sort out the utterances of children in these terms. Perhaps the present study can be followed up by someone who will be able to show that some of the conclusions reached there can be sharpened or changed if the complexities of syllable structure are taken into account. If the syllable is a useful unit, such a result will not be surprising.

Most of the differences from Pike (and other modern treatments of the articulatory phonetics of American English) stem from our object: to test certain theorems about the contributions of certain articulatory components to success or failure in acquisition. These components are: voicing, nasality, place of articulation, and friction. The precision of the phonetic system employed was judged to be sufficient to permit testing of these theorems; however, no stronger claim is made, and it is recognized that a good deal of phonetic detail that might have been of interest has been lost as the data were raked into the piles counted here. For example, differences between terminal [-l] (as in 'bell') and initial [l-] (as in 'late') have been ignored, though they can in part be reconstructed from the data presented in Chapter 7. In part, such decisions were dictated by the state of the literature: American English /r/ has been a problem for students of child language acquisition, so considerable attention was given to the differences between the retroflex vowels. Since the voiceless vowels have not constituted such a problem, they were handled as [h] (unrounded) and [w̥] (rounded), though they might have provided the opportunity for at least as much narrow phonetic nitpicking as the retroflex ones, had there been motivation to do so. Clearly, it would have been worth knowing about all these niceties, had there been time and money available. As it was, the magnitude of the task was staggering.

Two problems that loom up in any attempt to handle the phonetics of American English are the voiceless vowels and the retroflex vowels, traditional symbolized as 'h' and 'r' respectively. Since the various voiceless vowels are clearly allophones of one phoneme (which does NOT include, as I see it, a centering glide; for a contrary view see Trager and Smith 1951), and since previous studies of child-language learning have treated them all together — whether the study purported to be interested in the learning of phones or phonemes — I have bowed to tradition and done the same. There are two things to be said for such a procedure: comparability among studies is maintained, on the one hand, and, on the other, there has apparently been little loss of interesting information as a result of the traditional handling. For voiceless vowels, therefore, we utilized two symbols: [h] for the unrounded (the initial segments of 'heel', 'hit', 'head', 'hat', 'hot', 'who', 'hood', 'haul', 'hut', 'her') and [w̥] for the rounded (the initial segments of 'wheel', 'whip', 'when', 'wham', 'why', 'wharf', 'what', 'whir'. Some of the parents' dialects, of course, did not contain the rounded semivowel, in which case the model was [w].

The case of the retroflex vowels is different. For one thing, what seems to me (following the practice of Bernard Bloch, as exemplified in his lectures on the phonetics of American English in a course we gave jointly during the years 1952-54) to be retroflex vowels have been variously classified by different phoneticians (cf. Brosnahan 1957, Sledd 1955, Trager and Smith 1951, Stetson 1950, Kenyon 1945, Leopold 1947, Chomsky and Halle 1965). Some have regarded 'r' as a fricative, some (summarized, for example in Jakobson 1942) have handled 'r' as a liquid (i.e., in a class with [l]); all have apparently been influenced to a greater or lesser degree by the fact that the retroflex vowels, in those dialects where they occur, are written with the letter 'r', and have therefore wanted to include them with the consonants, partly because that letter has traditionally represented a consonant and still does so in other dialects of English and in other languages (e.g. Spanish, Italian) written in the same alphabet, and partly because some of the retroflex vowels 'pattern-like' consonants. In some cases (e.g. Chomsky and Halle 1965), the retroflex vowels have become confused with the alveolar flap (IPA [ɾ], Chomsky and Halle's [D]) for reasons which are obscure to me. Moreover, what is called /r/ has been the source of difficulty in evaluating children's acquisition of phonology (cf. Templin 1966, and the discussion of her paper which follows in Smith and Miller 1966). It seems possible that interesting information has been lost by the failure to investigate the retroflex vowels separately.[1] We therefore use, for those dialects where it is appropriate, the following symbols for the retroflex vowel phones:

[1] A work published after our data were collected, which reached my desk only after this book was written, (Delattre and Freeman 1968) suggests that the word 'retroflex' is far too simple adequately to convey the complexities of 'American r'. They distinguish several varieties of 'r' by syllable position, and, though they recognize the influence of preceding and following vowels, they do not pursue that matter very far. They do demonstrate that, in addition to retroflexion, bunching is also important as an articulation productive of the acoustic impression associated with 'retroflex r', both by itself and in various combinations with retroflexion. Indeed, the 'bunched' variety is probably the more important in American English. These factors, not taken into account in this study of phonological acquisition, should be considered when interpretation of the results concerning what I have called retroflex vowels is undertaken. It is, of course, very much in question whether we could have heard and reproduced such articulatory distinctions from taped records (since the acoustic impressions are, in some cases at least, identical or nearly so); in any event the arti-

[i̜]	for	the	initial	segment	of	*reef*, *reel*
[I̜]	,,	,,	,,	,,	,,	*rib*, *ring*
[ɛ̜]	,,	,,	,,	,,	,,	*red*, *wren*
[æ̜]	,,	,,	,,	,,	,,	*ran*, *rat*
[a̜]	,,	,,	,,	,,	,,	*Robert*, *rock*
[u̜]	,,	,,	,,	,,	,,	*rule*, *room*
[U̜]	,,	,,	,,	,,	,,	*roof* (very few models had this, thus it is attempted by the fewest children of any phone).
[ɔ̜]	,,	,,	,,	,,	,,	*roar*, *raw*
[ʌ̜]	,,	,,	,,	,,	,,	*rough*, *Russell*
[ə̜]	,,	,,	medial	,,	,,	*bird*, *hurt*, *work*, *jerk*

It is easy enough to judge the position of articulation of retroflex vowels when they stand between C or # and a vowel (as in the first cases above), between consonants (as in the last case above) or between a vowel and C or # (as in *beard* and *bear*. More difficult are the cases in which the retroflex vowel occurs between two vowels (as in *berry*, *around*, *you rang*.) In these utterances, the retroflex vowels (semi-vowels) constitute a class of semi-vowels characterized by movements of the tongue between the articulatory positions characteristic of the preceding and following vowels. In order to simplify matters, such cases were registered as having the tongue position of the retroflex vowel most like the immediately preceding non-retroflex vowel, EXCEPT where the position of onset of stress indicated that the retroflex semi-vowel went with the following vowel, in which case the tongue position of the former was registered as like the latter. Thus, in *berry* and *around*, the tongue position of the retroflex semi-vowel was registered as agreeing with the preceding vowel ɛ̜ and ʌ̜, respectively), whereas in *you rang* it was re-

culatory complexity is evidently much greater than anyone had previously realized. Whether retroflexed, bunched, or some combination of the two, they are still vowels and semivowels according to the Blochian system adopted for use in this study; the point is not devoid of importance since vowels and consonants are counted separately with respect to errors of place of articulation (see Chapter 3).

gistered as agreeing with the following vowel (æ). It is recognized that this procedure violates the principle that each phone ought to be treated separately; it is hoped that the aggregation of data thus undertaken will not result in the loss of interesting information. Whether there will be such a loss is not immediately obvious; an answer may be provided by future accoustic-phonetic studies of the intervocalic retroflex semi-vowels. Judging from the discussion in Smith and Miller (1966, 180 ff.), it is not certain that the question has been correctly formulated, let alone answered. The reader should remember that, in this study, the symbol [r] is used to indicate an alveolar flap, never anything else.

A most important circumstance in our attempts to achieve reliability in our phonetic work was the fact that both investigators had learned articulatory phonetics from me. Both had had a number of courses in linguistics which required them to do extended eliciting and recording from informants. They had then gone on to serve as graders in my course. Since it has been my practice to go over all papers even when marked by graders, I had thus had a chance to evaluate the phonetic consistency of both investigators by reference to many thousands of separate phonetic data. In order further to check on the comparability of the results from the two investigators, it was arranged that they each record, separately, one of the longer, more complicated tapes; the differences between their versions were minor idiosyncracies of symbol choice and shape comparable to handwriting differences and in no case substantial. In addition, every tape whose phonetic record was made by one of the investigators was later heard by me (with the investigator's version before me); all differences of opinion were either settled by rerunning the tape until reasonable certainty could be attained, or, if the result continued to be doubt, ruled out. Thus, about 90 % of the phonetic records represented the concurrence of two judges (one of the investigators and myself) practiced in attaining replicability; the other 10 % were seen only by one (me), since they were not scored by the investigators but by me, at a time when the vicissitudes of life had separated the investigators from the project.

Before any phonetic record could be made of something on the tape, it had to be decided by the investigator whether the child's vocalizations were recognizable as attempts to say something in the language or not. This decision was not too difficult in the cases of older children, but some of the younger ones interspersed recognizable utterances with babbling, thus presenting a major problem of interpretation. The investigator was instructed to alert the mother to this problem at the beginning of the session, so that ambiguous utterances could be interpreted by the mother when they occurred. If the utterance was understandable to the investigator, no interruption occurred, but if it was ambiguous, she would indicate by gesture (usually raised eyebrows) her state of indecision; then the mother would interpret the utterance if it was interpretable. If she did not find it interpretable, it was regarded as babbling and plays no further part in this project. Thus, from the universe of the child's vocal activity, only certain utterances (those recognizable by the mother or the investigator as attempts to say something specific in English) are written out phonetically. This choice followed directly from the theory, which offered predictions concerning utterances of this type and had nothing to say about the characteristics of utterances not recognizable as such attempts.

The mother's interpretations, offered as glosses on puzzling infantile productions, also served another purpose: they provided the investigator with naturally-occurring, unstudied, spontaneous examples of the mother's dialect. These were of great utility in the construction of the model.

They also served, occasionally, to set in motion a train of unforeseen events, viz., a repetition, by the child, of the mother's interpretation of his previous utterance. Since the mother's interpretation was usually an exact version, on her part, of what she thought he was aiming at the first time, it is possible to compare his first, spontaneous version, with his later, imitated one. These imitations will form the subject of another study and are not treated in the present work. They are excluded from consideration in the belief, held at the time the theory was formulated, that the child's linguistic competence at any given time is best represented by some sample of his spontaneous, unprompted utterances at that time, rather than by his ability to match his utterances to models provided by others. The child's imitative ability is of great interest, and unsystematic observation of the imitations in his corpus suggests that the child's imitative productions have far fewer errors than his spontaneous ones; however, inclusion of the imitations would have seriously compromised the homogeneity of the sample, since the percentages of correct and incorrect attempts would have depended, in a fairly obvious way, on factors not contemplated by the theory: the tendency of the mother to offer interpretations, the tendency of the child to imitate, etc.

Thus, to recapitulate, the investigator recorded, in phonetic orthography, all the non-imitative utterances identifiable as attempts at specific English utterances. This was done from the tape, ideally as soon as possible after the recording session. No attempt was made to mark intonation, and utterances were judged to extend from the beginning of phonation to the next pause. Utterances measured from pause to pause constitute an easily replicable unit of analysis and one that is obviously relevant to the child's behavior. No use was made of phonological junctures, in the various forms in which they have been proposed, or of word-divisions, in the belief that their introduction would be gratuitous gerontomorphism, i.e., an attribution to the child of adult behavior patterns, before there is any evidence from the child's own behavior that suggests or requires such an attribution. For example, it is difficult enough to try to define the adult 'word' in a replicable way; it seems quite pointless to try to do so to account for the sound production of a child, when there is no evidence that any such unit as 'word' enters into his perception or production. Moreover, restriction of one's scope to the level of the 'word' would involve much loss of interesting information, as was the case when linguists studied the *phonologie du mot*; e.g., the number and variety of utterance-medial consonant clusters are far greater and more interesting then those of word-medial ones.

Each utterance of the child was placed below its presumed model. In doubtful cases, the model was usually the actual interpretive utterance of the mother; in cases where the utterance's meaning was clear to the investigator, she wrote out an appropriate model making sure it was consistent with the dialect of the mother. Thus, each protocol consists of lines written in groups of two, the upper being the model, the lower being the child's version. An example is the following:

(1) Model [ðʌgə̥lkɛymbæk] [ðætsʌbi·] [ʌnʌðə̥maws]
Child [ðʌgə̥lkɛymbæk] [ðɛtsʌbi·] [nʌðə̥maw]

Differences between the two versions are, by definition, ERRORS. The only exceptions to this statement are those cases in which the child differed from the mother's version, but agreed with the father, or with some known variant differing in formality. E.g., where the model is presumed to be (2) [ændðʌdɔg], but the child says [ænðʌ dɔg], no error is scored because the child's version corresponds to one possible adult version, an informal one that might well have served, at least part of the time, as a model for the child's acquisition. In example (1) above, the first utterance shows complete agreement and thus no error is scored. The second utterance reveals the child as producing [ɛ] where the model has [æ]; this is scored as an attempt at [æ] that ended up as [ɛ], while the rest of the utterance is scored as correct. In the final utterance on that line, there are two errors of omission: of the initial vowel and final consonant of the model. In model-construction and in scoring errors by comparison of the two lines, every care was taken to ensure that errors should be genuine; the result is that cases where the model is doubtful are invariably resolved in favor of the child, i.e., by scoring his phones as correct, rather than as errors. Thus the criterion for error is somewhat more strict than that for success; while example (2) above could have been regarded as containing an error of omission of [d], the utterance was scored as correct because of the possible model identical with the child's utterance. To say that the utterance was scored as correct means that each and every phone occuring in the child's production was scored as correctly made; it does not mean that [d] which occurred in the provisional model but not in the one finally adopted (or allowed) is scored as occurring (or attempted).

It appeared, as a matter of research tactics, to be important to have the phonetic representation done, as far as possible, by the person who had done the interviewing. Such a procedure insured that maximal use would be made of the situational cues (remembered from the recording session) that would help explain what the child "meant" by a given utterance. However, it was felt — also as a matter of research tactics — that the scoring of the errors ought to be done by persons other than those who wrote out the child's version and constructed the model. Since those operations were done at about the same time, anyone who had the scoring of errors also in mind might possibly have been influenced in choice of model by the consequences of a given choice on the predictions of the theory. Thus, the development of a system for scoring errors was put off until the data were substantially collected and written out.

In the scoring of errors, I was assisted by Louise Tanous and Charles Plopper, both of whom had demonstrated their grasp of articulatory phonetics and who had had special training in scoring errors according to the present system as part of their completion of class projects dealing with children's phonology. Mrs. Tanous scored thirty-eight of the protocols, Mr. Plopper seven, and I did the remaining fifty-five. In transferring the rudimentary system used in the class projects to the new situation, a number of problems of adaptation had to be faced; Mrs. Tanous was the first to attempt to score errors and the present study owes a good deal to her ingenuity in identifiying — and suggesting solutions for — some of these problems of adaptation.

The performance of each child was recorded on a sheet having the following form:

1.	C			A			O			P			P-L			Pv		
2.	I	M	F	I	M	F	I	M	F	I	M	F	I	M	F	I	M	F
p																		
t																		
k																		
b																		
d																		
g																		
etc.																		

1.	P-V			V			F			N			F-P			F-V		
2.	I	M	F	I	M	F	I	M	F	I	M	F	I	M	F	I	M	F
p																		
t																		
k																		
b																		
d																		
g																		
etc.																		

The phonetic symbols extending down the left-hand side of the paper are the phones attempted, as taken from the model. The categories across the top serve to classify the possible outcomes of such attempts. The abbreviations of line 1 are as follows: C = correct, A = added, O = omitted, P = place of articulation, P-L = place of articulation and laterality, Pv = place of articulation (vowels), P-V = place of articulation and voicing, V = voicing, F = friction, N = nasality, F-P = friction and place of articulation, F-V = friction and voicing. The symbols of line 2 are as follows: I = initial, M = medial, F = final. Thus, every time [p] was produced correctly in utterance-initial position, a mark was entered in the uppermost lefthand cell; every time it was produced correctly in utterance-medial position, a mark was entered in the next cell to the right, and so on. When a phone was added (meaning it corresponded to nothing in the model) or omitted, the procedure for marking was similar. Beginning with the next column, however, the method of marking was different. The change was desirable since there are several different possible errors of place of articulation (and the same holds good, to a lesser extent, for the other categories) and it was necessary to record exactly what the error was, i.e., what phone appeared in place of [p]. For example, [t] or [k] or [ʔ] would all be scored as errors of place when [p] was the phone attempted. If [b] turned up instead of [p], the error would be one of voicing; [d] and [g] would constitute errors of both place and voicing, when [p] was the phone attempted.

In order not to miss anything, and hoping for additional comparability with previous studies, certain combinations which are not unit phones but which have been alleged to pattern as if they were, were scored separately as units; these were: ɛy, ay, ɔw, ɔy, aw, tš (č), dž (ǰ), The complete list of phones is as follows: p t k b d g f v θ ð s z š ž tš dž r ʔ l m n ŋ h w w̥ i i̢ I I̢ ɛ ɛ̢ æ æ̢ a a̢ ɫ ə ə̢ ʌ ʌ̢ u u̢ U U̢ ɔ ɔ̢ ɛy ay ɔw ɔy aw. (Y̢ = retroflex vowel.) Though "place of vowels" is simply part of "place of articulation" in general, it seemed reasonable to keep a separate tabulation, since the original article by Miller and Nicely (1955), from which assumptions were drawn about discriminability, dealt with consonants only. Since, in the main, errors involved in the substitution of one vowel for another that were handled by this system would turn out to be errors of place, it could be argued that the theory's chances of predicting successfully would be unduly enhanced thereby; consequently, predictions were made separately concerning the effects of place (including vowels) and place without vowels, i.e., excluding the data from the "place of vowels" column.

Except for the first two lines of table 11 — added and omitted — the contents of the columns can be reversed in any line and still serve as examples of the type of error. For example, if the target is [m] and the child's phone is [b], the error is still one of nasality.

A phone revealing errors of more than one kind can be accommodated by entering it under more than one column. For example, if the target is [n] and the child's phone is [z], the errors are those of nasality and friction. In such a case, on the line for 'n', one would enter [z] under the heading "friction" and also under "nasality".

In order to determine the number of errors of "place of articula-

TABLE 11

Examples of the Types of Errors

Type of error	Target phone	Child's production
Added	#	p
Omitted	p	#
Place	p	t
Place-Laterality	l	w
Place of vowels	u	U
Place-Voicing	p	d
Voicing	t	d
Friction	t	s
Nasality	b	m
Friction-Place	t	θ
Friction-Voicing	t	z

tion", one simply adds the contents of the columns having "place" as one of the components, i.e., the columns headed "place", "place-laterality", "place of vowels", "place and voicing", "friction and place". For "place without vowels", one takes the same sum minus the figure from the column headed "place of vowels". To determine the number of errors of "voicing", "friction" and "nasality", similar procedures are appropriate; i.e., if the target is [p] and the child's phone is [d], then [d] is entered in the column headed "place and voicing": it therefore contributes equally to the sum of errors of place and the sum of errors of voicing.

Sums of the numbers on each horizontal line give roughly the total number of attempts of a specific phone; sums of the numbers in each column give totals of all correct phones or of all examples of a given type of error for a given child.

3

THE PREDICTION OF ERROR

"speech copious without order, and energetic without rule;...
Samuel Johnson

After the data were subjected to the preliminary analysis outlined in Chapter 2, the totals for the various columns and rows on the error record sheet were punched onto IBM cards, together with data about the child's age, sex, parents' education, sibling position, etc. The punching and verifying of these cards was the work of Ted Cooper and Katharine Holbrook of the staff of the Center for Advanced Study in the Behavioral Sciences, whose patient and accurate contributions are gratefully acknowledged. From these cards, the computing center at Stanford University, using an IBM 7090 machine, carried out the calculations that will be given in this and the following chapters, except for those in Chapter 7 and those for reciprocity of error, which were done by hand. The design of the keypunching system, the computer programming and the selection and application of the proper statistical apparatus were all the work of David Peizer, statistical consultant on the staff of the Center, whose creative contribution to the project cannot be adequately summed up in a few words.

Those parts of the earlier theory that dealt with the prediction of error were as follows:

Postulate 21. While we cannot predict individual errors, partly because of the variations in noise level, we are able to predict, in general, the direction of error, as follows.

Theorem. At any stage before the phones of the language are learned to asymptote, there are more errors based on place of articulation than on friction or duration.

Theorem. At any stage before the phones of the language are learned to asymptote, there are more errors based on place, friction or duration than on voicing or nasality.

Theorem. At any stage before the phones of the language are learned to asymptote, there are about as many errors based on voicing as on nasality. (Olmsted 1966, 533)

The only changes made in these propositions before testing was to combine Miller and Nicely's two categories "friction" and "duration" since, in their original study, the only phones for which duration was a factor were also spirants. Accordingly, duration disappears from our discussion, replaced by "friction" as a cover term for the "friction-duration" category. However, since we made no systematic attempt to subject the entire corpus to accurate measurement of duration with respect to spirants or any other classes of phones, the term "friction" is operationally defined as the spirant component; it includes duration only insofar as duration is an important factor in the discriminability of spirants, a point on which the present study offers no information beyond that contributed by Miller and Nicely.

Since the Miller and Nicely experiment takes only a sample of consonants as its objects of study, there was a real danger that, in expanding the study to cover all phones, we might render some of the predictions meaningless. This was particularly true of the category "place of articulation", since it applies to vowels as well as consonants. There was an especial problem in this case, since the error that results from substituting one vowel for another is almost bound to be an error of place of articulation, even though some other type of error may also be involved, such as the addition or subtraction of lip-rounding. Accordingly, two different scores for errors of place of articulation were calculated, one for place errors in general and one for place errors less the contribution of the vowels (the first will hereafter be called "place errors", the second "place (consonants)" errors"), The category "voice" might also be assumed to be affected similarly by the addition of vowels to the sample, since, by adding them, one increases the corpus by a large group of voiced phones without any corresponding addition of voiceless ones, voiceless vowels (h) being considerably rarer in English than the set of voiced vowels taken together. However, no separate calculation was made to correct for this, on the assumption that, since an error of voice can either consist of adding voice to what should be a voiceless phone or of subtracting voice from what should be a voiced phone, errors of voice are equally possible in connection with voiced and voiceless phones.

Thus, our extra calculation in the case of place of articulation is designed to correct for a situation that might tend to favor, in an uncontrolled way, the chances of the theory to predict successfully, whereas our failure to do so in the case of voice leaves, possibly, an extra strike AGAINST the theory's chances of predicting successfully.

Taking the entire sample of 100 children, the mean errors per child per type were as follows:

place 46.3
Place (consonants) 21.2
Friction 12.7
Voicing 7.5
Nasality 1.6

By Chi-square test, all these differences are significant at the 1% level. It is clear that, as far as this sample of children goes, the theory predicts the general trend of errors and does so correctly. Whether it predicts successfully for individual children is another matter, to which we now turn.

In Table 12, below, the fate of the predictions regarding individual children is displayed:

Thus, the first 800 predictions regarding individual children turned out correctly 752 times; the theory thus predicted correctly 94%of the time. If, for reasons given earlier concerning the category of place, one disregards the first three lines, the score is 452 correct predictions out of 500 attempts, or a rate of 90.4% correct. Clearly, as far as this sample of children is concerned, the theory displays considerable predictive power, at least with respect to errors (it has a poorer record when it comes to predicting about successes, cf. Chapter 6).

TABLE 12

Prediction	Correct outcomes	Incorrect outcomes
	(numbers of children)	
Place greater than friction	100	0
Place greater than voice	100	0
Place greater than nasality	100	0
Friction greater than voice	78	22
Friction greater than nasality	99	1
Place (consonants) greater than friction	84	16
Place (consonants) greater than voice	93	7
Place (consonants) greater than nasality	98	2
	752	48

It is necessary to interrupt this fiesta of self-congratulation with the observation that the theory's prediction concerning the proportion of errors of voicing and nasality is not confirmed. One would like to weasel out by noting that the theorem is, in its present form, difficult to interpret, since the expression 'about as many' is crucially imprecise. But however vague, it is decisively disconfirmed by the five-to-one ratio of voicing errors over those of nasality. Nor is relief to be found in the high proportion of vowels in this sample as opposed to Miller and Nicely's consonantal corpus. For the errors of voicing, like those of nasality, are overwhelmingly consonantal. One possible explanation is that nasality, in English, is always linked to voice — there being no voiceless nasals — whereas the reverse is not true. Thus a phone that is nasalized has always the added discriminability lent by voice. On the other hand, voiced phones are usually non-nasalized. The weakness of the argument is that it ought to apply equally to Miller and Nicely's sample, except that the proportion of voice to nasalized phones is different in the two samples. In the Miller and Nicely (1955) sample, there are two nasals and seven voiced, non-nazalized consonants, whereas in the sample considered here, there are three nasals and

33 voiced, non-nasalized phones (only ten of them are consonants, however). Moreover, the partial linkage of nasality with voicing in English is of unclear relevance, since the shape of errors is not limited by what is permissible in English. Though errors are often substitutions of one English phone for another, they need not be.

One way of checking whether predictions made in terms of the discriminability of phonological components are influenced by other factors is to examine the reciprocity of error. For example, it is worth inquiring whether errors of voice are more often produced by subtracting voice from voiced phones or by adding voice to voiceless ones. The basic data are set forth in Table 13 (page 71). The phones listed down the left-hand side represent the model (the phones aimed at) while on each horizontal line are the numbers of the different errors in connection with each of them.

The totals at the bottom of Table 13 represent the numbers of times each phone appeared as an erroneous substitute for some other (attempted) phone. The totals at the side represent the number of attempts at each phone which resulted in errors. The ratios between such numbers are functions not only of the relative difficulty of the phones but also of their relative frequency in the utterances tried. In Table 14 below, the consonants of Table 13 are shown in rank order of frequency of attempts (both successes and errors) so that frequency may be compared with number of errors. The numbers on the left of Table 14 may be read as indicating the rank order of the phones with respect to frequency of attempts. Comparison of that number with the rank-order for errors will allow a rough estimate of the extent to which a phone is more (or less) error-prone than its frequency would suggest. Thus, [t n k d b m g f ʔ] are all LESS subject to errors than their frequencies would suggest, while [ð l s z ŋ š v θ ž] are MORE error-prone than expected. Only [p r] have about the same rank order in both columns: [p] is tied for tenth (eleventh and twelfth) place with two other phones in the "number of errors" column, which is compatible with its twelfth position in the frequency column. The great extent to which [ð] contributes to the errors among consonants is

TABLE 13

		p	t	k	b	d	g	f	v	θ	ð	s	z	š	ž	l	m	n	ŋ	ʔ	tš	dž	x	γ	β	w	y	r	V	Ṿ	~	ñ
89	p	—	1	7	56	3	1	11						1		1	2	1		3					1	1						
297	t	6	—	36	8	135	2	13	2	13	6	6		3			1	9		37	13					5	2					
140	k	9	35	—	4	17	45					4		3		1		3	3	8	7		1									
59	b	10			—	8	3	1	8								7	2		2		1				16	1					
112	d	1	33	4	5	—	35	1	1		3	1	2		1	4		4		9		2				1	5					
62	g		3	30	2	12	—	3	4	1					1			2	1	1				1		1						
26	f	2		1	3			—	7	2		5	2								1					3						
54	v			1	37	2		10	—			1					2								1							
89	θ	7	9		1	7		36	2	—	1	21		3				2														
840	ð		9	1	1	753	4	1	5	2	—	4	43			3		2			1	2				1	8					
197	s	2	19	7		7		28		59	2	—	18	50						2	1	1				1						
151	z		3			13		3	1	25	15	67	—	17	2		1	1		1						2						
130	š		2	4		3				12		85	2	—	7					2	10	1	2									
3	ž													3	—																	
427	l		1		3	12	1		2							—	1	5					1			238	22	1	123	17		
40	m	5			13				1								—	10	4				1			4					2	
89	n		4		2	11										2	17	—	10	4											28	11
193	ŋ				1		6									1	3	175	—	3						1		1			2	
	ʔ																			—												
5	r		1			2														1						1		—				
73	tš		38	3	1	7	1			6		5		9	1						—					2						
57	dž					24	2			8	4	6	2		7						3	—				1						
		42	158	94	137	1016	100	107	33	128	31	205	69	89	19	12	34	216	18	73	36	7	5	1	2	278	38	2	123	17	32	11
		p	t	k	b	d	g	f	v	θ	ð	s	z	š	ž	l	m	n	ŋ	ʔ	tš	dž	x	γ	β	w	y	r	V	Ṿ	~	ñ

(V = non-retroflex vowel, Ṿ = retroflex vowel)

TABLE 14

Rank order, Frequency	Phone	Mean attempts per child[a]	Total errors[b]	Rank order number of errors
1	t	19	297	3
2	n	13	89	10
3	ð	12	840	1
4	l	12	427	2
5	s	11	197	4
6	k	11	140	7
7	d	10	112	9
8	b	8	59	14
9	z	7	151	6
10	m	7	40	16
11	g	6	62	13
12	p	5	89	10
13	ŋ	4	193	5
14	f	3	26	17
15	š	3	130	8
16	θ	2	89	10
17	v	2	54	15
18	r	1	5	18
19	ʔ	.3	0	20
20	ž	.06	3	19
			3008	

[a] These data taken from Table 31, rounded off to nearest whole number, except for the last two cases.
[b] These data do not include errors in attempted consonant clusters, which are discussed separately in Chapter 8.

apparent when we consider that its 840 are not far under one third of the total. Moreover, they are 71 percent of its total attempts (1176; to get a rough idea of total attempts, multiply the number of mean attempts listed in the table by 98; the total is not exact because of rounding-off and because it omits those in consonant clusters). Similarly, attempts at [l] resulted in errors about 35 percent of the time. The lateral phone is also noteworthy in that erroneous substitutes for it were overwhelmingly vowels or semivowels; there were 123 of the former, and 277 of the latter, a total of 400 out of its total of 427 errors. In this [l] is sharply divergent from the other consonants.

The status of [r] is also interesting. The alveolar flap was rarely attempted but was pronounced correctly more than 90 percent of the time, a quite unexpected finding in view of the results of Templin (1957, 1966) who found 'r' to be a major pronounciation problem for youthful learners. The difficulties evidently inhere in the retroflex vowels — handled by Templin as part of 'r' —, which we here treat separately from the alveolar flap and from each other. The results for [r] not only justify such an approach, but also, since they are very unlike those for [l], cast doubt upon the wisdom of the traditional practice of grouping [l] and [r] together as 'liquids' (exemplified in Jakobson 1941). From the standpoint of the learning problems revealed by the members of this sample, such a grouping has little to recommend it. [ž] was rarely attempted and is, of course, very rare in adult English. It is therefore of interest to note that it turned up 19 times as a substitute for other phones, as opposed to the two times it was pronounced correctly when attempted. The lack of errors in connection with [ʔ] is illusory, since it was difficult to find unambiguous instances of errors concerning it, there being few morphs in English where [ʔ] is a mandatory constituent. In forms where it is frequently found (e.g. button, mountain) other pronunciations are also possible, and, among our models, at least as frequent, as far as we could tell. Thus, correct instances of [ʔ] were recorded, but what might have been errors for [ʔ] tended to get recorded as correct instances of something else, because of conditions of variation or alternation. Discussion of the other results will be put off until after the consideration (in Chapter 6) of the factors making for success in pronunciation.

In Table 15 below, we arrange the phones in order of the number of times they figures as substitutes for other phones. Table 15, it should be noted, includes some phones over and above those in Table 14. The extra symbols are to be read as follows:

[x] a voiceless velar spirant
[γ] a voiced velar spirant
[β] a voiced bilabial spirant

TABLE 15

Rank order	Phone	Number	Rank order	Phone	Number	Rank order	Phone	Number
1	d	1016	11	š	89	21	ž	19
2	w	278	12	ʔ	73	22	ŋ	18
3	n	216	13	z	69	23	l	12
4	s	205	14	p	42	24	ñ	11
5	t	158	15	y	38	25	dž	7
6	b	137	16	tš	36	26	x	4
7	θ	128	17	m	34	27	r	2
8	f	107	18	v	33	28	β	2
9	g	100	19	~	32	29	γ	1
10	k	94	20	ð	31			

[~] nasalization (of adjacent vowel) — counted as an error of place of articulation, since everything about the originally nasal consonant is retained except the primary oral occlusion.
[ñ] a palatal nasal
[V] any non-retroflex vowel
[V̩] any retroflex vowel

The very high number of times [d] serves as an erroneous substitute is mostly due to its relations with [ð] and [t], for both of which it is by far the most frequent substitute. If one substracts the 888 instances attributable to those two cases, then [d] is seen as a not especially frequent substitute. Similarly, [w] owes the bulk of its number to the cases in which it substitutes for [1]: 238 out of 278. Likewise, 175 of the 216 instances of [n] are substitutions for [ŋ].

To get a rough measure of reciprocity in error, we present in Table 16, below, data concerning most-frequent relationships in both directions, i.e., for each phone, its most frequent substitute when a model, and its most frequent model when a substitute, together with the number of instances of each case.

These data are interesting both for what they reveal about reciprocity of error and in that they go some way toward explaining why earlier observers have tended to regard voicing errors as the most frequent type. As we have seen, they are in fact relatively rare; however, the fact that errors of voice are represented in several of these cases in the phone most frequently substituted for a model could easily be metamorphosed into the generalization that errors of voice were 'most frequent' or 'very frequent'.

The phone most frequently substituted for a voiceless stop is the corresponding voiced one; of the voiced stops only [g] reciprocates by having [k] as its most frequent error. Of the eight spirants, [f z ž] find their most frequent substitutes in the corresponding member of the voiced/voiceless pair. Two, [v] and [ð], show the roughly corresponding voiced stop as most frequent error, while [θ s š] all find their most frequent substitutes among the other voiceless spirants. Two of the nasals — [n] and [ŋ] — have other nasals as their most frequent substitutes, whereas [m] has [b]. Thus, of the

TABLE 16

Model	Most frequent error		Substitute	Most frequent model	
p	b	56	p	b	10
t	d	135	t	k	35
k	g	35	k	t	36
b	w	16	b	v	37
d	g	35	d	ð	753
g	k	30	g	k	45
f	v	7	f	θ	36
v	b	37	v	b	8
θ	f	36	θ	s	59
ð	d	753	ð	z	15
s	θ	59	s	š	85
z	s	67	z	ð	43
š	s	85	š	s	50
ž	š	3	ž	š	6
l	w	238	l	d	4
m	b	13	m	n	17
n	~	28	n	ŋ	175
ŋ	n	175	ŋ	n	10
r	d	2			
ʔ	—	—	ʔ	t	37

twenty consonants considered here, seven have a most-frequent error which differs in voice; six find a most-frequent substitute which differs in place; for one the difference is one of friction while another differs in both friction and place; for the other three — [b r l] — the difference is not classifiable in terms of the predictions delivered by the theory.

So far we have limited the discussion to columns 1 and 2. If we now turn to columns 3 and 4, we find a somewhat different situation. When consonants appear as errors, the most frequent model differs by voicing only three times out of twenty: when [p g ž] are errors, their most frequent models are, respectively, [b k š]. In twelve cases — [t k f θ ð s z s m n ŋ ʔ] — the most frequent model differs by both place and friction. Friction alone accounts for the cases of [b] and [v]. The case of [l] is not classifiable by our criteria, and [r] had no most frequent model, since it substituted once for each of two phones.

In general, it can be said that, labials tend to be the most frequent substitutes for labials, even if it means that the error must therefore be one of the relatively rare types: nasality, voicing, or friction. On the other hand, errors of place characterize the more frequent substitutes for consonants in other positions. The findings reported in Chapter 6 make it clear that labial position confers a great advantage on a phone as far as learning is concerned; evidently the same factor is at work here. One might go so far as to suggest that errors of voicing, nasality and friction are as frequent as they are because of the power of labial position, which is visible as well as audible.

A more general approach to the reciprocity of error is possible. It will be remembered that nasality, voice and friction are two-way errors, i.e., the component in question can either be added or subtracted from the phone attempted, depending on whether the phone possessed the component in the first place. For example, nasality can be subtracted from the three nasals or added to any other phone. In either case, the error was scored as one of nasality. Similarly, any voiced phone can have voice subtracted and any voiceless one can have voice added. The only phone that does not figure in calculations of errors of voice is [ʔ] which is neither voiced nor voiceless, by definition. Friction can be subtracted from any of the spirants or affricates or it can be added to any other phone.

A breakdown of these three types of errors into their constituent parts reveals, for the consonants of Table 13, the following results:

TABLE 17

	Added	Subtracted	Total
Voice	390	275	665
Nasality	49	53	102
Friction	117	993	1110

To get some idea of whether these results are skewed by the frequencies of the phones involved, we assume that adding a component is equally likely with subtracting that component, *ceterus paribus*. If that is so, then the number of errors resulting from adding a component ought to be about equal to the number resulting from subtracting it, when we have corrected for the number of phones for which a given sub-type of error is possible and their frequencies.

Using the rounded-off frequencies (mean attempts per child) from Table 14 and adding to them the ones for [tš] and [dž], which are about 2 and 1, respectively, we get the following average frequencies of attempts per child for the groups of phones pertinent to the sub-typing of error:

TABLE 18

No. of phone types		Av. freq. of attempts/child
8	Voiceless phones	7
12	Voiced phones	6.9
3	Nasals	8
19	Non-nasals	6
10	Spirants and Affricates	4.3
12	Non-spirants and Non-affricates	8

The above groups are limited to the consonants listed vertically in Table 13.

Since the frequencies of voiceless and voiced phones are, on the average, essentially the same, they can be disregarded in the discussion of errors of voice. Since the additions of voice are to 8 phones and the subtraction from 12 phones, the proportions would be as follows, if our assumption of equiprobability were correct: $\frac{390}{8} = \frac{275}{12}$. In fact, of course $\frac{390}{8} = \frac{x}{12}$ when solved for 'x', gives an answer of 582. In short, the children in this sample either added voice at a higher rate than expected, or subtracted it at a lower rate than expected. The latter hypothesis is consistent with the postulates of our theory, since subtraction at a lower rate than chance would suggest can be interpreted as resistance of voicing, when present, to error. In fact, subtraction of voicing in this sample was less than half of the expected, showing a strong tendency for voicing to be retained as a component; that tendency is quite in accord with our assumption that the powerful contribution of voice to discriminability helps to 'protect' phones from error. No such assumptions support the alternative hypothesis, viz. that the children added voice more often than expected.

If we use a similar method in connection with the nasals (except that the denominators are products of the number of phones and the average frequency in each group) we find that nasalization has either been subtracted about five times as often as expected or added about one fifth as often as expected. The latter hypothesis seems the more probable, since nasality is quite resistant to subtraction: of 322 errors in connection with the nasals, nasality was retained in 262 cases, or more than 81%.

Turning to the problem of friction we find, by the same method, that friction has either (1) been subtracted about 17 times as often as expected, or (2) been added about 1/17th as often as expected. The former hypothesis seems the more probable and it is fully in accord with the traditional view that fricatives are harder to pronounce than stops, so that a frequently reported error in many studies of infant phonology is the replacement of spirants by homorganic stops (i.e., subtraction of friction). The overwhelming preponderance of instances of subtraction of friction in our sample are of precisely this type, if we include the 753 instances of [d] as an error for [ð]. Though there is an error of place (alveolar vs. interdental) involved too, they are homorganic with respect to the moveable articulator (the apex).

In contrast to the two-way errors — nasality, voice and friction — PLACE is multidimensional. With five positions of articulation, an error can take any one of four forms. The reciprocity of errors of place is displayed in Table 19, below. In Table 19, [ñ], though a palatal nasal, is counted along with the postalveolar phones, to avoid creating a separate position with no other representatives. The only place where the table is affected is at the intersection of the alveolar (model) line and postalveolar (error) column: since

TABLE 19a

Model	Errors					
	Labial	Interdental	Alveolar	Postalveolar	Velar	Total
Labial	—	2	35	3	17	57
Interdental	53	—	850	6	5	914
Alveolar	92	123	—	101	94	410
Postalveolar	1	30	174	—	12	217
Velar	25	1	251	11	—	288
Totals	171	156	1310	121	128	1886

there are 11 instances of [ñ] for [n], readers who do not approve of merging palatal and postalveolar positions can correct completely by subtracting 11 from the 101 there.

Before considering the significance of the data reported in Table 19a, we need to make allowances for relative frequencies. The average frequencies (mean attempts per child) of the groups of phones involved are approximately as follows:

TABLE 19 b

Labials (p b f v m)	:	5
Interdentals (θ ð)	:	7
Alveolars (t d n s z r)	:	10
Post-alveolars (š ž t͜š d͜ž)	:	1.5
Velars (k g ŋ)	:	7

We may calculate the Index of Vulnerability (to error) by dividing the number of errors by the average frequency of phones in the pertinent group. For example, for labials I.V. $= \frac{57}{5} = 11.4$.

The indices of Vulnerability are, respectively:

TABLE 20
Indices of Vulnerability

Labials	11.4
Interdentals	130.5
Alveolars	41.0
Postalveolars	144.6
Velars	41.1

The higher the I.V., the more prone a phone (or group of phones) to error. Thus the labial position is three or four times more resistant to error than the alveolar and velar positions; these, in turn, are about three times as resistant to error as the interdental and postalveolar positions. These proportions may be compared with those of the positional scores worked out (in Chapter 6) to express the contributions of the various places of articulation to acquisition.

The relations among the various positions are also of interest. There appears to be a centralizing tendency in place errors among consonants: erroneous attempts at labial, interdental, postalveolar and velar phones are all more likely — by a large margin — to turn up in alveolar position than in any of the other positions. On the other hand, place-erroneous attempts at alveolar phones are relatively evenly represented in all the other four positions.

We display in Table 21 below, the I.V.'s of the individual consonants. It should be noted that the I.V. of each phone is almost equal to the percentage of errors in total attempts; this is because the sample of children for whom mean attempts were calculated

TABLE 21

	Mean attempts	Errors	Index of Vulnerability
p	5	89	17.8
t	19	297	15.6
k	11	140	12.7
b	8	59	7.4
d	10	112	11.2
g	6	62	10.3
f	3	26	8.6
v	2	54	27.0
θ	2	89	44.5
ð	12	840	70.0
s	11	197	17.9
z	7	151	21.5
š	3	130	43.3
ž	.06	3	50.0
l	12	427	35.6
m	7	40	5.7
n	13	89	6.8
ŋ	4	193	48.2
r	1	5	5.0
t͜š	2	73	36.5
d͜ž	1	57	57.0

was 98, whereas the sample for whom errors were counted was 100. The difference between the two is represented by the two children for whom errors were counted, but successes were not. They therefore could not be included in a determination of mean attempts, though their errors were as interesting as the next child's.

The extent of reciprocity among errors on attempts at vowels can be seen by consulting Table 22 (pages 84 + 85).

Comparison of the totals at the bottom of Table 22 allows an estimate of the extent to which vowel and semivowel phones appear as erroneous substitutes for other vowel phones. Most of the contribution of [w] is made as a substitute for the retroflex vowels. Aside from [w], there seems to be a tendency to concentrate vocalic errors in the low central region, since the two most frequent substitutes are [ʌ] and [a]. There is thus a parallel between consonantal errors of place, which are preponderantly alveolar, and vocalic errors of place which tend toward the low central position. Various explanations come to mind; discussion of them will be postponed until later chapters.

The extent of reciprocity among errors on attempts at semivowels is displayed in Table 23. Since semivowels appear as substitutes for consonants, vowels and semivowels, the complete picture of semivowel reciprocity has to be obtained by comparing Tables 13, 22, and 23.

Once again, the totals of errors on attempts at a given phone must be corrected for frequency of attempts. The I.V.s of the vowel and semivowel phones are displayed below in Table 24.

The substitutive patterns of the semivowels [h w y w̥] lend support to the traditional notion that semivowels function after the manner now of vowels, now of consonants. They substitute, in these corpora, mostly for other semivowels (the retroflex ones) and consonants; they seem to turn up as errors for full vowels only when the latter stand next to another full vowel, so that the sequence of V V can be turned into (for example) wV or Vw. They also differ sharply in I.V. from the other classes of phones, cf. Table 25, below.

TABLE 22

Reciprocal Errors — Vowels (Models listed vertically at left, errors horizontally at top and bottom)

	i	I	ɛ	æ	ə	ʌ	a	u	U	ɔ	w	y	į	Į	ę	æ̨	ə̨	ʌ̨	ą	ų	Ų	ɔ̨	ɛy	ay	ɔw	aw	ɔy	C	Total
i	—	17	6			8		5		3		3					1						7	2	1				54
I	67	—	33	14	37	66	2	2	4	4		1	7		3		3		1				4	1	5			sl	256
ɛ	7	39	—	18	2	21	19		3	2		1			1								6						120
æ	2	16	22	—	6	41	28		1	2	3						1						2	5	4	1			138
ə	5	7	4		—	16	1	1	2	3	2													1	2				44
ʌ	9	31	19	18	3	—	35	21	4	48							2						1	3	14	1			211
a	2	1	2	1		11	—		4	13		11			1		1								2	2			50
u	2	2	4		3	35	1	—	4	3	2	2					5								3				93
U	1	5			4	13	5	15	—	6															2				53
ɔ		1	1	5	1	33	63	6	7	—					1									2	16	5	3	w͜s	150
ɔw				1	2	25	1	10	3	4	1						1							1	—	8		1, β	79
aw	1		3	2		3	17			2	5												1	1	5			av	66
ɛy	26	9	10	6	2	7	7										12							8	1		3		94
ay	13		7	6	2	11	23								1								6				8		77
ɔy							3																	3				dz, t	10
į	2							3			32		—																38
Į		8			7	6					16			—	1		5						5		1				48
ę	5	5	36	4	4	6	9	1		4	44	1		6	—		8		3				12	2				dž, n	194
æ̨		1				1	1				33	1			1	—													39
ə̨	7	11	16	1	27	87	6	45	33	23	2	1		5	18	1	—				2				4			ʔ	304
ʌ̨						1	9			3	15				1			—											29

	i	I	ε	æ	ə	ʌ	a	u	U	ɔ	w	y	į	Į	ę	æ̨	ə̨	ʌ̨	ą	ų	Ų	ɔ̨	εy	ay	ɔw	aw	ɔy		
ą					4	2	8			8	47						10		—									lz,d,ʔ	85
ų										4	4									—								n	9
Ų		1				3	1	2										1	1		—			1				ʔ	11
ɔ̨		2		1	2	8	10	1	2	9	31						3		4			—			3				79
	149	56	163	77	106	403	249	113	67	141	237	21	7	11	28	1	52	1	8	0	2	0	44	30	63	17	14	17	

Additional vowel errors, with model at left of hyphen. Errors occuring more than once are followed by a number indicating how many times.

i — hε
I — ü
ε — εʌ
æ — æ̨, ʌε 3
ʌ — æ, yæ
u — uə üz εw wi 4, yu 18

U — Ü 2
ɔ — εɔ, ʌ̃, əy 3
ɔw — Uə, aɔ, ɔεw, wə, æw 13
aw — εyɔw εw, 2, æw 22
εy — æw 3
ɔy — ʌy

į — əw
ę — εyə̨ 4 yəz
æ̨ — æw
ə̨ — iw εʌ wə 7 əʌ 3, ɨ, yε
ą — α ɨ
ɔ̨ — wɔ 1 wə

TABLE 23

Reciprocal Errors — Semivowels

	p	t	k	b	d	g	f	v	θ	ð	s	z	š	ž	l	m	n	ŋ	ʔ	tš	dž	x	γ	β	w
h	0	2	1	1	0	0	1	0	0	0	1	0	1	1	1	0	0	0	2	0	0	0	1	0	4
w	1	2	0	0	2	0	1	1	0	0	0	0	0	0	3	2	1	0	1	0	0	0	0	0	–
y	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2
w̥	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7

	i	I	ɛ	æ	a	ɔ	U	u	ə	ʌ	į	Į	ɛ̨	æ̨	ą	ɔ̨	Ų	ų	ə̨	ʌ̨	y	w	h	r	~
h	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	–	0	0
w	0	0	0	0	0	1	0	3	0	0	0	1	1	2	0	1	0	0	0	1	3	0	0	0	0
y	6	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	–	0	1	0	0
w̥	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	–	2	0	0

Total Errors: h = 17
w = 27
y = 16
w̥ = 11

TABLE 24

Phone	Mean Attempts	Total Errors	I.V.	Phone	Mean Attempts	Total Errors	I.V.
i	11	54	4.9	i̢	1	38	38.0
I	11	256	23.2	I̢	1	48	48.0
ε	4	120	30.0	ε̢	5	194	38.8
æ	8	138	17.2	æ̢	1	39	39.0
ə	1	44	44.0	ə̢	6	304	50.6
ʌ	13	211	16.3	ʌ̢	.4	29	72.5
a	4	50	12.5	a̢	3	86	28.6
u	4	93	23.2	u̢	.3	9	30
U	2	53	26.5	U̢	.05	10	200
ɔ	6	150	25.0	ɔ̢	2	79	39.5
ɔ͜w	5	79	15.8	w	4	24	6
a͜w	2	66	33.0	y	1	16	16
ε͜y	3	94	31.3	w̥	1	11	11
a͜y	6	79	12.8	h	5	17	3.4
ɔ͜y	.2	10	50.0				

TABLE 25

Class of phones	Mean Index of Vulnerability
Full vowels (non-retroflex)	22.3
Diphthongs	28.6
Semivowels (h w y w̥)	9.1
Consonants	26.3
Retroflex vowels	58.5

The high I.V. characteristic of the retroflex vowels accords well with the difficulties reported by other investigators (e.g. Templin 1957) in connection with 'r' which presumably includes, in large part, the phenomena classed as retroflex vowels in the present study.

4

PREVIOUS STUDIES OF PHONOLOGICAL ACQUISITION

"...the actions which make up language."
Leonard Bloomfield

"To be part of science, non-introspective observations must be formulated in terms that will place them in the public domain."
Jerry Hirsch

There is a considerable literature devoted to this topic. One quickly discovers that not one, but several, topics are involved since different investigators mean different things by 'acquisition' and by 'elements'. 'Elements' has been taken to mean, on the one hand, 'sounds' (phones) and, on the other, 'phonemic oppositions' or 'phonemes'. 'Acquisition' has been measured in a number of ways, none of them entirely satisfactory. We take up each of these topics in turn.

4.1. PHONOLOGICAL ELEMENTS

Speech consists of audible productions of the vocal organs. Articulatory phonetics suggests that such audible productions can be analyzed in terms of the movements of the movable articulators used in their production. The movable articulators are the lips, the lower teeth (whose position is changed by opening or closing the jaw), the apex, blade, front, and dorsum of the tongue, the uvula, the velum, the pharynx and the larynx. Each of these is now in one position or state, now in another. For example, the phonetically relevant states of the larynx (after Arnold 1957) are:

1. Extreme abduction of the vocal cords (deep inspiration)
2. Moderate abduction of the vocal cords (expiration)
3. Intermediary (cadaveric) position (shallow respiration)
4. Incomplete adduction (sighing, voiceless vowels: /h/)
5. Anterior adduction (whispering)
6. Complete adduction (voicing)
7. Forceful adduction (glottal stop)

In practice, only four positions would have to be distinguished: that for voiceless consonants (2 or 3), 4, 6 and 7. Similar classifications can be made of the states and positions of the other movable articulators. A record showing the state or position of each movable articulator at a given time is a sufficient description of the method of production of the sound occurring at that time. The boundary between sounds is marked by a change in the record for one or more of the articulators. A sound is an event unique in time and space; many of them are identical, i.e., have identical records of the states and positions of the articulators involved. A class of such identical sounds is a PHONE.

One of the traditional tasks of phonetics is the description of phones. In phonemics, on the other hand, the principal concern is not with the description but rather with the FUNCTION of phones. Some of the differences between phones are also differences between utterances (e.g. *bin* vs. *din*); such differences, when the meanings of the utterances are different, serve to carry the contrast in meaning. It follows that the difference between the two phones has communicatory value. Some other differences between phones are not also differences between utterances having different meanings; e.g., in utterance-final position, some dialects of English have, on occasion, an unreleased [t˺]. It is the case, however, that utterances ending in unreleased [t˺], are matched in the same dialects by ones, otherwise identical, terminating in an ordinary released [t]. There is no difference in meaning between the utterances, otherwise identical, ending in the two types of alveolar stop, e.g. [hæt˺], with unreleased stop, and [hæt] with released stop; both mean 'hat'. So the difference between these two phones does not have communicatory value. PHONEMICS, in registering the functions of phones in a given dialect, seeks by a process of matching utterances and comparing meanings, to identify those differences (between phones) that have communicatory value. Two phones separated by such a difference are said to be in contrastive distribution (or, for short, IN CONTRAST; other phones are in non-contrastive distribution.

Such are the bases upon which the ensuing discussion will rest; it should be noted that, since the first use of the term phoneme by Jan Baudouin de Courtenay, there has seldom, if ever, been general agreement as to what the terms 'phoneme' and 'phonemics' mean. There is certainly no generally-accepted algorithm which, supplied with data from some language, will automatically crank out the phonemes of that language. For examples of different approaches, the reader is directed to Pike 1947, Bernard Bloch 1948, Jakobson and Halle 1956.

Before turning to the consideration of specific studies, it should be noted that a phone, by the above definition, can be identified by its register of articulatory activity; this holds good quite aside from the linguistic system of which it is a part. A phoneme, on the other hand, can only be identified as part of a system (of classes of phones having communicatory value); of course, the identification of distinctive features or phonemic oppositions goes hand in hand with the identification of phonemes and also presupposes the analysis of the whole system. Thus, one who purports to study the acquisition of phonemes obligates himself to make phonemic analyses of each relevant stage of the development of each child in his study. It appears that some of the investigators who have set out to trace the development of 'phonemes' have not realized this and have in fact been tracing the development of phones, rather than phonemes.

A pioneering work that deserves to have been better known than it seems to have been is Wellman, Case, Mengert and Bradbury (1931). The sample included 204 children between the ages of 2 and 6 years. Considering what linguists were doing with the phonetics of American English at that time, the phonetic accuracy is surprisingly good. There are a few deficiencies: the final vocoids of 'they' and 'row' are not recognized as diphthongs but are written as [e] and [o] respectively; some retroflex vowels were written as consonants, e.g. the one at the beginning of 'row', written [r], while others appeared differently, e.g., the one at the end of 'chair', written with [ɹ]; it is unclear whether the authors consider the latter a vowel or a consonant; if the latter, it is not clear why they think it any more different from the initial retroflex vowel than a final [-w] is from an initial [w-]. Despite these minor blemishes, the study is quite adequate, from the standpoint of articulatory phonetics. The authors have a clear aim in view: the study of the child's acquisition of phones (their 'sounds'). Their use of the 'word' as a unit of analysis was perfectly consistent with the practice of the day.

The great strength of the study was the rather revolutionary attempt to register, for a large sample of children, all the phones in all positions as the result of systematic elicitation. A preselected set of words containing the different phones in initial, medial and final positions was drawn up and these were systematically elicited using pictures, toys, etc. Thus, each child had a chance to produce, under comparable circumstances, each phone in each position; this feature gives the Wellman, Case, Mengert and Bradbury study a comprehensiveness that, in a sense exceeds that of later studies, including the present one. However, the value of their results is largely vitiated by one disastrous oversight, derived from their desire to sample as many children as possible in as brief a time as possible. That oversight is their failure to secure a given sound more than once, with a few exceptions. The upshot is that the authors miss all of the variability of success and error that are found in the attempts of a given child to pronounce a given phone at a given time. Under the procedure they used, the child either scored a success or an error, and that was all there was to it. Small wonder that theorists have concluded, from this and other similar studies, that the child's phonological learning is an all-or-nothing affair; without a sample of ATTEMPTS at a given phone to show that successes and failures can be contemporaneous, they could hardly have concluded otherwise.

The Wellman, Case, Mengert and Bradbury study also made a ground-breaking attempt to evaluate the type of error made.

Unfortunately, the categories chosen are not very useful: e.g., one type of articulatory error is labeled 'approximation', without specifying for the reader what is meant. Another type of error, which suggests that some sounds at least were obtained more than once, were labeled 'inconsistency'. This meant that sometimes the child got the phone right, and sometimes, got it wrong. Clearly, this is not a type of error but rather a record that errors were interspersed with successes. Unfortunately no further specifications were provided concerning the erroneous attempts. Despite the unsatisfactory nature of their analysis of errors, the authors deserve credit for recognizing that it was a valuable endeavor; one can hardly ask more of those sailing uncharted seas.

Another study apparently in the same vein is that of Poole (1934). This work, an unpublished dissertation, is known to me only from the reviews by Templin (1957) and Sharf and Prins (n.d.). According to them, the Poole study uses articulation tests of the variety used by Wellman et al. If the all-or-none testing principle still obtained, it perhaps accounts for the considerable differences between their results; for example, the Wellman study found [f] produced correctly by 75% of the subjects at age three, whereas the same standard was attained by Poole's subjects only at age 5.5. Poole attempted to relate the number of errors made by children with respect to a given phone to the frequency of occurrence of that in the children's speech. There was a low negative correlation between frequency and the number of errors.

According to Templin (1957), Poole's method sought spontaneous utterance of the desired words in response to the elicitation techniques employed in articulation tests, but, if the hoped-for item was not forthcoming, the investigator prompted the child and recorded his imitation of her utterance. The consequences of such a procedure are referred to below in the discussion of Templin's work.

The work of Templin (1957, 1966) is characterized by the use of very large samples (probably the most inclusive ever studied), but with reliance upon articulation tests, with some of the difficulties outlined above in connection with their use by the Wellman group.

Templin (1966) apparently assumes that she is studying the production of phonemes ("Mature articulation refers to utterances that are recognized as the phonemes of English; a broad classification of a phoneme is used, and no consideration is given to variations of utterance within a phoneme" 1966, p. 174); it seems clear, however, that no phonemic analysis of the idiolects of the many children in her samples was even attempted, let alone performed. Therefore, she, too, is apparently studying, for the most part, the acquisition of phones, but in a way that, judging from the passage quoted above, tends to blur the differences between different allophones of the same phoneme. A good example is her handling of '/r/' by which is presumably meant the retroflex vowels, a complex class including a variety of vowels as great as all the non-retroflex vowels (minus 'ɪ', which apparently does not occur in a retroflex variety, at least in my sample) put together. In this case, at least Templin does seem to be working with a single phoneme, but if the separate allophones are not considered as different entities, much important information may be lost. That is, it appears that the different retroflex vowels are learned at different ages in separate stages, a set of facts that is obscured by the Templin criterion of correct production of '/r/', i.e. some particular allophone of /r/. Thus her approach to the problem is complicated by being a mixed one, now phonetic, now phonemic.

Templin's conclusions, based on the productions of her sample of 480 children (3-8 years of age) were:

1. Word-initial consonants are easiest, word-medial ones next, and word-final ones hardest.
2. Phones have the following order of increasing difficulty: nasals, plosives, semivowels and fricatives.
3. While voiceless fricatives were produced correctly more often than voiced ones, there was no difference between voiced and voiceless for other types of paired consonants.

Templin's study is exceptionally thorough in the sense that the sample was carefully controlled for socio-economic class, IQ, sex and other factors thought to be important in language acquisition. She used articulation tests, as noted above, without electrical recording and with herself as the sole phonetician. Though it is not clear, it appears that complete utterances were not transcribed (Templin 1957, p. 12); her description of the experiment allows the inference that if the part of the utterance in question was heard as correct, then the fact was noted — perhaps by a check mark or some such device — since the only time she mentions the use of the International Phonetic Alphabet is in connection with the transcription of 'substitutions'. The procedure is not unreasonable, given her goal of rapid processing of a large sample, but it does raise the questions of correctness (what is a 'standard English sound', what were the dialects of the parents, how does one decide among possibly competing models for a given utterance) and observer reliability. Templin recognizes that the latter was a problem but apparently does not see that the question of dialect differences in model-attribution could have affected her results. Her method of work meant that once the observer decided that a given utterance was correct, and noted the decision, there would remain no possibility of ever checking the decision, since apparently there would be no record of the utterance, and information about the dialects of the parents was apparently not obtained.

Another aspect of Templin's method is worthy of note, particularly since it may affect the age-norms she established. In eliciting, her practice was that "Children 6 to 8 either read the test words or repeated them after the examiner. The preschool children repeated the words after the examiner or uttered them spontaneously in the identification of pictures". She believed this procedure justified since "It has been previously demonstrated that similar results are obtained in the measurement of speech sound articulation of normal children whether a repeated or a spontaneous utterance is used". This belief is in sharp contradiction to the findings in the present study, where it appeared that children had far greater success when imitating an utterance directly modeled for them than in producing the same utterance spontaneously.[1] Since the present study makes

[1] In the study referred to as "demonstrating the point" (Mildred C. Templin, "Spontaneous Versus Imitated Verbalization in Testing Articulation in Preschool Children", *The Journal of Speech Disorders* Vol. 12, (1947), No. 3, pp.

use of no prompted utterances, the data are not strictly comparable with Templin's where spontaneous and repeated (prompted) utterances are mixed together in unknown proportions. The effect of reading on the performance of the 6 to 8 year olds is hard to calculate, but it raises interesting questions: what did the investigator do if the child produced a 'spelling pronunciation' (e.g. sounding the 't' in OFTEN); what was the investigator's response to incorrect reading — did she then model the utterance for the child?

Another difficulty in the evaluation of the Templin data is the fact that, in most cases, a given sound in a given position was tested

293-300, several methodological questions invite comment. The "spontaneous" utterances were elicited by pictures, previously chosen because they were successful in eliciting the desired test word from the children at the ages in question. This means that, by and large, they were getting at well-practiced utterances; in those cases where the utterances were not well-practiced (i.e., were not part of the child's vocabulary), the children did not respond with the proper word and therefore the trial was recorded neither for nor against the score made on "spontaneous" utterances. One curious result was that the scores from "spontaneous verbalization" were *higher* than those from imitated trials in the case of nine different phones in which many of the children did not respond to the pictures: evidently the *best-performing* children's "spontaneous" utterances were being compared with the imitations of ALL the children, good and bad. When difficulties of this sort were eliminated, the remaining two phones where there were differences both showed that the child did BETTER when imitating than when talking "spontaneously".

Another problem is that, with a few exceptions, the Templin study gave the child only one trial on each phone in each position. This is, as noted earlier, a reasonable procedure in view of her goal, but, particularly when the elicited utterances are well-practices items, tends to mask the variability that characterizes the pronunciation of phones in the stream of the child's speech, since that stream is composed of differing mixtures of well-practiced, less-well-practiced, and first-time items.

Templin's procedure is well-devised to determine whether a child CAN produce a phone in a well-practiced word so that, e.g., if he can't pronounce it, remedial action can be taken. Her procedure is less successful if one wants to discover how well the child DOES pronounce a given phone in the stream of speech. The view held here is still that imitation and spontaneous production are two different tasks and that further work is needed to determine when the results from one may be used for the other.

The matter of imitation vs. spontaneous production of sounds is evidently a complicated one requiring further investigation. For example, cf. Leopold (1947:261) "Wundt also observed correctly that the child often articulates sounds which he is unable to produce imitatively...."

on a SINGLE TRIAL, following in the Wellman and Poole traditions. The possibility of tracing the gradual learning of a phone, by charting the changing mixture of successes and errors, is thus eliminated.

The problems pointed out above are in a sense direct products of Templin's admirable goal, viz. to obtain a measure of each test phone in all positions for each child. The present study, depending as it does on spontaneous speech, falls short of Templin's standards in this respect, since some phones are simply not tried by some children; research designs generally make gains only at the expense of some losses.

The work of Irwin (1957), which reports a solid and laborious description of the vocalizations of infants beginning within a month or two of birth, exemplifies the dangers of forgetting the difference between the prelinguistic (pre-meaningful) utterances and the attempts to say something in the adult language. Irwin recognizes this difference in his introduction and then promptly forgets it, with ludicrous results. As to units of analysis, he states: "The phoneme, which is the elemental speech sound unit, is the obvious one for showing the infant's phonetic development". Of course the phoneme, which is discovered by comparing meaningful utterances, is quite inapplicable as a unit for the analysis of the cooing and squalling of newborn infants. However, Irwin says that "the average baby, under two months of age, is endowed with 7½ phonemes..." (p. 412). At that age, the infant has neither phones nor phonemes; Irwin's studies are therefore useful only in showing what the vocalizations of the infant are like. Even so, there are difficulties; e.g. when he says that 'b', 'p', and 'm' are not, as "has generally been thought", the consonants which are "first mastered", the question immediately arises: what does it mean to say that a six-month old infant has "mastered" a consonant? That it occurs in his vocalizations? That it occurs more often than other sounds?

The most enduring contribution of the work of Irwin and his colleagues (cf. the references in Irwin 1957, also Winitz and Irwin 1958) is likely to be the collection of data supporting the suggestion that there is little continuity between the babbling and speaking periods. The sounds appearing most frequently in the prelinguistic period were front vowels and back consonants; on the other hand, the first to appear in the speaking period were back vowels and front consonants. An additional interesting finding of Irwin's is that the occupational status of the parents has no effect on articulatory development until about one and one half years of age, after which children of middle class parents have the advantage. This conclusion deserves further checking in other samples and under other conditions.

Several investigators have attempted to approach the study of the acquisition of phones by way of analysis of errors rather than successes. Perhaps the first of these was Williams (1937), who used the data from the original study by Wellman, *et al* (1931). His study suffers, as he recognizes, from the limitations of the method of data collection employed in the earlier study. Particularly limiting is the 'one-trial' nature of the testing situation used in administering articulation tests. Moreover, Williams considers only initial and final positions for consonants, since he uses, in effect, the syllable as his unit of analysis. His findings are inconclusive but suggest that "there is no consistent difference in difficulty between voiced sounds and their voiceless equivalents or between three positions of phonation (articulation-DLO)". He notes a tendency to replace the "more difficult fricative by the easier stop". Williams concludes that "the variability of substitutions is so great that the normative conception seems to be of little value". As possible explanations, he advances two: the easier sounds (defined as those learned earlier by subjects in the sample) showed a slight tendency to be substituted for the harder ones; otherwise, children tend to replace sounds with ones that are "acoustically similar". How one measures this last attribute is not explained. Though Williams's specific findings can hardly be taken seriously because of methodological shortcomings in his study and the one from which the data were obtained, he deserves much credit for seeing the possibilities inherent in an analysis of errors and for beginning the search for general explanations of them.

Templin also considers the analysis of errors. Unfortunately, her study does not present enough phonetic detail to allow comparison on most points of interest. Errors are classified by her as omissions, "defective sounds" and substitutions. The difference between the latter two categories seems to have been that substitutions involved replacement by another sound of "standard English", while defective replacements were not standard English phones. Farther than that, she does not go in phonetic specificity. The result is that her table, comparing the different types of errors (Templin 1957, p. 59) is more a roster of judgments by the investigator as to what is and what is not 'standard English' than it is a record of the gradual progress of the child in learning, as revealed by possible shifts in the phonetic make-up of the erroneous phones.

Levina (1940), in a study summarized in Slobin (1966), lists the following as the most common pronunciation errors of Russian children:

1. replacement of voiceless by voiced stops (*naka* for *noga, tom* for *dom*)
2. confusion of *r* and *l* (*tli* for *tri*)
3. confusion of *m* and *n* (*nisok* for *meshok*)
4. confusion of voiced and voiceless sibilants (*zhdorovo* for *zdorovo*)
5. double shift, from voiceless to voiced, and from alveopalatal to alveolar (*zlyapka* for *shlyapka*)
6. "splintering of sounds": disturbance of the type of *abiskvo* for *yablochko*
7. confusion of palatalized and unpalatalized consonants (*tul'* for *stul*)
8. replacement of *ĭ* in diphthongs by *l'* (*tal* for *chaĭ*)
9. replacement of *r* and *l* by a diphthong with *i* (*boino* for *bol'no*)
10. replacement of *z* by *d* (*Danka* for *Zanka*)
11. replacement of *s* by *t* (*tabaka* for *sobaka*)

Interpretation of Levina's findings is difficult. For one thing, in line 1, the examples given show voiceless stops replacing voiced ones, not the other way around. In line 4, the example given shows *zh* (an alveopalatal) replacing *z* (an alveolar); the error is thus one of place of articulation and not one of voicing. In the absence of the original study by Levina, it is impossible to tell whether the analysis of errors is carried on at this level of accuracy, or whether these are typographical errors, or whether some other explanation fits the case. In any event, the lack of statistics concerning the sample, and the methods of collecting the data render the study of limited usefulness, except to show that interest in the problem was developing in many centers of research at about the same time.

4.2. PHONEMIC OPPOSITIONS

Emphasis upon the importance of tracing the development of phonemic oppositions in children's language is due primarily to Jakobson (1941, and many subsequent publications, cf. also Velten 1943, Leopold 1939-49). Evaluation of Jakobson's work regarding child language is an intricate task, since combined in his contributions to the subject are three distinct threads, theoretically separable, but, in his actual writings, closely intertwined. These are: (1) an original method of phonological analysis (characterized by binary, distinctive features), (2) a theory of the development of child language (that it is related to aphasia and recovery from aphasia, and also to language universals), (3) his interpretation of the factual evidence concerning the linguistic productions of children. We discuss each of these in turn below.

A recent account of the Jakobsonian distinctive feature system is to be found in Jakobson and Halle (1956). Their definitions of the categories are contained in the following passage:

3.6 *The two classes of inherent features.* The inherent distinctive features which have so far been discovered in the languages of the world and which, along with the prosodic features, underlie their entire lexical and morphological stock, amount to twelve oppositions, out of which each language makes its own selection. All the inherent features are divided into two classes that might be termed sonority features and tonality features and the latter to the prosodic pitch features. The sonority features utilize the amount and concentration of energy in the spectrum and in time. The tonality features involve the ends of the frequency spectrum.

3.61 *Sonority features*

I. Vocalic/non-vocalic:

acoustically — presence *vs.* absence of a sharply defined format structure;
genetically — primary or only excitation at the glottis together with a free passage through the vocal tract.

II. Consonantal/non-consonantal:

acoustically — low (*vs.* high) total energy;
genetically — presence *vs.* absence of an obstruction in the vocal tract.

Vowels are vocalic and non-consonantal; consonants are consonantal and non-vocalic; liquids are vocalic and consonantal (with both free passage and obstruction in the oral cavity and the corresponding acoustic effect); glides are non-vocalic and non-consonantal.

III. Compact/diffuse:

acoustically — higher (*vs.* lower) concentration of energy in a relatively narrow, central region of the spectrum, accompanied by an increase (*vs.* decrease) of the total amount of energy;
genetically — forward flanged *vs.* backward-flanged. The difference lies in the relation between the volume of the resonance chamber in front of of the narrowest stricture and behind this stricture. The ratio of the former to the latter is higher for the forward-flanged phonemes (wide vowels, and velar and palatal, including post-alveolar, consonants) than for the corresponding backward-flanged phonemes (narrow vowels, and labial and dental, including alveolar, consonants).

IV. Tense/lax:

acoustically — higher (*vs.* lower) total amount of energy in conjunction with a greater (*vs.* smaller) spread of the energy in the spectrum and in time;
genetically — greater (*vs* smaller) deformation of the vocal tract — away from its rest position. The role of muscular strain affecting the tongue, the walls of the vocal tract and the glottis requires further examination.

V. Voiced/voiceless:

acoustically — presence *vs.* absence of periodic low frequency excitation;
genetically — periodic vibrations of the vocal cords *vs.* lack of such vibrations.

IV. Nasal/oral (nasalized/non-nazalized):

acoustically — spreading the available energy over wider (*vs.* narrower) frequency regions by a reduction in the intensity of certain (primarily the first) formants and introduction of additional (nasal) formants; genetically — mouth resonator supplemented by the nose cavity *vs.* the exclusion of the nasal resonator.

VII. Discontinuous/continuant:

acoustically — silence (at least in frequency range above vocal cord vibration) followed and/or preceded by spread of energy over a wide frequency region (either as burst or as a rapid transition of vowel formants) *vs.* absence of abrupt transition between sound and such a silence;
genetically — rapid turning on or off of source either through a rapid closure and/or opening of the vocal tract that distinguishes plosives from constrictives or through one or more taps that differentiate the discontinuous liquids like a flap or trill /r/ from continuant liquids like the lateral /1/.

VIII. Strident/mellow:

acoustically — higher intensity noise *vs.* lower intensity noise; genetically — rough edges *vs.* smooth-edged: supplementary obstruction creating edge effects (*Schneidenton*) at the point of articulation distinguishes the production of the rough-edged phonemes from the less complex impediment in their smooth-edged counterparts.

IX. Checked/unchecked:

acoustically — higher rate of discharge of energy within a reduced interval of time *vs.* lower rate of discharge within a longer interval; genetically — glottalized (with compression or closure of the golttis) vs. non-glottalized.

3.62 *Tonality features.*

X. Grave/acute:

acoustically — concentration of energy in the lower (*vs.* upper) frequencies of the spectrum;
genetically — peripheral *vs* medial: peripheral phonemes (velar and labial) have an ampler and less compartmented resonator than the corresponding medial phonemes (palatal and dental).

XI. Flat/plain:

acoustically — flat phonemes in contradistinction to the corresponding plain ones are characterized by a downward shift or weakening of some of their upper frequency components;
genetically — the former (narrowed slit) phonemes in contradistinction to the latter (wider slit) phonemes are produced with a decreased back or front orifice of the mouth resonator, and a concomitant velarization expanding the mouth resonator.

XII. Sharp/plain:

acoustically — sharp phonemes in contradistinction to the corresponding plain ones are characterized by an upward shift of some of their upper frequency components;
genetically — the sharp (widened slit) *vs.* plain (narrower slit) phonemes exhibit a dilated pharyngeal pass, i.e. a widened back orifice of the mouth resonator, a concomitant palatalization restricts and compartments the mouth cavity.

The system of analysis in terms of distinctive features, is, despite shortcomings, clearly a serviceable one; it represents an ambitious attempt to unify knowledge from the sister disciplines of articulatory phonetics and acoustics. Since the first publication dealing with the subject (Jakobson, Fant and Halle 1952), a considerable literature both *pro* and *contra* has come into existence. It is not my purpose to review that body of work here, but to note the fact that the analysis according to distinctive features is not adopted in the present study. Although the Jakobsonian system is presented as a point of departure for the analysis of phonemic oppositions, it is not necessarily unadaptable for the analysis of phones, c.f. Sharf, Baehr and Fleming 1967. The problem of choice of system revolved around the question of replicability. First, there was the fact that the available research workers, including myself, were practiced in conventional articulatory phonetics and not in acoustic phonetics. Second, there was a disinclination to try to subject our large mass of data to acoustic analysis. It was felt that this would have been necessary since, though one could make a mechanical translation of articulatory phonetic categories into Jakobsonian ones, there would be little motivation to do so. After all, the principal reason for grouping velar and labial consonants and calling them "grave" as opposed to the palatal and dental ones called "acute" is the acoustic condition of concentration of energy in the lower (vs. upper) frequencies of the spectrum. Moreover, in some cases it appears to be difficult to assign operational definitions to some of the realizations of the features. As Fant (1967) notes: "One major shortcoming of 'Preliminaries' is the lack of a realistic discussion of the time-varying aspects of speech patterns and the temporal distribution of the acoustic, articulatory and perceptual characteristics underlying the distinctive features..." He goes on to suggest that some of the defining rules in "Preliminaries" are "oversimplified and need to be reformulated and expanded."

Some of the Jakobsonian terms are apparently simply different names for traditional categories, e.g., "checked" for "glottalized", others like "voiced", and "nasal" use the same terms for the same things. But some, e.g. "vocalic", appear to use the traditional terms in new ways. There is nothing the matter with this provided it is done consistently. However, in the case of some of the distinctive feature categories there would appear to be either loss of information, vagueness of definition, or both.

For example, the definitions of vocalic and consonantal in the passage quoted above from Jakobson and Halle (1956) are difficult to apply. If "primary or only excitation at the glottis" means voicing, then it would appear to exclude the possibility of handling voiceless vowels, which would be a pity. The "free passage through the vocal tract" appears to be equivalent to the definition of non-consonantal "absence of an obstruction in the vocal tract". If that is so, then glides, which are said to be non-vocalic and non-consonantal, would be the latter by virtue of lacking an obstruction in the vocal tract. But by the same token, they would be vocalic, unless they differ in the other part of the definition of vocalic ("primary or only excitation"); however, they manifestly do not: glides are like other vowels as far as glottal activity is concerned. In short, the system does not handle glides (semivowels) at all well. From the standpoint of articulatory phonetics, glides are simply vowels with one important difference: they are produced when the highest point of the tongue is in motion rather than relatively stationary. This view is not far from the latter-day views of Fant, one of the original authors: "One of the weaker parts of the distinctive feature theory is that of defining consonants and vowels." (Fant 1967).

Similarly, Fant criticizes parts of the definition of the tense/lax opposition, stating that the question of higher subglottal pressure in the case of tense vs. lax vowels leaves him "somewhat sceptic". In Fant's opinion, this factor "has not been sufficiently well documented in experimental work". Certainly, the articulatory definition given in Jakobson and Halle (1956) "greater vs. smaller deformation of the vocal tract — away from its rest position" seems almost impossible to apply in any replicable way. For one thing, different people have, apparently (Birdwhistell 1967), different positions of rest for parts of the vocal tract. As Jakobson and Halle recognize, the role of muscular strain "requires further examination"; Haugen (1967) calls the tense/lax classification "a well-known if not wholly clarified set of terms in the Jakobson feature system".

Some of the categories in distinctive feature analysis appear to be included in others. For example, DISCONTINUOUS ("rapid closure and/or opening...") would seem to be, by definition, a sub-class of CONSONANTAL ("...obstruction in the vocal tract."). By the same token, STRIDENT seems also to be such a sub-class.

Jakobson (1962), in a recent overview of his work, recognizes that the distinctive feature system is still open to improvement:

> The tentative list of distinctive features so far encountered in the languages of the world (see above, p. 477ff.) is intended just as a preliminary draft, open to additions and rectifications. A framework was traced by the close cooperation of the three authors of *Preliminaries*, supported by many helpful suggestions of our Harvard and M.I.T. friends; but a further, revised and specified version will undoubtedly bring more precise definitions for the correlates of single distinctive features at the different stages of the speech event.

The above comments do not constitute an integrated or complete critique of the distinctive feature system of analysis; nor do they adequately present the strengths of the method; for a concise outline of them, see Jakobson 1962. They are included here to suggest the main reasons why the Jakobsonian variety of feature analysis was not adopted in this study. Insofar as the present study deals with phonological components, it owes something to Jakobson, who has been a pioneer in emphasizing their importance in linguistics.

Jakobson's theory of child language development was first elaborated in his *Kindersprache, Aphasie und allgemeine Lautgesetze* (1942), a work that has been a landmark in the development of the study of both child language and aphasia. All quotations from this work, long virtually unobtainable, are from a translation made by Burton S. Rosner and me (Rosner and Olmsted n.d.).

Jakobson was among the first to insist that the differences between the rich phonetic inventory of the babbling period and the meagre repertory characteristic of the beginnings of meaningful speech are profitable viewed as by-products of the development of a phonemic system:

> Accordingly, one can uniquely explain the SELECTION OF SOUNDS during the transition from babbling to language from the fact of this transition itself, i.e. from the new function of the sounds, through their becoming speech sounds, or more precisely from their PHONEMIC VALUE, which the sound thereby receives.

In a footnote, Jakobson credits K. von Ettmayer with having given clear expression to this idea as early as 1938.

We have seen that Wellman, *et al.*, Templin, Irwin and others have tended to treat phones as if they were learned once and for all; indeed, it is clear that their methods, particularly the prevailing use of the one-trial test of articulation, made such a conclusion almost foregone. The notion that children learned the elements of language all at one jump must have been part of the *Zeitgeist*, for we see Jakobson taking much the same position with respect to oppositions:

> Straightway these arbitrary sound-discriminations, occurring for the first time and based upon meaning, produce simple, meaningful, and stable sound oppositions, which are capable of being impressed on the

memory, reproduced by desire and necessity and which become easy to remember.

Jakobson goes on to suggest that there is a universal order of acquisition of phonemic contrasts, a "strong, lawful, generally applicable succession". Specifically:

The... phonemic opposition of fricative and stop consonants belongs in child language to the relatively late stages."
"Thus the fact that the palatal sounds first appear in children's speech after the dentals is apparently universal."
"At the start of the first speech stage the vocalism is begun with a broad vowel and at the same time the consonantism is begun with a stop at the front part of the mouth. An *a* appears as the FIRST VOWEL and usually a labial stop as the FIRST CONSONANT of children's speech. As the first consonant opposition the ORAL and NASAL sounds appear (like *papa-mama*); the opposition of LABIALS and DENTALS follows this (like *papa-tata* or *mama-nana*).

Since the first consonant is said to be labial, and since palatals are said to follow dentals, one can set up the sequence labial-dental-palatal.

Another aspect of Jakobson's theory is that universal elements are learned earlier than ones which are not universal:

the astoundingly precise agreement between the time series of these developments and the GENERAL LAWS OF THE LIMITED FOUNDATION (solidarite irreversible) which rule the structure of all dialects... Thus the development of the spirants presupposes that of the stops in children's speech, and in the world's languages the former cannot exist without the latter... The development of the BACK CONSONANTS presupposes in the speech development of the child the development of the FRONT consonants, i.e. the labials and dentals, and in some cases the development of the oral or nasal stops of the back of the mouth presupposes that of the front oral or nasal consonants. The acquisition of the back spirants likewise presumes that of the front spirants and, on the other hand, that of the back stops; the existence of the back consonants in the tongues of the world includes correspondingly the simultaneous presence of the front consonants...

With respect to vowels:

the child does not acquire any opposition between two VOWELS OF THE SAME DEGREE OF APERTURE, as long as the corresponding opposition of vowels of CLOSER DEGREES OF APERTURE is absent — to this corresponds the fact in the vowels of adult speech the more open degrees of aperture are never represented by more numerous phonemes than is the case for the closer.

And again:

No differentation in the speeɔh of children can arise between the rounded vowels according to degree of aperture as long as the same opposition is lacking for the unrounded vowels... Correspondingly, a number of adult dialects have an *e*-phoneme without showing an *o*-phoneme comp. (Trubetskoy *op. cit.*, 98 on the Lesghian vowel system) but there is hardly a language with *o* and at the same time without *e*.

The reverse also holds, according to Jakobson's theory, as set forth in *Kindersprache* (1942): "Oppositions which occur relatively SELDOM in the languages of the world belong to the LATEST sound acquisitions of the child."

Moreover, the primary (universal or quasi-universal) elements, not only presuppose the secondary ones logically and precede them in children's language acquisiton, but are said to possess a higher "relative intensity of use" in the language, defined as relative frequency of appearance plus capacity for combination. For example, "if, therefor, the two phonemes — the primary one as well as the secondary — have found entry into children's speech, the primary element generally appears more frequently in speech than the other, participates in a greater number of phoneme combinations and possesses a more active assimilatory power."

Another important idea of Jakobson's first elaborated in the work under consideration, is that language-loss in aphasia is under control of the same "laws" as language-acquisition in the child. Thus, the secondary items are lost first, loss of the primary items presupposes loss of the secondary; in short, as far as the phonology is concerned, aphasic deterioration is the 'mirror image' of the child's acquisition.

Once again we see Jakobson's genius for synthesis at work. His bold attempt to find general laws governing acquisition, loss, universality and frequency was far in advance of its day and, indeed, has stimulated the collection of some of the necessary data to test various facets of his theory. Unfortunately, the rise and fall of fads and fashions in linguistics — as elsewhere in science — has diverted attention from these matters to such an extent that definitive tests of many of these propositions are still not yet possible. But the questions posed remain as challenging as ever.

Jakobson's interpretation of the evidence concerning the acquisition of phonology by children is, as has been noted, intertwined with his theoretical contributions. But, while the latter are timeless and still open to test, the former are dated by virtue of having been presented when the evidence was much sparser; moreover, they sometimes go beyond what the data appear to support. It is therefore necessary to discuss Jakobson's interpretations separately from his theories.

Twenty-five years ago, when his *Kindersprache* was published, Jakobson had, for the most part, to rely upon diaries kept by investigators concerning the linguistic development of a small number of children, usually only one or two; e.g., Bloch 1921a and 1921b, Bolin 1916, Brenstiern Pfanhauser 1930, Buhler 1926, 1929, Cohen 1925, Delacroix 1934, Deville 1890, 1891, Eng 1923, Feyeux 1932, Franke 1912, Fröschels 1918, 1925, Gad 1932, Grammont 1902, Grégoire 1933, 1937, Gutzmann 1894, 1897, 1899, Gvozdev 1927, Jespersen 1916, Neumann 1903, Ohwaki 1933, Oltuszewski 1897, Pavlović 1920, Piaget 1930, Preyer 1895, Rasmussen 1913, Ronjat 1913, Ross 1937, Rottger 1931, Royssey 1899-00, Saareste 1936, Schultze 1880, Scupin 1907, Stern 1928, and Stumpf 1901. In spite of the rather small number of children and languages involved, Jakobson did not hesitate to interpret the results as indicative of the facts of child development in general, e.g.: "In the development of children's speech *k* also fuses with *t*, and later *k* first turns up as an independent phoneme": or, "The relation of succession appears in children before that of mutual replacement, the successive before the simultaneous contrast ".

Not only is there a disinclination to recognize the insufficiency of the sample of children whose data were available to him, but sometimes also seemingly no need for any kind of sample; e.g. "...the nasal vowels ...appear relatively seldom in various tongues and relatively late in the children of those who speak those tongues". (a footnote to this last statement, which purports to be a GENERAL FINDING ABOUT CHILDREN, refers only (as far as child language is concerned) to Kroeber's study of the speech of a SINGLE ZUNI CHILD). This last must surely be a bibliographic mix-up of some kind, since the paper of Kroeber cited reports only his observations of the linguistic development of a single Zuni child. It contains no material from other languages, cites no literature and has no comparative hypotheses or speculations. The subject of nasal vowels, not being a factor in the linguistic data of the child he had under observation, is never even mentioned. A commendable enthusiasm for the discovery of general laws prompted Jakobson in this case — and in other places in his monograph — to overstate the generality of his findings beyond what the data warranted.

In a later work (Jakobson and Halle, 1956), Jakobson amplifies his views on the development of phonology in the child: (p. 26-7)

3.5 *General laws of phonemic patterning*. The comparative description of the phonemic systems of diverse languages and their confrontation with the order of phonemic acquisitions by infants learning to speak, as well as with the gradual dismantling of language and of its phonemic pattern in aphasia, gives us important insights into the interrelation and classification of the distinctive features. The linguistic, especially phonemic progress of the child and the regression of the aphasic obey the same laws of implication. If the child's acquisition of distinction B implies his acquisition of distinction A, the loss of A in aphasia implies the absence of B, and the rehabilitation of the aphasic follows the same order as the child's phonemic development. The same laws of implication underlie the languages of the world both in their static and dynamic aspects. The presence of B implies the presence of A and, correspondingly, B cannot emerge in the phonemic pattern of a language unless A is there; likewise A cannot disappear from a language as long as B exists. The more limited the number of languages possessing a certain phonemic feature or combination of features, the later is it acquired by the native children and the earlier is it lost by the native aphasics.

Further: (p. 37)

Ordinarily child language begins, and the aphasic dissolution of language preceding its complete loss ends, with what psychopathologists have termed the "labial stage". In this phase, speakers are capable of only one type of utterance, which is usually transcribed as /pa/. (p. 37) ...The choice between /pa/ and /a/ and /or/ /pa/ and /ap/ may become the first carrier of meaning in the very early stages of child language. Usually, however, the infant preserves for a time a constant syllable scheme and splits both constituents of this syllable, first the consonant and later the vowel, into distinctive alternatives. (p. 38).

These formulations are, with respect to testability, a mixed bag. That child language "ordinarily" begins with the utterance transcribed /pa/ is difficult to test, since it requires a number of assumptions that are by no means obvious: (1) since, during the babbling period, the child has produced many other sounds, this formulation requires the assumption that the beginning stage of child LANGUAGE can be unambiguously identified. This proposition is dubious, since some children continue to intersperse babbling with 'intentional language' during the transition period. (2) the transcription of /pa/, with phonemic brackets, suggests that the items within the brackets are in (to use Jakobson's term) opposition with each other or with other phonemes in the same positions. Since the child at the beginning has but the one utterance, the fact of opposition seems impossible to demonstrate. (3) In order to be sure that /ap/ is a carrier of meaning as opposed to, say, /a/, one has to be able to ascertain that the two items have meanings and that the meanings are different. These tasks are of a high order of difficulty, as veteran observers of very young children will attest. And finally (p. 41):

The development of the oral resonance features in child language presents a whole chain of successive acquisitions interlinked by laws of implication. We tentatively tabulate this temporal series in the following chart, using for the distinctions acquired the traditional articulatory terms and designating each of these acquisitions by a sequence of numbers preceded by 0., i.e. writing each sequence as a decimal fraction. The sequences were composed in such a way that if sequence S_1 is assigned to distinction A and sequence S_2 to distinction B, and S_1 is an initial subsequence of S_2 (i.e. S_1 is an initial subsequence of S_2 if the first digits of S_2 are identical with S_1; e.g. $S_1 = 0.19$ and $S_2 = 0.195$), then the acquisition of distinction B implies that of A. The numerical values of the digits and their number have no other significance. It is obvious that only those distinctions are acquired by the child that are present in the language being learned.

Consonants: dental vs. labial	0.1
Vowels: narrow vs. wide	0.11
Narrow vowels: palatal vs. velar	0.111
Wide vowels: palatal vs. velar	0.1111
Narrow palatal vowels: rounded vs. unrounded	0.1112
Wide palatal vowels: rounded vs. unrounded	0.11121
Velar vowels: unrounded vs. rounded	0.1113
Consonants: velopalatal vs. labial and dental	0.112
Consonants: palatal vs. velar	0.1121
Consonants: rounded vs. unrounded or pharyngealized vs. non-pharyngealized	0.1122
Consonants: palatalized vs. non-palatalized	0.1123

These formulations are more easily testable than those discussed earlier: they will be taken up again when data from the present study are considered in connection with them. For the moment, suffice it to note that the principal problem in connection with testing is to know when a distinction has been ACQUIRED. Does one correct use of dental vs. labial constitute acquisition if it is followed by numerous instances in which the child 'relapses' to an 'earlier' stage? This question is crucial because it leads on, if one isolated instance is NOT enough, to the necessity to establish standards of performance that will be taken as indicating ACQUISITION. These questions have been either ignored or side-stepped by most workers heretofore.

In a later work (Jakobson 1961), he carried his ideas to their logical conclusion: "At first, child's language is devoid of any hierarchy of linguistic units and obeys the equation: one utterance — one sentence — one word — one morpheme — one phoneme — one distinctive feature. The *mama-papa* pair is a vestige of that stage of one-consonant utterances". Logically impeccable, this statement again raises the question of testability. How does one recognize a one-consonant utterance; specifically, how does one tell it apart from babbling or an instance of mouth-closure without any communicatory significance? It appears that Jakobson's theories about the middle stages of child language are more easily brought into confrontation with the data than those that concern the earliest stages, and it is to the former that we will turn when considering the evidence.

An interesting early treatment of the linguistic and psychological aspects of child language acquisition is M. M. Lewis's *Infant Speech* (Lewis 1951, first edition, 1936). Its value consists in its thorough-going coverage of the literature, its persistent and ingenious consideration of psychological hypotheses appropriate to the many separate learning-situations connected with the acquisition of language, and its sensible balance between maturational and learning explanations; particularly noteworthy is Lewis's tendency toward scepticism in dealing with the inadequate phonetics of earlier work. His readiness to discuss evidence contradictory to his own theories is especially laudable. The main weaknesses of the work, viewed from the present day, are the outdated psychological theories that Lewis, quite naturally, chose to test. Thus, much of his long discussion of babbling — which is methodologically quite exemplary — is rendered otiose by Mowrer's contribution of the notion of 'secondary reinforcement' to the theory of babbling. Though Lewis makes an occasional error in phonetics, his use of that discipline is generally quite satisfactory and his knowledge and critical handling of the psychological literature, methods and theories are admirable.

A weakness in Lewis's contribution to the study of phonological development is — as he recognizes — the fact that his data derive principally from only three children: those observed by Stern, Deville and himself. However, these lead him to ask interesting questions:

> there are three moments of importance in the history of every acquisition: the time when the sound or combination appears in the child's speech, the time when he first attempts to imitate it as it occurs in an adult word, and the time when he succeeds in this imitation. (p.171 — all references to Lewis are to the second edition).

Though the quoted passage reveals Lewis, like the other investigators discussed above, to be under the influence of the doctrine that children learn a phone or phoneme all at one jump, he seems almost ready to move away from that doctrine and to take the next step to a statistical determination of 'frequency of correctness' vs. 'frequency of error' (the approach adopted in the present study). He does not quite do so, despite tentative moves in that direction, because of his concern with imitation and training as important components in the learning of sounds. This forces him to concentrate upon situations where adults are intervening in the child's articulatory activity — modeling, rewarding, etc. — and to overlook the possibility that the child's learning of phonology proceeds by closer and closer approximations, with variation in the degree to which a particular phone is pronounced correctly or in error, and with most of the 'training' being, during both the babbling and speaking periods, the product of the child's own activity without the conscious intervention of adults.

When discussing the type of error he calls substitution, Lewis (1951, p. 179) recognizes that phones once learned are not necessarily handled perfectly thereafter, though he does not formulate it in that way, and apparently does not recognize the implications for the method he employs elsewhere. However, the results are interesting: in a total of 355 substitution errors (consonants only), 81% occurred during attempts upon consonants already "in the child's repertory". This, of course, raises the question of what it means to be in the repertory. Of these 286 cases, 77% of the substitutions consisted in replacing the attempted phone by one which had appeared chronologically earlier in the child's history, while in 20% of the cases the replacement was a phone chronologically later, the other 3% being doubtful because of the incompleteness of the records. His data being sparse, Lewis cannot make "clear generalizations" but suggests that the "chief factor is the replacement of a comparatively unfamiliar consonant by one more securely established in the child's repertory" (p. 181).

An outstanding treatment of a single case is Leopold's (1947) record of the phonological development of his bilingual daughter, Hildegard. Unlike many of the writers whose works are discussed above, Leopold understood and faced the problem of the definition of 'acquisition'. His record deals with all articulatory products from the first month of life up well into the speaking period, and he notes both the first occurrence of a phone and the point at which he considered it "lastingly added to the repertory of sounds". Moreover, he also analyses the material phonemically and registers the changing phonemic systems for both English and German. The work is thus a *tour de force* of linguistic method, since the multiplicity of examples and their cautious interpretation inspire confidence in the author's phonetic and phonemic skill and in his objectivity.

Leopold's work is more than a record of one child's accomplishments; it is also a fine guide to the literature on child language, described from the point of view of a linguist who is free of the dogmas of any school and whose standards are high. Leopold realized, and adhered to, the principle that amateur phonetics is especially unreliable as a basis for generalizing about child language, which is notoriously difficult even for practiced phoneticians. His work is therefore especially valuable in marking out for the neophyte the path through earlier treatments of the subject.

Of particular interest is Leopold's detailed comparison of his data with the formulations of Jakobson (196 ff. and elsewhere passim). Hildegard's development agreed well with Jakobson's formulations regarding the vowels. With respect to consonants, she had both [b] and [d] from the beginnings of speaking. This circumstance supports the Jakobsonian notion that the front stops develop before the back ones, but is not in agreement with his notion that 'p' (representing a greater contrast with a vowel) is always the first consonant. As a matter of fact, all Hildegard's voiceless stops were acquired later than her voiced ones. The opposition between nasal and oral consonants, postulated by Jakobson as earlier than that between oral consonants, appeared late in Hildegard's speech:

> The opposition between labial and dental stops definitely preceded the opposition between buccal and nasal consonants in Hildegard's case, reversing the order postulated by Jakobson. The opposition between low and high vowels also antedated this distinction, again contrary to Jakobson's contention. (200).

Perhaps partly in response to Leopold's data, Jakobson, in his later formulations (1957) (cf. the quoted passage above, p. 4-30) removed the nasal/oral opposition from the list of ordered acquisitions and contented himself with saying that it "belongs to the earliest acquisitions of the child" (38). Leopold sums up: "Jakobson's theory, as applied to our case, seems to be too rigid, but our observations so far do not invalidate it in its essential features." (200).

In a review of Jakobson's book (Leopold 1942), Leopold recognized the major stature of the contribution but cautioned:

> My fundamental conviction, however, that we have not reached the stage when trustworthy generalizations concerning children's language can be made is not shaken by this book. We still need many more monographic studies, particularly from observers with linguistic training. In many details Jakobson's postulates are simply not borne out by the facts of observation. In part this defect is due to the insufficient amount of data thus far collected. Some of the objectionable generalizations, however, could have been avoided by more careful use of the available literature.

As Leopold (1947, 257 ff.) makes clear, there have been two mainstreams of theory regarding the reason for children's substitutions of sounds: one concentrated on articulatory difficulties and the other on perceptual problems. The first derives from Schultze (1880) who, according to Leopold, tried to formulate "definite laws of sound-shift, by which the child unconsciously performs the transformations, replacing a difficult sound by the most closely related one of less physiological difficulty". The second current is exemplified by Noble, Wundt and Oscar Bloch, according to Leopold. The wisest course, at the present stage of investigation, is to agree with Leopold that both factors probably play a role, but that it is difficult to sort out their relative contributions to incorrect production (or inadequate learning). The present study has as one of its aims an attempt to see how much of children's error can be accounted for by the perceptual difficulties presented by each phone, as calculated from the discriminability of its phonological components; the unpredictable residue may be attributed, provisionally at least, in part to articulatory difficulties and may help to sharpen the focus of research upon the little-understood aspects of the topic.

A latter-day attempt to apply Schultze's principle of least effort to the interpretation of the facts of infantile phonological development is to be found in the valuable contributions of Ohnesorg (1948, 1959). These presented a careful study of the linguistic development of his two children Karel (born 1942) and Marie (born 1944). It is still not clear how one is to measure "least effort", and the order of the two children's acquisition of consonants does not entirely square with Ohnesorg's theories. For example, outside of the notoriously difficult Czech 'ř', which is last to appear, Ohnesorg states that the next most difficult consonants are 'l' and 'r'; in this he agrees, though apparently for different reasons, with Jakobson. However, in the development of Karel, 'l' was the eleventh consonant to appear, coming ahead of such 'easier' ones as 'k', 'g', 'f', 'y', 's', 'z', 'š' and 'ž'.

Ohnesorg's material is of interest as a test of Jakobson's revised formulations (quoted above, p. 111). According to this roster, the opposition between palatalized and non-palatalized consonants should be the last to appear. However, according to Ohnesorg (1959, p. 151) the three palatalized dentals ('t'', 'd'', 'ň') appeared as the seventh, eighth and ninth consonants in the development of BOTH children. Since the first six were, in both cases, 'p', 'b', 'm', 't', 'd', 'n', one is forced to the conclusion that the opposition between palatalized and non-palatalized consonants preceded the opposition velopalatal vs. labial and dental.

An interesting general account of child language learning, based upon I.P. Pavlov's theory of primary and secondary signaling systems, is that of Smoczynski (1955). Including observations of two children, Annie (born 1947) and Pawle (born 1948), the study gives considerable attention to the prelinguistic periods (crying, cooing and babbling) and also to the development of control over the morphosyntactic and semantic systems of language and their relationships to psychological ontogeny. Partly as a result of these emphases, the author does not go into great detail regarding the acquisition of phones and phonemes. One useful device employed by Smoczynski is that of noting all the different ages at which a given item was noted from each child, thus giving the reader a chance to learn something about the author's samples for each item discussed. Unfortunately, items are frequently given as strings of alternants, and one cannot always determine which alternant was recorded in which day or whether more than one was so recorded. This interesting and scholarly study deserves to be better known, but the fact that it was written in Polish will probably limit the number of investigators who will come to appreciate its nuances.

5

THE ACQUISITION OF PHONES: SUDDEN ACCOMPLISHMENT OR GRADUAL PROCESS?

"The progress toward phonetic perfection is continual,
but not always steady and even."
W. F. Leopold

In this chapter the data from this study are presented and discussed. The forty-nine phones and phone combinations are considered in this section without regard to position in the utterance, i.e., data from initial, medial and final positions are pooled for each phone. The data for each phone are presented in Contingency Tables 1 through 49. Each table is a six-by-six display in which the labels are to be read as follows:

Blank:	Children in this column did not attempt the phone.
All wrong:	Children in this column attempted the phone and got none right.
Some right:	Children in this column got at least one wrong and at least one right, but got less than 50% of their attempts right.
Half right:	Children in this column got exactly half right and half wrong.
Most right:	Children in this column got more than 50% right and at least one wrong.
All right:	Children in this column got 100% correct.
Under 24:	Children 23 months of age and younger. (age-group 1)
Under 30:	Children 24 to 29 months of age. (age-group 2)
Under 36:	Children 30 to 35 months of age. (age-group 3)

Under 42:	Children 36 to 41 months of age.	(age-group 4)
Under 48:	Children 42 to 47 months of age.	(age-group 5)
Over:	Children 48 months of age and older.	(age-group 6)

Each cell may have two numbers in it. The lower one is the number of children fitting the intersection of age-group and condition of correctness in question. The upper one is a percentage based on the column sum. Outside the matrix, the totals and percentages are calculated both horizontally and vertically. The line labeled 'mean' indicates the average age of the children in that column by age-group: i.e., the range is 1 to 6. Thus, in Contingency Table 1, the children who got the phone [p] all wrong (second column) had a mean age-group of 2.00, since there was one from age-group 1, three from age-group 2 and one from age-group 3. Approximating the mean age of a group by its midpoint age, the mean age of group 2 is about 26.5 months. The following table may help the reader use the Contingency Tables:

TABLE 26

Mean age-group	Approximate mean age
1.00	20 months
1.50	23.25
2.00	26.5
2.50	29.5
3.00	32.5
3.50	35.5
4.00	38.5
4.50	41.5
5.00	44.5
5.50	47.75
6.00	51

S D = Standard Deviation

CONTINGENCY TABLE NO. 1

Phone [p]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	14.3 1	20.0 1		22.2 2	20.6 7	16.7 6	17	17.3
Under 30	57.1 4	60.0 3	71.4 5	33.3 3	29.4 10	19.4 7	32	32.7
Under 36		20.0 1	14.3 1	22.2 2	20.6 7	38.9 14	25	25.5
Under 42	14.3 1		14.3 1	11.1 1	11.8 4	16.7 6	13	13.3
Under 48				11.1 1	8.8 3	5.6 2	6	6.1
Over	14.3 1				8.8 3	2.8 1	5	5.1
Total	7	5	7	9	34	36	98	
Percent	7.1	5.1	7.1	9.2	34.7	36.7		100.0
Mean	2.71	2.00	2.43	2.56	2.85	2.83		2.73
SD	1.70	0.71	0.79	1.33	1.56	1.23		1.34

CONTINGENCY TABLE NO. 2

Phone [*t*]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	50.0 1	66.7 2	20.5 8	50.0 3	7.0 3		17	17.3
Under 30	50.0 1	33.3 1	33.3 13	33.3 2	27.9 12	60.0 3	32	32.7
Under 36			28.2 11	16.7 1	30.2 13		25	25.5
Under 42			12.8 5		16.3 7	20.0 1	13	13.3
Under 48			5.1 2		9.3 4		6	6.1
Over					9.3 4	20.0 1	5	5.1
Total	2	3	39	6	43	5	98	
Percent	2.0	3.1	39.8	6.1	43.9	5.1		100.0
Mean	1.50	1.33	2.49	1.67	3.21	3.20		2.73
SD	0.71	0.58	1.12	0.82	1.39	1.79		1.34

CONTINGENCY TABLE NO. 3

Phone [k]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	50.0 1		22.2 2	50.0 1	17.8 8	12.8 5	17	17.3
Under 30	50.0 1	100.0 1	22.2 2	50.0 1	33.3 15	30.8 12	32	32.7
Under 36			44.4 4		22.2 10	28.2 11	25	25.5
Under 42			11.1 1		13.3 6	15.4 6	13	13.3
Under 48					6.7 3	7.7 3	6	6.1
Over					6.7 3	5.1 2	5	5.1
Total	2	1	9	2	45	39	98	
Percent	2.0	1.0	9.2	2.0	45.9	39.8		100.0
Mean	1.50	2.00	2.44	1.50	2.78	2.90		2.73
SD	0.71	0.	1.01	0.71	1.43	1.33		1.34

CONTINGENCY TABLE NO. 4

Phone [b]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	20.0 1		100.0 1		22.2 8	13.0 7	17	17.3
Under 30	20.0 1			50.0 1	38.9 14	29.6 16	32	32.7
Under 36	20.0 1				16.7 6	33.3 18	25	25.5
Under 42				50.0 1	13.9 5	13.0 7	13	13.3
Under 48					5.6 2	7.4 4	6	6.1
Over	40.0 2				2.8 1	3.7 2	5	5.1
Total	5		1	2	36	54	98	
Percent	5.1		1.0	2.0	36.7	55.1		100.0
Mean	3.60		1.00	3.00	2.50	2.83		2.73
SD	2.30		0.	1.41	1.30	1.26		1.34

CONTINGENCY TABLE NO. 5

Phone [d]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24		33.3 1	20.0 4	14.3 1	16.7 9	15.4 2	17	17.3
Under 30	100.0 1	33.3 1	50.0 10	14.3 1	29.6 16	23.1 3	32	32.7
Under 36			25.0 5	28.6 2	25.9 14	30.8 4	25	25.5
Under 42		33.3 1		14.3 1	13.0 7	30.8 4	13	13.3
Under 48			5.0 1	14.3 1	7.4 4		6	6.1
Over				14.3 1	7.4 4		5	5.1
Total	1	3	20	7	54	13	98	
Percent	1.0	3.1	20.4	7.1	55.1	13.3		100.0
Mean	2.00	2.33	2.20	3.43	2.87	2.77		2.73
SD	0.	1.53	0.95	1.72	1.44	1.09		1.34

CONTINGENCY TABLE NO. 6

Phone [g]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	20.0 1	50.0 4		16.7 1	16.0 4	15.6 7	17	17.3
Under 30	40.0 2	12.5 1	44.4 4	50.0 3	20.0 5	37.8 17	32	32.7
Under 36		25.0 2	44.4 4	33.3 2	36.0 9	17.8 8	25	25.5
Under 42	20.0 1	12.5 1	11.1 1		20.0 5	11.1 5	13	13.3
Under 48	20.0 1				8.0 2	6.7 3	6	6.1
Over						11.1 5	5	5.1
Total	5	8	9	6	25	45	98	
Percent	5.1	8.2	9.2	6.1	25.5	45.9		100.0
Mean	2.80	2.00	2.67	2.17	2.84	2.89		2.73
SD	1.64	1.20	0.71	0.75	1.18	1.56		1.34

CONTINGENCY TABLE NO. 7

Phone [ʃ]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	36.4 8	20.0 1			15.0 3	11.6 5	17	17.3
Under 30	50.0 11	40.0 2		42.9 3	35.0 7	20.9 9	32	32.7
Under 36	9.1 2	40.0 2	100.0 1	14.3 1	20.0 4	34.9 15	25	25.5
Under 42	4.5 1			28.6 2	15.0 3	16.3 7	13	13.3
Under 48					10.0 2	9.3 4	6	6.1
Over				14.3 1	5.0 1	7.0 3	5	5.1
Total	22	5	1	7	20	43	98	
Percent	22.4	5.1	1.0	7.1	20.4	43.9		100.0
Mean	1.82	2.20	3.00	3.29	2.85	3.12		2.73
SD	0.80	0.84	0.	1.50	1.42	1.37		1.34

CONTINGENCY TABLE NO. 8

Phone [v]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	28.0 / 14	12.5 / 2				6.7 / 1	17	17.3
Under 30	42.0 / 21	37.5 / 6		50.0 / 2		20.0 / 3	32	32.7
Under 36	14.0 / 7	37.5 / 6	37.5 / 3	25.0 / 1	40.0 / 2	40.0 / 6	25	25.5
Under 42	6.0 / 3		62.5 / 5	25.0 / 1	20.0 / 1	20.0 / 3	13	13.3
Under 48	6.0 / 3	6.2 / 1			20.0 / 1	6.7 / 1	6	6.1
Over	4.0 / 2	6.2 / 1			20.0 / 1	6.7 / 1	5	5.1
Total	50	16	8	4	5	15	98	
Percent	51.0	16.3	8.2	4.1	5.1	15.3		100.0
Mean	2.32	2.69	3.63	2.75	4.20	3.20		2.73
SD	1.33	1.30	0.52	0.96	1.30	1.26		1.34

CONTINGENCY TABLE NO. 9

Phone [θ]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	23.1 9	22.2 8					17	17.3
Under 30	38.5 15	38.9 14	20.0 1		14.3 1	12.5 1	32	32.7
Under 36	25.6 10	25.0 9	40.0 2	66.7 2	14.3 1	12.5 1	25	25.5
Under 42	5.1 2	11.1 4			42.9 3	50.0 4	13	13.3
Under 48	2.6 1		40.0 2	33.3 1	14.3 1	12.5 1	6	6.1
Over	5.1 2	2.8 1			14.3 1	12.5 1	5	5.1
Total	39	36	5	3	7	8	98	
Percent	39.8	36.7	5.1	3.1	7.1	8.2		100.0
Mean	2.41	2.36	3.60	3.67	4.00	4.00		2.73
SD	1.27	1.13	1.34	1.15	1.29	1.20		1.34

CONTINGENCY TABLE NO. 10

Phone [ð]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	55.6 5	30.0 12					17	17.3
Under 30	33.3 3	37.5 15	31.4 11	50.0 2	14.3 1		32	32.7
Under 36	11.1 1	25.0 10	31.4 11	25.0 1	28.6 2		25	25.5
Under 42		7.5 3	22.9 8		14.3 1	33.3 1	13	13.3
Under 48			8.6 3	25.0 1	14.3 1	33.3 1	6	6.1
Over			5.7 2		28.6 2	33.3 1	5	5.1
Total	9	40	35	4	7	3	98	
Percent	9.2	40.8	35.7	4.1	7.1	3.1		100.0
Mean	1.56	2.10	3.26	3.00	4.14	5.00		2.73
SD	0.73	0.93	1.17	1.41	1.57	1.00		1.34

CONTINGENCY TABLE NO. 11

Phone [*s*]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	50.0 3	66.7 4	22.7 5	25.0 1	8.5 4		17	17.3
Under 30	50.0 3	16.7 1	36.4 8	25.0 1	34.0 16	23.1 3	32	32.7
Under 36		16.7 1	13.6 3	25.0 1	29.8 14	46.2 6	25	25.5
Under 42			13.6 3		17.0 8	15.4 2	13	13.3
Under 48			9.1 2		6.4 3	7.7 1	6	6.1
Over			4.5 1	25.0 1	4.3 2	7.7 1	5	5.1
Total	6	6	22	4	47	13	98	
Percent	6.1	6.1	22.4	4.1	48.0	13.3		100.0
Mean	1.50	1.50	2.64	3.00	2.91	3.31		2.73
SD	0.55	0.84	1.47	2.16	1.23	1.18		1.34

CONTINGENCY TABLE NO. 12

Phone [z]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	40.0 / 4	54.5 / 6	6.2 / 1	18.2 / 2	8.6 / 3	6.7 / 1	17	17.3
Under 30	50.0 / 5	36.4 / 4	50.0 / 8	27.3 / 3	22.9 / 8	26.7 / 4	32	32.7
Under 36			18.7 / 3	54.5 / 6	34.3 / 12	26.7 / 4	25	25.5
Under 42	10.0 / 1		18.7 / 3		17.1 / 6	20.0 / 3	13	13.3
Under 48		9.1 / 1			14.3 / 5		6	6.1
Over			6.2 / 1		2.9 / 1	20.0 / 3	5	5.1
Total	10	11	16	11	35	15	98	
Percent	10.2	11.2	16.3	11.2	35.7	15.3		100.0
Mean	1.80	1.73	2.75	2.36	3.14	3.40		2.73
SD	0.92	1.19	1.24	0.81	1.26	1.59		1.34

CONTINGENCY TABLE NO. 13

Phone [š]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	30.0 6	9.5 2	25.0 4	12.5 1	20.0 2	8.7 2	17	17.3
Under 30	15.0 3	66.7 14	6.2 1	37.5 3	20.0 2	39.1 9	32	32.7
Under 36	30.0 6	14.3 3	37.5 6	12.5 1	30.0 3	26.1 6	25	25.5
Under 42	20.0 4	9.5 2	12.5 2	25.0 2	10.0 1	8.7 2	13	13.3
Under 48			12.5 2	12.5 1	10.0 1	8.7 2	6	6.1
Over	5.0 1		6.2 1		10.0 1	8.7 2	5	5.1
Total	20	21	16	8	10	23	98	
Percent	20.4	21.4	16.3	8.2	10.2	23.5		100.0
Mean	2.60	2.24	3.00	2.88	3.00	2.96		2.73
SD	1.39	0.77	1.55	1.36	1.63	1.43		1.34

CONTINGENCY TABLE NO. 14

Phone [ž]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	17.2 16	25.0 1					17	17.3
Under 30	31.2 29	50.0 2				100.0 1	32	32.7
Under 36	25.8 24	25.0 1					25	25.5
Under 42	14.0 13						13	13.3
Under 48	6.5 6						6	6.1
Over	5.4 5						5	5.1
Total	93	4				1	98	
Percent	94.9	4.1				1.0		100.0
Mean	2.77	2.00				2.00		2.73
SD	1.36	0.82				0.		1.34

CONTINGENCY TABLE NO. 15

Phone [l]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	33.3 1	60.0 9	11.8 6		5.9 1		17	17.3
Under 30	33.3 1	20.0 3	39.2 20	37.5 3	23.5 4	25.0 1	32	32.7
Under 36	33.3 1	13.3 2	29.4 15	25.0 2	23.5 4	25.0 1	25	25.5
Under 42		6.7 1	9.8 5	12.5 1	23.5 4	50.0 2	13	13.3
Under 48			7.8 4		11.8 2		6	6.1
Over			2.0 1	25.0 2	11.8 2		5	5.1
Total	3	15	51	8	17	4	98	
Percent	3.1	15.3	52.0	8.2	17.3	4.1		100.0
Mean	2.00	1.67	2.69	3.50	3.47	3.25		2.73
SD	1.00	0.98	1.17	1.69	1.46	0.96		1.34

CONTINGENCY TABLE NO. 16

Phone [m]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	36.4 4	50.0 1		25.0 1	20.6 7	9.8 4	17	17.3
Under 30	36.4 4	50.0 1	33.3 2	50.0 2	44.1 15	19.5 8	32	32.7
Under 36	18.2 2		16.7 1		23.5 8	34.1 14	25	25.5
Under 42			16.7 1	25.0 1	5.9 2	22.0 9	13	13.3
Under 48			16.7 1		5.9 2	7.3 3	6	6.1
Over	9.1 1		16.7 1			7.3 3	5	5.1
Total	11	2	6	4	34	41	98	
Percent	11.2	2.0	6.1	4.1	34.7	41.8		100.0
Mean	2.18	1.50	3.67	2.25	2.32	3.20		2.73
SD	1.47	0.71	1.63	1.26	1.07	1.33		1.34

CONTINGENCY TABLE NO. 17

Phone [*n*]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	33.3 1	100.0 1	27.3 3	33.3 2	16.4 9	4.5 1	17	17.3
Under 30	33.3 1		36.4 4	66.7 4	29.1 16	31.8 7	32	32.7
Under 36	33.3 1		27.3 3		30.9 17	18.2 4	25	25.5
Under 42			9.1 1		10.9 6	27.3 6	13	13.3
Under 48					9.1 5	4.5 1	6	6.1
Over					3.6 2	13.6 3	5	5.1
Total	3	1	11	6	55	22	98	
Percent	3.1	1.0	11.2	6.1	56.1	22.4		100.0
Mean	2.00	1.00	2.18	1.67	2.78	3.36		2.73
SD	1.00	0.	0.98	0.52	1.32	1.47		1.34

CONTINGENCY TABLE NO. 18

Phone [ŋ]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	36.4 8	11.1 3	10.5 2	25.0 1	9.1 1	13.3 2	17	17.3
Under 30	50.0 11	44.4 12	10.5 2		18.2 2	33.3 5	32	32.7
Under 36	13.6 3	22.2 6	26.3 5	50.0 2	36.4 4	33.3 5	25	25.5
Under 42		11. 1 3	36.8 7		9.1 1	13.3 2	13	13.3
Under 48		11.1 3	15.8 3				6	6.1
Over				25.0 1	27.3 3	6.7 1	5	5.1
Total	22	27	19	4	11	15	98	
Percent	22.4	27.6	19.4	4.1	11.2	15.3		100.0
Mean	1.77	2.67	3.37	3.25	3.55	2.73		2.73
SD	0.69	1.18	1.21	2.06	1.75	1.28		1.34

CONTINGENCY TABLE NO. 19

Phone [h]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	41.7 / 5		28.6 / 2	30.0 / 3	16.7 / 5	5.4 / 2	17	17.3
Under 30	41.7 / 5	100.0 / 2	14.3 / 1	50.0 / 5	33.3 / 10	24.3 / 9	32	32.7
Under 36	8.3 / 1		42.9 / 3	10.0 / 1	23.3 / 7	35.1 / 13	25	25.5
Under 42			14.3 / 1	10.0 / 1	13.3 / 4	18.9 / 7	13	13.3
Under 48					6.7 / 2	10.8 / 4	6	6.1
Over	8.3 / 1				6.7 / 2	5.4 / 2	5	5.1
Total	12	2	7	10	30	37	98	
Percent	12.2	2.0	7.1	10.2	30.6	37.8		100.0
Mean	2.00	2.00	2.43	2.00	2.80	3.22		2.73
SD	1.41	0.	1.13	0.94	1.42	1.25		1.34

CONTINGENCY TABLE NO. 20

Phone [*r*]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	21.0 13	16.7 2			50.0 1	5.0 1	17	17.3
Under 30	30.6 19	58.3 7		50.0 1		25.0 5	32	32.7
Under 36	24.2 15	16.7 2				40.0 8	25	25.5
Under 42	12.9 8	8.3 1			50.0 1	15.0 3	13	13.3
Under 48	6.5 4			50.0 1		5.0 1	6	6.1
Over	4.8 3					10.0 2	5	5.1
Total	62	12		2	2	20	98	
Percent	63.3	12.2		2.0	2.0	20.4		100.0
Mean	2.68	2.17		3.50	2.50	3.20		2.73
SD	1.38	0.83		2.12	2.12	1.32		1.34

CONTINGENCY TABLE NO. 21

Phone [ʔ]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	20.2 17						17	17.3
Under 30	34.5 29	50.0 2				11.1 1	32	32.7
Under 36	23.8 20	25.0 1				44.4 4	25	25.5
Under 42	13.1 11				100.0 1	11.1 1	13	13.3
Under 48	6.0 5					11.1 1	6	6.1
Over	2.4 2	25.0 1				22.2 2	5	5.1
Total	84	4			1	9	98	
Percent	85.7	4.1			1.0	9.2		100.0
Mean	2.57	3.25			4.00	3.89		2.73
SD	1.25	1.89			0.	1.45		1.34

CONTINGENCY TABLE NO. 22

Phone [*i*]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	100.0 1				15.4 8	19.0 8	17	17.3
Under 30				66.7 2	36.5 19	26.2 11	32	32.7
Under 36				33.3 1	26.9 14	23.8 10	25	25.5
Under 42					7.7 4	21.4 9	13	13.3
Under 48					9.6 5	2.4 1	6	6.1
Over					3.8 2	7.1 3	5	5.1
Total	1			3	52	42	98	
Percent	1.0			3.1	53.1	42.9		100.0
Mean	1.00			2.33	2.71	2.83		2.73
SD	0.			0.58	1.32	1.41		1.34

CONTINGENCY TABLE NO. 23

Phone [*I*]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	100.0 1	50.0 3	5.3 1		15.4 8	23.5 4	17	17.3
Under 30		50.0 3	21.1 4	66.7 2	34.6 18	29.4 5	32	32.7
Under 36			36.8 7	33.3 1	25.0 13	23.5 4	25	25.5
Under 42			21.1 4		11.5 6	17.6 3	13	13.3
Under 48			15.8 3		5.8 3		6	6.1
Over					7.7 4	5.9 1	5	5.1
Total	1	6	19	3	52	17	98	
Percent	1.0	6.1	19.4	3.1	53.1	17.3		100.0
Mean	1.00	1.50	3.21	2.33	2.81	2.59		2.73
SD	0.	0.55	1.13	0.58	1.41	1.37		1.34

CONTINGENCY TABLE NO. 24

Phone [ε]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	38.5 5	31.2 5	11.1 1	50.0 5		5.0 1	17	17.3
Under 30	23.1 3	31.2 5	44.4 4	30.0 3	26.7 8	45.0 9	32	32.7
Under 36	23.1 3	31.2 5	22.2 2	20.0 2	23.3 7	30.0 6	25	25.5
Under 42	7.7 1	6.2 1	11.1 1		30.0 9	5.0 1	13	13.3
Under 48					13.3 4	10.0 2	6	6.1
Over	7.7 1		11.1 1		6.7 2	5.0 1	5	5.1
Total	13	16	9	10	30	20	98	
Percent	13.3	16.3	9.2	10.2	30.6	20.4		100.0
Mean	2.31	2.13	2.78	1.70	3.50	2.85		2.73
SD	1.49	0.96	1.48	0.82	1.22	1.27		1.34

CONTINGENCY TABLE NO. 25

Phone [æ]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	100.0 2	33.3 1		16.7 1	14.3 8	19.2 5	17	17.3
Under 30		66.7 2	20.0 1	50.0 3	32.1 18	30.8 8	32	32.7
Under 36			20.0 1	16.7 1	25.0 14	34.6 9	25	25.5
Under 42			20.0 1		14.3 8	15.4 4	13	13.3
Under 48			20.0 1	16.7 1	7.1 4		6	6.1
Over			20.0 1		7.1 4		5	5.1
Total	2	3	5	6	56	26	98	
Percent	2.0	3.1	5.1	6.1	57.1	26.5		100.0
Mean	1.00	1.67	4.00	2.50	2.89	2.46		2.73
SD	0.	0.58	1.58	1.38	1.41	0.99		1.34

CONTINGENCY TABLE NO. 26

Phone [ə]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	18.6 / 11	6.7 / 1	60.0 / 3	50.0 / 1		6.7 / 1	17	17.3
Under 30	35.6 / 21	40.0 / 6	20.0 / 1			26.7 / 4	32	32.7
Under 36	22.0 / 13	33.3 / 5			50.0 / 1	40.0 / 6	25	25.5
Under 42	11.9 / 7	20.0 / 3			50.0 / 1	13.3 / 2	13	13.3
Under 48	5.1 / 3			50.0 / 1		13.3 / 2	6	6.1
Over	6.8 / 4		20.0 / 1				5	5.1
Total	59	15	5	2	2	15	98	
Percent	60.2	15.3	5.1	2.0	2.0	15.3		100.0
Mean	2.69	2.67	2.20	3.00	3.50	3.00		2.73
SD	1.41	0.90	2.17	2.83	0.71	1.13		1.34

CONTINGENCY TABLE NO. 27

Phone [ʌ]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	50.0 1	50.0 1	26.7 4	75.0 3	8.5 5	18.7 3	17	17.3
Under 30	50.0 1	50.0 1	46.7 7	25.0 1	33.9 20	12.5 2	32	32.7
Under 36			6.7 1		32.2 19	31.2 5	25	25.5
Under 42			13.3 2		11.9 7	25.0 4	13	13.3
Under 48			6.7 1		5.1 3	12.5 2	6	6.1
Over					8.5 5		5	5.1
Total	2	2	15	4	59	16	98	
Percent	2.0	2.0	15.3	4.1	60.2	16.3		100.0
Mean	1.50	1.50	2.27	1.25	2.97	3.00		2.73
SD	0.71	0.71	1.22	0.50	1.34	1.32		1.34

CONTINGENCY TABLE NO. 28

Phone [a]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	28.6 4		50.0 1		5.9 1	19.6 11	17	17.3
Under 30	28.6 4			40.0 2	58.8 10	28.6 16	32	32.7
Under 36	35.7 5	50.0 2	50.0 1		11.8 2	26.8 15	25	25.5
Under 42	7.1 1	50.0 2			11.8 2	14.3 8	13	13.3
Under 48				20.0 1	11.8 2	5.4 3	6	6.1
Over				40.0 2		5.4 3	5	5.1
Total	14	4	2	5	17	56	98	
Percent	14.3	4.1	2.0	5.1	17.3	57.1		100.0
Mean	2.21	3.50	2.00	4.20	2.65	2.73		2.73
SD	0.97	0.58	1.41	2.05	1.17	1.37		1.34

CONTINGENCY TABLE NO. 29

Phone [*u*]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	31.2 5	16.7 1	36.4 4	33.3 1	10.5 2	9.3 4	17	17.3
Under 30	18.7 3	50.0 3	27.3 3	33.3 1	36.8 7	34.9 15	32	32.7
Under 36	25.0 4			33.3 1	15.8 3	39.5 17	25	25.5
Under 42	18.7 3	33.3 2	18.2 2		15.8 3	7.0 3	13	13.3
Under 48			18.2 2		15.8 3	2.3 1	6	6.1
Over	6.2 1				5.3 1	7.0 3	5	5.1
Total	16	6	11	3	19	43	98	
Percent	16.3	6.1	11.2	3.1	19.4	43.9		100.0
Mean	2.56	2.50	2.55	2.00	3.05	2.79		2.73
SD	1.46	1.22	1.63	1.00	1.47	1.23		1.34

CONTINGENCY TABLE NO. 30

Phone [U]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	18.7 / 6	21.4 / 3		28.6 / 2	11.1 / 1	15.2 / 5	17	17.3
Under 30	21.9 / 7	64.3 / 9	33.3 / 1	14.3 / 1	55.6 / 5	27.3 / 9	32	32.7
Under 36	34.4 / 11			42.9 / 3	22.2 / 2	27.3 / 9	25	25.5
Under 42	9.4 / 3	7.1 / 1	66.7 / 2	14.3 / 1		18.2 / 6	13	13.3
Under 48	9.4 / 3					9.1 / 3	6	6.1
Over	6.2 / 2	7.1 / 1			11.1 / 1	3.0 / 1	5	5.1
Total	32	14	3	7	9	33	98	
Percent	32.7	14.3	3.1	7.1	9.2	33.7		100.0
Mean	2.88	2.21	3.33	2.43	2.56	2.88		2.73
SD	1.43	1.31	1.15	1.13	1.42	1.32		1.34

CONTINGENCY TABLE NO. 31

Phone [ɔ]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	33.3 1	38.5 5	25.0 1		16.7 7	10.0 3	17	17.3
Under 30	66.7 2	30.8 4	50.0 2	50.0 3	31.0 13	26.7 8	32	32.7
Under 36		15.4 2		50.0 3	26.2 11	30.0 9	25	25.5
Under 42					16.7 7	20.0 6	13	13.3
Under 48		15.4 2			2.4 1	10.0 3	6	6.1
Over			25.0 1		7.1 3	3.3 1	5	5.1
Total	3	13	4	6	42	30	98	
Percent	3.1	13.3	4.1	6.1	42.9	30.6		100.0
Mean	1.67	2.23	2.75	2.50	2.79	3.03		2.73
SD	0.58	1.42	2.22	0.55	1.37	1.27		1.34

CONTINGENCY TABLE NO. 32

Phone [i̥]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	28.8 15	4.8 1		33.3 1			17	17.3
Under 30	26.9 14	38.1 8	40.0 2	66.7 2	50.0 1	33.3 5	32	32.7
Under 36	23.1 12	23.8 5	60.0 3			33.3 5	25	25.5
Under 42	9.6 5	23.8 5			50.0 1	13.3 2	13	13.3
Under 48	5.8 3	9.5 2				6.7 1	6	6.1
Over	5.8 3					13.3 2	5	5.1
Total	52	21	5	3	2	15	98	
Percent	53.1	21.4	5.1	3.1	2.0	15.3		100.0
Mean	2.54	2.95	2.60	1.67	3.00	3.33		2.73
SD	1.45	1.12	0.55	0.58	1.41	1.40		1.34

CONTINGENCY TABLE NO. 33

Phone [ɭ]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	15.2 7	19.2 5		50.0 3		18.2 2	17	17.3
Under 30	37.0 17	23.1 6	33.3 1	33.3 2	50.0 3	27.3 3	32	32.7
Under 36	23.9 11	30.8 8	33.3 1	16.7 1	33.3 2	18.2 2	25	25.5
Under 42	13.0 6	11.5 3			16.7 1	27.3 3	13	13.3
Under 48	4.3 2	7.7 2	33.3 1			9.1 1	6	6.1
Over	6.5 3	7.7 2					5	5.1
Total	46	26	3	6	6	11	98	
Percent	46.9	26.5	3.1	6.1	6.1	11.2		100.0
Mean	2.74	2.88	3.33	1.67	2.67	2.82		2.73
SD	1.36	1.48	1.53	0.82	0.82	1.33		1.34

CONTINGENCY TABLE NO. 34

Phone [ɛ]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	46.7 7	15.4 4	11.1 2	27.3 3	6.7 1		17	17.3
Under 30	26.7 4	46.2 12	38.9 7	27.3 3	20.0 3	23.1 3	32	32.7
Under 36	13.3 2	23.1 6	38.9 7	18.2 2	33.3 5	23.1 3	25	25.5
Under 42	13.3 2	7.7 2	5.6 1	9.1 1	26.7 4	23.1 3	13	13.3
Under 48		3.8 1	5.6 1		13.3 2	15.4 2	6	6.1
Over		3.8 1		18.2 2		15.4 2	5	5.1
Total	15	26	18	11	15	13	98	
Percent	15.3	26.5	18.4	11.2	15.3	13.3		100.0
Mean	1.93	2.50	2.56	2.82	3.20	3.77		2.73
SD	1.10	1.21	0.98	1.83	1.15	1.42		1.34

CONTINGENCY TABLE NO. 35

Phone [æ]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	24.6 / 14	10.0 / 2	33.3 / 1				17	17.3
Under 30	31.6 / 18	40.0 / 8	33.3 / 1	66.7 / 2		20.0 / 3	32	32.7
Under 36	26.3 / 15	30.0 / 6		33.3 / 1		20.0 / 3	25	25.5
Under 42	5.3 / 3	15.0 / 3	33.3 / 1			40.0 / 6	13	13.3
Under 48	7.0 / 4	5.0 / 1				6.7 / 1	6	6.1
Over	5.3 / 3					13.3 / 2	5	5.1
Total	57	20	3	3		15	98	
Percent	58.2	20.4	3.1	3.1		15.3		100.0
Mean	2.54	2.65	2.33	2.33		3.73		2.73
SD	1.39	1.04	1.53	0.58		1.28		1.34

CONTINGENCY TABLE NO. 36

Phone [ə]

	Blank		All wrong		Some right		Half right		Most right		All right		Total	Percent
Under 24	45.5	5	37.5	9	9.1	2			5.0	1			17	17.3
Under 30	45.5	5	37.5	9	40.9	9	16.7	1	20.0	4	26.7	4	32	32.7
Under 36	9.1	1	12.5	3	13.6	3	66.7	4	45.0	9	33.3	5	25	25.5
Under 42			4.2	1	18.2	4	16.7	1	15.0	3	26.7	4	13	13.3
Under 48			8.3	2	4.5	1			10.0	2	6.7	1	6	6.1
Over					13.6	3			5.0	1	6.7	1	5	5.1
Total		11		24		22		6		20		15	98	
Percent	11.2		24.5		22.4		6.1		20.4		15.3			100.0
Mean	1.64		2.08		3.09		3.00		3.20		3.33			2.73
SD	0.67		1.21		1.57		0.63		1.20		1.18			1.34

CONTINGENCY TABLE NO. 37

Phone [ʌ̣]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	21.9 14	11.5 3					17	17.3
Under 30	34.4 22	30.8 8		50.0 1		16.7 1	32	32.7
Under 36	23.4 15	34.6 9				16.7 1	25	25.5
Under 42	10.9 7	15.4 4				33.3 2	13	13.3
Under 48	4.7 3			50.0 1		33.3 2	6	6.1
Over	4.7 3	7.7 2					5	5.1
Total	64	26		2		6	98	
Percent	65.3	26.5		2.0		6.1		100.0
Mean	2.56	2.85		3.50		3.83		2.73
SD	1.33	1.29		2.12		1.17		1.34

CONTINGENCY TABLE NO. 38

Phone [ɑ̜]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	29.6 8	24.2 8				7.7 1	17	17.3
Under 30	33.3 9	33.3 11	25.0 3	37.5 3	20.0 1	38.5 5	32	32.7
Under 36	25.9 7	30.3 10	16.7 2	25.0 2	40.0 2	15.4 2	25	25.5
Under 42	7.4 2	6.1 2	41.7 5	25.0 2	20.0 1	7.7 1	13	13.3
Under 48	3.7 1	6.1 2		12.5 1		15.4 2	6	6.1
Over			16.7 2		20.0 1	15.4 2	5	5.1
Total	27	33	12	8	5	13	98	
Percent	27.6	33.7	12.2	8.2	5.1	13.3		100.0
Mean	2.22	2.36	3 67	3.13	3.60	3.31		2.73
SD	1.09	1.11	1.37	1.13	1.52	1.70		1.34

CONTINGENCY TABLE NO. 39

Phone [ʉ]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	21.5 17						17	17.3
Under 30	32.9 26	33.3 3		33.3 1	100.0 1	16.7 1	32	32.7
Under 36	22.8 18	33.3 3		66.7 2		33.3 2	25	25.5
Under 42	10.1 8	33.3 3				33.3 2	13	13.3
Under 48	6.3 5					16.7 1	6	6.1
Over	6.3 5						5	5.1
Total	79	9		3	1	6	98	
Percent	80.6	9.2		3.1	1.0	6.1		100.0
Mean	2.66	3.00		2.67	2.00	3.50		2.73
SD	1.42	0.87		0.58	0.	1.05		1.34

CONTINGENCY TABLE NO. 40

Phone [Ų]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	17.9 17						17	17.3
Under 30	33.7 32						32	32.7
Under 36	26.3 25						25	25.5
Under 42	10.5 10		100.0 1			100.0 2	13	13.3
Under 48	6.3 6						6	6.1
Over	5.3 5						5	5.1
Total	95		1			2	98	
Percent	96.9		1.0			2.0		100.0
Mean	2.69		4.00			4.00		2.73
SD	1.35		0.			0.		1.34

CONTINGENCY TABLE NO. 41

Phone [ʔ]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	31.6 6	25.8 8	10.0 1		16.7 1	4.5 1	17	17.3
Under 30	31.6 6	38.7 12	50.0 5	20.0 2	16.7 1	27.3 6	32	32.7
Under 36	15.8 3	25.8 8	10.0 1	50.0 5	16.7 1	31.8 7	25	25.5
Under 42	10.5 2	6.5 2		20.0 2	50.0 3	18.2 4	13	13.3
Under 48		3.2 1	10.0 1	10.0 1		13.6 3	6	6.1
Over	10.5 2		20.0 2			4.5 1	5	5.1
Total Percent	19 19.4	31 31.6	10 10.2	10 10.2	6 6.1	22 22.4	98	 100.0
Mean SD	2.47 1.58	2.23 1.02	3.10 1.85	3.20 0.92	3.00 1.26	3.23 1.27		2.73 1.34

CONTINGENCY TABLE NO. 42

Phone [ɔw]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	20.0 2	33.3 2	50.0 3		12.1 4	14.6 6	17	17.3
Under 30	50.0 5	33.3 2	16.7 1	100.0 2	27.3 9	31.7 13	32	32.7
Under 36	20.0 2	16.7 1	16.7 1		24.2 8	31.7 13	25	25.5
Under 42	10.0 1	16.7 1			21.2 7	9.8 4	13	13.3
Under 48					12.1 4	4.9 2	6	6.1
Over			16.7 1		3.0 1	7.3 3	5	5.1
Total	10	6	6	2	33	41	98	
Percent	10.2	6.1	6.1	2.0	33.7	41.8		100.0
Mean	2.20	2.17	2.33	2.00	3.03	2.80		2.73
SD	0.92	1.17	1.97	0.	1.33	1.36		1.34

CONTINGENCY TABLE NO. 43

Phone [aw]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	25.9 7	11.1 1		22.2 2	23.5 4	9.4 3	17	17.3
Under 30	37.0 10	33.3 3		33.3 3	29.4 5	34.4 11	32	32.7
Under 36	18.5 5	22.2 2	25.0 1	22.2 2	17.6 3	37.5 12	25	25.5
Under 42	7.4 2	11.1 1	25.0 1	22.2 2	17.6 3	12.5 4	13	13.3
Under 48	11.1 3	11.1 1	25.0 1			3.1 1	6	6.1
Over		11.1 1	25.0 1		11.8 2	3.1 1	5	5.1
Total	27	9	4	9	17	32	98	
Percent	27.6	9.2	4.1	9.2	17.3	32.7		100.0
Mean	2.41	3.11	4.50	2.44	2.76	2.75		2.73
SD	1.28	1.62	1.29	1.13	1.60	1.11		1.34

CONTINGENCY TABLE NO. 44

Phone [εy]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	16.7 3	77.8 7	10.0 1	20.0 1	10.0 2	8.3 3	17	17.3
Under 30	38.9 7	22.2 2	40.0 4	60.0 3	35.0 7	25.0 9	32	32.7
Under 36	11.1 2		30.0 3	20.0 1	20.0 4	41.7 15	25	25.5
Under 42	16.7 3				25.0 5	13.9 5	13	13.3
Under 48	11.1 2				10.0 2	5.6 2	6	6.1
Over	5.6 1		20.0 2			5.6 2	5	5.1
Total	18	9	10	5	20	36	98	
Percent	18.4	9.2	10.2	5.1	20.4	36.7		100.0
Mean	2.83	1.22	3.00	2.00	2.90	3.00		2.73
SD	1.50	0.44	1.70	0.71	1.21	1.22		1.34

CONTINGENCY TABLE NO. 45

Phone [ay]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	42.9 3	40.0 2	40.0 2	33.3 1	16.1 5	8.5 4	17	17.3
Under 30	28.6 2	60.0 3	20.0 1	33.3 1	29.0 9	34.0 16	32	32.7
Under 36	28.6 2				25.8 8	31.9 15	25	25.5
Under 42			20.0 1	33.3 1	16.1 5	12.8 6	13	13.3
Under 48			20.0 1		3.2 1	8.5 4	6	6.1
Over					9.7 3	4.3 2	5	5.1
Total	7	5	5	3	31	47	98	
Percent	7.1	5.1	5.1	3.1	31.6	48.0		100.0
Mean	1.86	1.60	2.60	2.33	2.90	2.91		2.73
SD	0.90	0.55	1.82	1.53	1.47	1.25		1.34

CONTINGENCY TABLE NO. 46

Phone [ɔy]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	19.8 17						17	17.3
Under 30	26.7 23	100.0 2	100.0 1	100.0 1	100.0 1	57.1 4	32	32.7
Under 36	26.7 23					28.6 2	25	25.5
Under 42	14.0 12					14.3 1	13	13.3
Under 48	7.0 6						6	6.1
Over	5.8 5						5	5.1
Total	86	2	1	1	1	7	98	
Percent	87.8	2.0	1.0	1.0	1.0	7.1		100.0
Mean	2.79	2.00	2.00	2.00	2.00	2.57		2.73
SD	1.41	0.	0.	0.	0.	0.79		1.34

CONTINGENCY TABLE NO. 47

Phone [*w*]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	36.8 7	44.4 4	20.0 1	20.0 2		10.3 3	17	17.3
Under 30	31.6 6	33.3 3	60.0 3	20.0 2	38.5 10	27.6 8	32	32.7
Under 36	21.1 4	11.1 1	20.0 1	40.0 4	23.1 6	31.0 9	25	25.5
Under 42	5.3 1	11.1 1		10.0 1	30.8 8	6.9 2	13	13.3
Under 48	5.3 1			10.0 1	3.8 1	10.3 3	6	6.1
Over					3.8 1	13.8 4	5	5.1
Total	19	9	5	10	26	29	98	
Percent	19.4	9.2	5.1	10.2	26.5	29.6		100.0
Mean	2.11	1.89	2.00	2.70	3.12	3.21		2.73
SD	1.15	1.05	0.71	1.25	1.11	1.57		1.34

CONTINGENCY TABLE NO. 48

Phone [*y*]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	28.9 13	25.0 3				3.3 1	17	17.3
Under 30	33.3 15	50.0 6	33.3 1	20.0 1		30.0 9	32	32.7
Under 36	28.9 13	16.7 2		40.0 2		26.7 8	25	25.5
Under 42	6.7 3		33.3 1	20.0 1	33.3 1	23.3 7	13	13.3
Under 48			33.3 1	20.0 1	33.3 1	10.0 3	6	6.1
Over	2.2 1	8.3 1			33.3 1	6.7 2	5	5.1
Total	45	12	3	5	3	30	98	
Percent	45.9	12.2	3.1	5.1	3.1	30.6		100.0
Mean	2.22	2.25	3.67	3.40	5.00	3.27		2.73
SD	1.08	1.36	1.53	1.14	1.00	1.28		1.34

CONTINGENCY TABLE NO. 49

Phone [w̥]

	Blank	All wrong	Some right	Half right	Most right	All right	Total	Percent
Under 24	21.0 13	28.6 2				9.5 2	17	17.3
Under 30	35.5 22	28.6 2		50.0 2	33.3 1	23.8 5	32	32.7
Under 36	24.2 15	28.6 2	100.0 1	25.0 1	66.7 2	19.0 4	25	25.5
Under 42	9.7 6	14.3 1				28.6 6	13	13.3
Under 48	4.8 3					14.3 3	6	6.1
Over	4.8 3			25.0 1		4.8 1	5	5.1
Total	62	7	1	4	3	21	98	
Percent	63.3	7.1	1.0	4.1	3.1	21.4		100.0
Mean	2.56	2.29	3.00	3.25	2.67	3.29		2.73
SD	1.33	1.11	0.	1.89	0.58	1.38		1.34

Before turning to the vicissitudes of the acquisition of particular phones, we pause to examine, in the light of these data, the traditional notion that phones are learned all in one jump. While it is true that some workers, notably Leopold, have recognized that the matter was not so simple, most investigators have proceeded as if a phone were, at any given time, either acquired or not acquired. Moreover, even in the cases where careful workers have noted that correct and incorrect attempts were interspersed, the actual extent of the coexistence is obscured by the decision to concentrate, in the interpretation, upon the time of acquisition, defined as relatively stable control of the phone. The contingency tables above reveal a rather different picture. If we leave out the column labeled "blank", on the grounds that a child who did not attempt a phone in this sample reveals nothing about the coexistence of error and success, we may compare the other five columns. The three columns labeled "some right", "half right", and "most right" all record the coexistence of success and error since all children in those columns have at least one right and at least one wrong for the phone in question. If we add the totals for those columns and compare the results with columns 2 "all wrong" and 6 "all right" we get a better measure of the degree to which success and error coexist at any given moment in the developmental process. The results are summarized in Table 27 below:

TABLE 27

	Blank	All wrong	Some wrong, some right	All right
p	7.1	5.1	51.	36.7
t	2.0	3.1	89.8	5.1
k	2.0	1.	59.2	39.8
b	5.1	—	39.7	55.1
d	1.	3.1	82.6	13.3
g	5.1	8.2	40.8	45.9
f	22.4	5.1	28.5	43.9
v	51.0	16.3	17.4	15.3
θ	39.8	36.7	15.3	8.2

Table 27 (continued)

	Blank	All wrong	Some wrong, some right	All right
ð	9.2	40.8	46.9	3.1
s	6.1	6.1	74.5	13.3
z	10.2	11.2	63.2	15.3
š	20.4	21.4	34.7	23.5
ž	94.9	4.1	—	1.
l	3.1	15.3	77.5	4.1
m	11.2	2.0	44.9	41.8
n	3.1	1.0	73.4	22.4
ŋ	22.4	27.6	34.7	15.3
h	12.2	2.0	47.9	37.8
r	63.3	12.2	4.0	20.4
ʔ	85.7	4.1	1.	9.2
w	19.4	9.2	41.8	29.6
y	45.9	12.2	11.3	30.6
w̥	63.3	7.1	8.2	21.4
i	1.	—	56.2	42.9
I	1.	6.1	75.6	17.3
ɛ	13.3	16.3	50.0	20.4
æ	2.	3.1	68.3	26.5
ə	60.2	15.3	9.1	15.3
ʌ	2.	2.	79.6	16.3
a	14.3	4.1	24.4	57.1
u	16.3	6.1	33.7	43,9
U	32.7	14.3	19.4	33.7
ɔ	3.1	13.3	53.1	30.6
į	53.1	21.4	10.2	15.3
Į	46.9	26.5	15.3	11.2
ę	15.3	26.5	44.9	13.3
æ̨	58.2	20.4	6.2	15.3
ə̨	11.2	24.5	48.9	15.3
ʌ̨	65.3	26.5	2.0	6.1
ą	27.6	33.7	25.5	13.3
ų	80.6	9.2	4.1	6.1
Ų	96.9	—	1.0	2.0
ɔ̨	19.4	31.6	26.5	22.4
ɔw	10.2	6.1	49.9	41.8
aw	27.6	9.2	30.6	32.7
ɛy	18.4	9.2	35.7	36.7
ay	7.1	5.1	39.8	48.0
ɔy	87.8	2.	3.	7.1

The phones listed above may be divided into three groups, depending upon which column has the largest percentage: all wrong, all right, or some right-some wrong. They are as follows:
All wrong: θ, i̦, I̦, æ̦, ʌ̦, a̦, u̦, ɔ̦, ž.
All right: b, g, f, r, y, w̥, a, u, U, U̦, aw, ɛy, ay, ɔy, ʔ.
Some right, some wrong: p, t, k, d, v, ð, s, z, š, l, m, n, ŋ, h, w, i, I, ɛ, æ, ʌ, ɔ, ɛ̦, ə̦, ɔw.
(The only exception is 'ə', which happens to show identical percentages of children who got the phone all right and all wrong.)

Thus, it turns out that 24 phones or combinations have the largest percentage of children with "some right-some wrong", 9 phones have the largest percentage with "all wrong", and 15 have the largest percentage with "all right". The latter two categories contain the phones that were very rarely attempted. In fact, if we compare the phones where the most frequent pattern was "some right some wrong" with all the others (including 'ə'), we find that the coexistence of success and error is strongly correlated with the extent to which the phone is attempted. The phones in the "some right-some wrong" group were attempted, on the average, by 88.8% of the children. The phones in the other groups, in contrast, were attempted by only 54.5 % of the children. In short, it looks as if the better sample of attempts we obtain, the stronger the tendency for there to be coexistence of success and error. For all the phones attempted in this sample, averaged together, the percentage of children who had "some right-some wrong" was 50.8.

The coexistence of success and error is further revealed by an analysis of the performance of individual children. Every child had at least one phone with both successess and errors, the range being between the child who had only one such and the one who showed 33 such phones. When it is remembered that 12 phones were rarely attempted (i.e., not attempted by 50% or more of the children), it is impressive that 65% of the children had more than fifteen phones with both successes and errors. 50% of the children had nineteen or more such phones.

That is to say that in this sample, The coexistence of success and error is:

1. the most frequent pattern among phones
2. the most frequent pattern among children
3. more frequent as a function of the representativeness of the sample.

We shall return to various aspects of this question later; for the moment these data seem enough to establish the widespread coexistence of success and error in attempts to pronounce the same phone and to cast very serious doubt upon the findings of studies whose bases included the assumption that phones are learned all in one jump. Indeed, as has been pointed out in Chapter 4, their methods often precluded recording the coexistence of success and error; thus the assumption remained virtually inviolate for many years because the results could never provide a direct test of it[1].

[1] The outstanding work of Gvozdev (1961, e.g. p. 52 ff.) is an exception to the suggestion that previous workers have tended to overlook the coexistence of success and error in developmental phonetics. He tells the reader that such-and-such a phone was substituted for another 'always', 'often', 'occasionally', 'twice', 'once' and so on. Moreover, Gvozdev's work is rich in examples of utterances showing the performances being discussed. Unfortunately, Gvozdev's failure to give the actual frequenties of substitutions in most cases makes impossible a point-for-point comparison of his results with ours. Since we are concerned here with testing a theory about the acquisition of English phones, the lack is not too serious. In any event, Gvozdev's work contains such a wealth of data that it, like Leopold's, seems certain to be indispensable to anyone who undertakes to write a comprehensive account of developmental phonetics.

6

SOME FACTORS INFLUENCING PHONOLOGICAL ACQUISITION

"...the boundless chaos of a living speech..."
Samuel Johnson

Once again we consider phones without regard to their position in the utterance, i.e., pooling the results from initial, medial and final positions. Before considering the effects of age, position in the utterance, or type of phone, it will be useful to register the frequency of attempts and percentage of successes for each phone, overall.

Table 28 reveals that phones differed greatly in the number of children attempting them.

TABLE 28

Basic Data Statistics

No.		Number of Children attempting the phone	Mean % Correct	SD of % correct
1	p	91*	75.5%	28.4%
2	t	96*	52.2%	26.9%
3	k	96*	80.4%	23.6%
4	b	93*	90.4%	14.8%
5	d	97*	64.9%	24.4%
6	g	93*	75.9%	31.8%
7	f	76*	81.9%	27.9%
8	v	48*	46.8%	43.4%
9	θ	59*	25.7%	37.7%
10	ð	89*	20.3%	27.2%
11	s	92*	61.4%	30.8%

Table 28 (continued)

No.		Number of children attempting the phone	Mean % correct	SD of % correct
12	z	88*	57.6%	32.2%
13	š	78*	49.4%	40.1%
14	ž	5*	20.0%	44.7%
15	l	95*	33.5%	28.3%
16	m	87*	81.1%	24.3%
17	n	95*	75.3%	22.4%
18	ŋ	76*	38.8%	40.0%
19	h	86*	77.7%	26.0%
20	r	36*	62.4%	46.5%
21	ʔ	14*	69.0%	46.2%
22	i	97*	90.6%	11.8%
23	I	97*	67.0%	28.5%
24	ɛ	85*	58.5%	35.5%
25	æ	96*	77.4%	23.0%
26	ə	39*	48.4%	45.0%
27	ʌ	96*	71.5%	25.1%
28	a	84*	85.2%	26.4%
29	u	82*	76.7%	31.5%
30	U	66*	66.6%	40.2%
31	ɔ	95*	68.7%	33.8%
32	į	46*	42.2%	44.6%
33	Į	52*	36.7%	41.3%
34	ɛ̨	83*	40.6%	36.6%
35	æ̨	41*	42.5%	46.5%
36	ə̨	87*	44.5%	38.7%
37	ʌ̨	34*	20.6%	39.2%
38	ą	71*	33.6%	39.2%
39	ų	19*	43.7%	45.7%
40	Ų	3*	77.8%	38.5%
41	ɔ̨	79*	42.9%	42.1%
42	ɔw	88*	78.6%	29.5%
43	aw	71*	71.2%	34.5%
44	ɛy	80*	70.5%	35.2%
45	ay	91*	80.2%	28.0%
46	ɔy	12*	70.8%	40.3%
47	w	79*	69.7%	33.2%
48	y	53*	67.2%	41.9%
49	w̥	36*	70.6%	40.1%

Although no phone was attempted by fewer than three children, no one phone was attempted by all 98 children in this sub-sample. (The sample excludes those two children whose performance was so nearly perfect that only their errors were scored.) The numbers of children attempting the various phones are displayed below in Table 29.

TABLE 29

No. of Children attempting															
90-97	p	t	k	b	d	g	s	l	n	i	I	æ	ʌ	ɔ	ay
80-89	ð	z	m	h	e	a	u	ę	ə̧	ɔw	ɛy				
70-79	f	š	ŋ	ą	ɔ̧	aw	w								
60-69	U														
50-59	θ	I̧	y												
40-49	v	ị	æ̧												
30-39	r	ə	ʌ̧	w̥											
20-29															
10-19	?	ų	ɔy												
3- 9	ž	Ų													

Thus it can be seen that 37 of the 49 phones (and combinations) were attempted by 50 or more of the 98 children; only twelve phones and combinations fell below this standard. It thus appears that about 75% of the phones treated in this study were attempted by sufficiently many children (50% or more) to support conclusions about rates of acquisition.

It does not follow that the phones attempted by fewer children are necessarily rare in the language (though it may be so), because some of the children had such small samples of speech that they were bound not to attempt some of the phones. The total group of 100 children produced a corpus of 47,533 phones attempted, giving a mean number of attempts per child of 475. The median was 275 and the standard deviation 651. Some idea of the individual differences is conveyed by the following table:

TABLE 30

Taciturnity-Loquacity Scale (by tenths of the group of children)	Corpus size (number of phones attempted)
Most Taciturn tenth	23 to 68
2nd tenth	85 to 132
3rd tenth	144 to 196
4th tenth	198 to 227
5th tenth	229 to 273
6th tenth	278 to 319
7th tenth	334 to 392
8th tenth	400 to 579
9th tenth	584 to 885
Most loquacious tenth	1198 to 4328

The smallest corpus is 23, the largest 4328; from the standpoint of the study of acquisition alone, it might have been advisable to exclude those children (say, the most taciturn tenth) whose corpora were so small that they failed to attempt many of the phones. However, the reader will remember that the original purpose of the study was to test a theory about ERRORS; one of the postulates of that theory was that corpus size did not matter much as far as prediction of errors was concerned. In order to obtain some idea about the degree to which that postulate is realistic, the smaller samples had to be retained. In fact, it turns out that the theory predicts somewhat less well about the proportions of errors in the smaller samples, but generally holds good even among them.

An indication of the degree to which phones were attempted is to be found by considering individual performances. At the lower end, two children attempted only 12 phones each, while at the upper end, two children attempted 45 out of the 49 phones and combinations. The mean was 35 phones and the median was 37. On the average, then, the children in the sample attempted about 35 phones each, a point worth remembering when we come to consider number of phones passed, below.

In addition to the number of children who attempted each phone, we need to take account of the number of times it was attempted. The average number of times each phone was attempted is displayed in Table 31:

TABLE 31

Phone	No. of Children	Mean Attempts	SD	Skewness	Logarithm of (number of tries + .5)		
					Mean	SD	Skewness
p	98	5.439	4.638	1.382	1.440	0.917	–0.647
t	98	18.755	16.194	2.774	2.641	0.902	–1.202
k	98	11.082	9.508	2.517	2.155	0.831	–0.760
b	98	8.469	6.816	1.950	1.882	0.902	–1.060
d	98	10.102	8.441	3.848	2.124	0.722	–0.596
g	98	5.531	4.346	1.712	1.530	0.806	–0.854
f	98	3.480	3.608	1.527	0.924	1.048	–0.328
v	98	1.602	3.035	4.487	0.169	1.002	0.732
θ	98	1.704	2.202	1.724	0.341	0.958	0.260
ð	98	11.900	14.009	2.273	1.920	1.232	–0.514
s	98	11.112	9.158	2.748	2.112	0.984	–1.343
z	98	7.378	7.990	2.927	1.592	1.081	–0.589
š	98	2.776	2.638	1.234	0.817	0.937	–0.371
ž	98	0.061	0.281	4.965	–0.632	0.270	4.312
l	98	11.857	9.502	1.449	2.179	0.932	–0.947
m	98	6.663	6.741	2.348	1.535	1.047	–0.698
n	98	12.898	12.614	4.094	2.267	0.903	–1.078
ŋ	98	3.898	3.889	1.213	1.003	1.091	–0.386
h	98	5.286	6.755	5.446	1.344	0.978	–0.621
r	98	1.010	1.830	2.377	–0.066	0.893	1.007
ʔ	98	0.245	0.674	2.910	–0.489	0.519	2.322
i	98	11.325	7.734	2.193	2.268	0.672	–0.983
I	98	11.306	10.229	2.893	2.168	0.831	–0.659
ε	98	3.888	4.331	2.949	1.075	0.955	–0.319
æ	98	8.316	6.972	3.134	1.926	0.762	–0.856
ɘ	98	0.969	2.048	3.486	–0.082	0.847	1.172
ʌ	98	12.888	13.304	3.726	2.262	0.859	–0.654
a	98	3.714	3.159	0.992	1.092	0.933	–0.632
u	98	4.041	4.695	2.733	1.058	1.018	–0.282
U	98	1.786	2.290	2.249	0.422	0.909	0.146
ɔ	98	6.357	5.432	2.419	1.659	0.774	–0.597
į	98	0.990	1.425	1.586	0.024	0.835	0.608
Į	98	1.235	1.757	1.930	0.142	0.881	0.498
ę	98	4.653	4.505	1.615	1.216	1.028	–0.556

Table 31 (continued)

Phone	No. of Children	Mean Attempts	SD	Skewness	Logarithm of (number of tries + .5)		
					Mean	SD	Skewness
æ̨	98	0.755	1.176	2.281	–0.092	0.758	0.732
ə̨	98	6.286	6.740	2.051	1.439	1.071	–0.468
ʌ̨	98	0.429	0.658	1.465	–0.272	0.597	0.840
ą	98	2.551	2.822	1.513	0.670	1.002	–0.101
ų	98	0.306	0.765	3.444	–0.432	0.559	1.926
Ʊ̨	98	0.051	0.333	7.685	–0.651	0.249	6.190
ɔ	98	2.418	2.588	1.978	0.722	0.872	–0.193
ɔw	98	4.786	4.684	2.290	1.304	0.929	–0.602
aw	98	2.418	2.620	1.633	0.653	0.975	–0.159
ɛy	98	3.204	3.066	2.375	0.948	0.942	–0.557
ay	98	5.939	5.890	2.921	1.511	0.915	–0.676
ɔy	98	0.194	0.586	3.341	–0.526	0.466	2.614
w	98	3.765	4.186	3.171	1.012	1.024	–0.417
y	98	1.122	1.607	2.346	0.117	0.833	0.470
w̥	98	0.755	1.479	3.023	–0.155	0.779	1.161

In Table 31, Columns 3, 4, and 5 display, respectively, the mean, standard deviation and skewness of the actual attempts at phones. Since ratios, rather than actual counts, are what are important in comparing phones, the same information is displayed in columns 6, 7, and 8, using the logarithm of (the number of tries + .5). Readers used to manipulating logs will find these columns more revealing of the relationships involved; others can ignore them and make use of the first five columns only.

Before discussing the relationship of data in Tables 29 and 31, we display Table 32, a rearrangement of the data on mean percent correct in Table 28.

TABLE 32

% correct													
90	b	i											
80-89	k	f	m	a	ay								
70-79	p	g	n	h	æ	ʌ	u	Ʊ	ɔw	aw	ɛy	ɔy	w̥

% correct									
60-69	d	s	r	ʔ	I	U	ɔ	w	y
50-59	t	z	ɛ						
40-49	v	š	ə	į	ę	æ̨	ə̨	ų	ɔ̨
30-39	l	ŋ	I̧	ą					
20-29	θ	ð	ž	ʌ̨					

As a summary of the data in Table 31, Part 1, we present a rearrangement of them in Table 31, Part 2:

TABLE 31, PART 2

Phones Listed in Descending Order of Frequency in each Group

Phones tried 10 or more times	t	n	ʌ	ð	l	I	i	s	k	d
Phones tried 5-9 times	b	æ	z	m	ɔ	ə̨	ay	g	p	h
Phones tried 3-4 times	w	ę	u	ŋ	ɛ	w	a	f	ɛy	
Phones tried 1-2 times	š	ą	ɔ̨	aw	U	θ	v	I̧	y	r
Phones tried less than one time	į	ɘ	æ̨	w̥	ʌ̨	ų	ʔ	ɔy	ž	U̧

If we compare the data in Table 31, Part 2 with those in Table 29, we see that, in general, there is good agreement between the two, viz. that the phones attempted by the greater number of children are also those with the greater number of separate tries. When, however, we compare Table 31, Part 2, with Table 28, we see that the relationship between frequency of tries and mean percent correct is not such a predictable one. Some of the rarely-tried phones (U̧ ɔy r ʔ y w̥) are among those with 60% or more correct; this result is perhaps not to be taken too seriously, since, with small numbers involved, the high percentages may not be too meaningful. However, the reverse situation also occurs and is probably more significant. Among the phones with 59% or less mean percent correct are some of the more frequently attempted ones: t z l ɛ ə̧ ð ŋ. Of these, [t] is outstanding as being attempted by 96 of the 98 children and, in addition, being far and away the most frequently tried phone (an average of nearly 19 times per child, as opposed to about 13 for the next most frequent, [n] — these figures do not include any occurrences of the voiceless alveolar stop as first element in [č], which was tabulated separately). Despite its great frequency, [t] had only 52.2% mean percent correct. The other especially surprising phones in this group are [l] and [ð]. Both were attempted by more than 80 children and both averaged more than 11 attempts for each child in the entire group; however, their mean correct percentages were only 33.5 and 20.3, respectively. The findings for the latter two would seem to lend weight to the traditional notion that [l] and [ð] are especially hard to pronounce; however that notion has never been associated with [t]. It is evident, as far as these data are concerned, that acquisition is governed by more than frequency of attempts; we accordingly take up the search for other contributing factors.

If we consider the performance of individual children with respect to the number of phones passed (defined as phones for which the child had a greater number of correct attempts than erroneous ones), we find that no child had fewer than four phones passed. Three children had 38 — the highest number — phones passed. The mean number of phones passed was 22 and the median was 21. Recalling that the mean number of phones attempted was about 35, we conclude that the children in this sample passed about 62% of the phones they attempted, on the average.

Another way of approaching this topic is to consider mean percent correct attempts, averaged over all phones for each child. These figures varied among children, from the child who got only 31% of all his attempts correct, to the child who got 98% of his attempts correct (the sample is again the one containing 98 children, i.e., excluding the two 'best' speakers). Both the mean and median of mean percent correct attempts were 62%. Since the "percentage of phones passed" and the "mean percent correct attempts" are different measures, it is remarkable that they agree so well upon 62%, and suggests that neither conceals great anomalies of variance. The correlation coefficient of the two measures is .820.

It is worth examining the correlations of some of the measures, discussed in this and the preceding chapter, with age:

TABLE 33

Measure	Correlation with age (1.000 is perfect positive correlation, −1.000 is perfect negative correlation)
number of phones with at least one correct	.588
number of phones with at least one error	−.004
number of phones with some right — some wrong	.259
number of phones attempted	.407
number of phones passed	.550
mean percent correct attempts	.524

All these indices are positively correlated with age, except the "number of phones with at least one error", which is essentially uncorrelated with age. As might be expected, the "number of phones attempted" is highly correlated with both "number of phones with at least one correct" (.874) and "number of phones with at least one error" (.691); both these latter measures, again as might be expected, are highly correlated with "number of phones with some right — some wrong" (.711 and .876; respectively). As was noted in the previous chapter, the "number of phones with some right — some wrong" is highly correlated (.775) with the "number of phones attempted".

In analyzing the acquisition of different phones at different rates, investigators, at least from the time of Schultze, have speculated about the role played by various aspects of the articulation of the phone. In an attempt to isolate the contribution of each of the phonological components, certain calculations were made, based upon the performance measure "mean percent correct" (cf. Table 28). Each child who attempts a given phone gets some percentage of his attempts (from 0 to 100) correct. These percentages, averaged for all the children who attempt a given phone, is the "mean percent correct" for that phone. The reader should note that the samples sizes vary among phones, since not all phones are attempted by all children (cf. Table 28 for the sample size for each phone).

Starting from the mean percent correct, scores intended to express the contribution of phonological components were calculated for voice, nasality, friction, labial position, interdental position, alveolar position, postalveolar position, and velar position. These indices were worked out in collaboration with David Peizer, who deserves principal credit, both for the original idea and for the final form. My contribution was largely limited to advice on phonetics.

The scores were calculated as follows: %x is to be read as mean percent correct of the phone x

V	=	voice score
N	=	nasality score
F	=	friction score
L	=	labial score
I	=	interdental score
A	=	alveolar score
P	=	post-alveolar score
Ve	=	velar score

Voice Score

$$V = \frac{(\%b-\%p)+(\%d-\%t)+(\%g-\%k)+(\%v-\%f)+(\%\,ð-\%θ)+}{7}$$

$$+\ \frac{(\%z-\%s)+(\%ž-\%š)}{7}$$

(In words, the contribution of voice to acquisition is expressed as the average of the differences between the members of pairs of paired voiced-voiceless phones.)

Nasality Score

$$N = \frac{\left[\%m - \frac{(\%b+(\%p+V))}{2}\right] + \left[\%n - \frac{(\%d+(\%t+V))}{2}\right] + \left[\% - \frac{(\%g+(\%k+V))}{2}\right]}{3}$$

(The contribution of nasality to acquisition is expressed as the average difference between nasals and the average of (a) their corresponding voiced stop and (b) voiceless stop plus the child's voice score.)

Friction Score

$$F = \frac{\left[\frac{(\%v+(\%f+V))}{2} - \frac{(\%b+(\%p+V))}{2}\right] + \left[\frac{(\%z+(\%s+V))}{2} - \frac{(\%d+(\%t+V))}{2}\right]}{2}$$

(The contribution of friction to acquisition is expressed as the average difference between (a) the average of (1) a voiced spirant and (2) the corresponding voiceless spirant plus V, and (b) the average of (1) the corresponding voiced stop and (2) the corresponding voiceless stop plus V. The only spirants used are those with non-spirant counterparts at the same position of articulation (labial and alveolar), so that subtraction of the means of the stops at that position is assumed to remove any effects of position of articulation. Thus the interdental and post-alveolar spirants could not be used in this calculation.)

Labial Score

$$L = \frac{\%p+(\%b-V)+(\%f-F)+(\%v-V-F)+(\%m-V-N)}{5}$$

(The contribution of labial position to acquisition is expressed as the average performance of the various labial and labiodental phones, each adjusted for the putative effects of its other components: voice friction, and nasality, as the case may be.)

Interdental Score

$$I = \frac{(\%\theta - F + (\%\eth - F - V)}{2}$$

(The contribution of interdental position to acquisition is expressed as the average performance of the interdental phones, each adjusted for effects of its other components.)

Alveolar Score

$$A = \frac{\%t + (\%d - V) + (\%s - F) + (\%z - V - F) + (\%n - V - N)}{5}$$

(The explanation for alveolar score is similar to that for labial score.)

Post-alveolar Score

$$P = \frac{(\%\check{s} - F) + (\%\check{z} - F - V)}{2}$$

(The explanation for post-alveolar score is similar to that for interdental score.)

Velar Score

$$Ve = \frac{\%k + (\%g - V) + (\%\eta - V - N)}{3}$$

(The explanation for velar score is similar to that for labial score.)

The formulae given above serve to indicate how these scores are calculated in case the child attempted all the phones in question. When the child did not attempt all the phones needed to apply a given formula, it was adjusted to permit its application insofar as possible. For example, if a child did not attempt [p], the calculation of his voice score must rest on the average of the other six pairs; thus his attempts at [b] can play no role, since its opposite number [p] was not attempted. As an extreme case, consider the (hypothetical) example of the child who attempted — of the phones listed above — only [b, p, f, m, n]; his scores would be calculated as follows:

$$V = \frac{(\%b-\%p)}{1}$$

$$N = \frac{\left[\%m - \frac{(\%b+(\%p+V))}{2}\right]}{1} = \%m - \%b$$ (since 'b' and 'p' are the only phones figuring in the voice score)

$$F = \frac{\left[\frac{\%f+V}{1} - \frac{(\%b+(\%p+V))}{2}\right]}{1} = \%f-\%p$$ (same reason as above)

I cannot be scored.

$$A = \frac{(\%n-V-N)}{1} = \%n+\%p-\%m = \%n-(\%m-\%p)$$

P cannot be scored.

Ve cannot be scored.

The mean values for these scores are displayed below in Table 33.

TABLE 33

	Number of Children	Mean	SD
Voice score	98	0.001	0.198
Nasality score	95*	−0.060	0.216
Friction score	94*	−0.074	0.184
Labial score	98	0.818	0.225
Interdental score	91*	0.275	0.347
Alveolar score	98	0.654	0.222
Postalveolar score	76*	0.554	0.435
Velar score	97*	0.691	0.271

Under the assumptions on which these scores were calculated, it appears that voice, on the average, provides neither advantage nor disadvantage in the acquisition of phones. This finding supports the views of Templin (1957). Nasality and friction appear to be slightly disadvantageous with respect to acquisition. The several articulatory positions cannot be said to be either advantageous or disadvantageous with respect to acquisition, since the scores, unlike those for voice, nasality and friction, do not represent differences.

These eight scores correlate with age and with each other as follows in Table 34 (p. 187).

The voice score is negatively correlated with all other scores; moreover, it is slightly negatively correlated with age. When it is remembered that voice gives neither advantage nor disadvantage overall, its negative correlation with age indicates that it gives a slight advantage in the earlier part of the period covered by the children in this sample, i.e., that voicing makes a phone slightly easier to learn when the child first starts his language-learning, but that the advantage soon disappears to be replaced by a slight but increasing disadvantage as the child grows older. Thus, if one examines the first fourteen phones in Table 28 — the ones paired voiced /voiceless — they turn out to be the stops and spirants. Of the seven pairs, only two show the voiced member with a higher mean percent correct than the voiceless member. Those are [b] (90.4) over [p] (75.5) and [d] (64.9) over [t] (52.2); the other pair of stops and all the spirant pairs show the voiceless members with the higher mean percent correct. Since almost all investigators have suggested that the front stops are learned before the back ones and the spirants these data seem to support the notion that voice is a valuable asset in the learning of the first phones, whereas its effect is flattened out and then reversed as the child begins to master the more difficult spirants. Why this should be so is a mystery. It may be due to the differential effects of voicing on (1) discriminability and (2) articulatory difficulty. It is possible that the effects of voicing in these two areas are acting in opposite directions. The analysis of errors in this study indicates that voicing contributes positively to discriminability; such a finding supports the conclusions of Miller and Nicely (1955). Voicing may therefore be supposed to give advantage in learning to the younger children, if it is assumed that discrimina-

TABLE 34

	AGE	V	N	F	L	I	A	P	Ve
Voice Score	-.115	1.000	-.501	-.068	-.626	-.480	-.443	-.389	-.572
Nasality Score	.043	-.501	1.000	.172	.255	.084	.044	.036	.401
Friction Score	.115	-.068	.172	1.000	.029	-.345	-.028	.021	-.040
Labial Score	.188	-.626	.255	.029	1.000	.550	.588	.398	.590
Interdental Score	.550	-.480	.084	-.345	.550	1.000	.638	.451	.514
Alveolar Score	.459	-.443	.044	-.028	.588	.638	1.000	.412	.575
Postalveolar Score	.201	-.389	.036	.021	.398	.451	.412	1.000	.408
Velar Score	.229	-.572	.401	-.040	.590	.514	.575	.408	1.000

bility of phones constitutes a more difficult part of the learning task for them than it does for the older children. On the other hand, the addition of the component of voicing to the pronunciation of a spirant may be presumed to add to its articulatory difficulty. It is recognized that this argument is deficient, since it can easily be turned around. Its acceptability depends upon two premises: (1) that there is maturation in the child's perceptual equipment during the age-period between the younger and older children in this sample and (2) that spirants present sufficiently greater articulatory difficulties than do stops so that the addition of even a well-practiced component raises the combined articulatory task above some threshold. While plausible, neither of these assumptions has any independent support as yet.

Both nasality and friction, by these calculations, contribute negatively to acquisition, though not to a great extent in either case. The case of friction is not too surprising, but the finding that nasality is disadvantageous with respect to acquisition flatly contradicts the theory of Olmsted (1966) in this respect, since that theory predicted that nasality would be highly resistant to errors (which it has proved to be) and highly favorable for success (which it has not proved to be). It therefore seems likely that predicting successes is a qualitatively different task from predicting errors and that they are not mirror-images of each other as had been crudely assumed when the original theory was formulated. We return to this topic in a later chapter.

The scores for the various positions of articulation are difficult to compare with each other in the form given in Table 33, because they represent means figured for a number of children who are in some cases not the same. In other words, we need to compare the positional scores with each other, considering only the children for whom both scores could be calculated. The results of such comparisons are displayed below in Table 35.

The results of Table 35 indicate that labial position confers more advantage (as far as acquisition is concerned) upon a phone than any of the other positions; that velar position is more advantageous for acquisition than any other position except labial; that alveolar

TABLE 35

Comparison	Number of Children	Mean Residual Difficulty	SD
Labial vs. Interdental	91*	0.531	0.291
Labial vs. Alveolar	98	0.164	0.203
Labial vs. Postalveolar	76*	0.241	0.450
Labial vs. Velar	97*	0.120	0.220
Interdental vs. Alveolar	91*	−0.383	0.267
Interdental vs. Postalveolar	74*	−0.278	0.438
Interdental vs. Velar	91*	−0.403	0.325
Alveolar vs. Postalveolar	76*	0.110	0.434
Alveolar vs. Velar	97*	0.035	0.225
Postalveolar vs. Velar	76*	−0.138	0.478

position is in the middle, being less advantageous than labial and velar, but more so than postalveolar and interdental; that postalveolar position is less advantageous than all others except interdental, which confers the least advantage as far as acquisition of phones is concerned. Perhaps it should be pointed out here that these data have no direct bearing upon the various hypotheses of Jakobson, which concern the order of acquisition of PHONEMIC OPPOSITIONS, not the order of acquisition of PHONES.

In order to integrate the effects of frequency of attempts with those of the various components, we calculated the frequency of attempts for the various scores. The result for voice score was that 73% of the children made fewer attempts at the voiced phones (used in calculating the voice score, N.B. not ALL voiced phones in the child's corpus, but only the voiced stops and spirants actually attempted, provided they were matched by a corresponding attempted voiceless phone) than at the voiceless phones used in figuring the score. The nasality score showed similar results; about 72% of the children had fewer attempts at the nasalized phones used than at the average of the corresponding voiced and voiceless stops. The results for friction score was that about 95% of the children attempted the fricatives involved (the labiodental and alveolar ones) less often than the corresponding labial and alveolar stops. Thus the slight negative advantage of nasality and friction may be in part due to the lower frequency of attempts of the phones involved in the calculation of those scores; the neutral status of voice is IN SPITE OF the lower frequency of attempts at the voiced phones used in figuring the score, so that one may infer that, were the numbers of attempts equal, the contribution of voice might be slightly positive, as far as acquisition is concerned.

The scores for the articulatory positions, unlike the voice nasality and friction scores, are not comparisons. We may therefore compare them with each other, in pairs. For each comparison, the percentage listed is the percentage of children who had a greater average number of attempts (at the phones USED TO COMPUTE THE SCORES IN QUESTION) in one articulatory position than another:

TABLE 36

Labial vs. Interdental	77% had more interdental attempts
Labial vs. Alveolar	99% had more alveolar attempts
Labial vs. Postalveolar	67% had more labial attempts
Labial vs. Velar	51% had more labial attempts
Interdental vs. Alveolar	80% had more alveolar attempts
Interdental vs. Postalveolar	88% had more interdental attempts
Interdental vs. Velar	76% had more interdental attempts
Alveolar vs. Postalveolar	96% had more alveolar attempts
Alveolar vs. Velar	95% had more alveolar attempts
Postalveolar vs. Velar	63% had more velar attempts

(All percentages in the above tabulation are rough approximations)

In summary, the positions of articulation rank, in order of frequency of attempts at phones used in the calculation, roughly in the following order:

1. Alveolar
2. Interdental
3. Labial, Velar
5. Postalveolar

Once again these data give evidence that advantage in acquisition is independent of frequency. It will be recalled that Table 35 showed labial position to be the most advantageous as far as acquistition is concerned, followed by velar, alveolar, postalveolar and interdental. Comparison of Table 35 with Table 36 reveals the alveolar and interdental positions to be less advantageous than their frequencies would suggest, while the labial and velar positions are more advantageous than their frequencies would imply. Only postalveolar position is relatively low on both scales.

It is of interest to inspect the performance on the various phones to see whether it is greater or less than would be expected, considering the components included in them. We do this by subtracting from the mean percent correct score for each phone (cf. Table 28) the calculated component scores appropriate to each phone. E.g., from %p we subtract the labial score (N.B.: figured separately from the data from those children who attempted [p]; i.e., it is not necessarily the same labial score that is subtracted from [b]); from %n we subtract the alveolar score, the nasality score and the voice score; from [š] we subtract the postalveolar score and the friction score. In each case the scores are the ones calculated for the children who tried the phones in question, NOT the means (of all children) given in Table 33. The result of such arithmetical peeling may be called the RESIDUAL DIFFICULTY of each phone, i.e., the degree to which it is correctly pronounced over and above what would be expected from an examination of its components. In Table 37, below, a minus number means that the phone is more difficult than would have been expected on the basis of the components it contains; a plus number indicates that it is less difficult than expected on that basis.

From Table 37, it appears that [p t d v ð z ž ŋ] are more difficult than expected, while [k b g f θ s š m n] are less difficult than expected. It will be remembered that among frequently-attempted phones were some with 'abnormally' low mean percentages correct. Of those, [l] and the vowels are not included in the group considered above; all the others — t z ð ŋ — turn up in the more-difficult-than-expected group above, suggesting that, by adjusting for the effects of the articulatory components, we have peeled off yet another set of factors, leaving us that much closer to the center of the onion: Schultze's articulatory difficulty.

TABLE 37

Phone	Number of Children	Mean Residual Difficulty	SD
p	91*	−0.059	0.148
t	96*	−0.135	0.150
k	96*	0.105	0.178
b	93*	0.094	0.140
d	97*	−0.013	0.149
g	93*	0.058	0.194
f	76*	0.038	0.185
v	48*	−0.229	0.245
θ	59*	0.014	0.150
ð	89*	−0.009	0.122
s	92*	0.017	0.181
z	88*	−0.014	0.166
š	76*	0.009	0.049
ž	5*	−0.132	0.156
m	87*	0.054	0.164
n	95*	0.146	0.170
ŋ	76*	−0.204	0.202

7

THE EFFECT ON ACQUISITION OF POSITION IN THE UTTERANCE

"...there is no reason to discourage detailed observational and experimental studies of processes of language learning, particularly as applied to language learning in the child..."

John B. Carroll

In the preceding chapter, we considered the data on the acquisition of phones, without taking into account the position in the utterance. A number of earlier investigators (e.g. Wellman, *et al.*, Templin) have assumed that the learning of a phone in initial position in the utterance was a rather different task from learning a phone in medial or final position; they regarded it as different enough to justify recording initial 'p-' as a separate entity from final '-p' and medial '-p-'. Moreover, their results have tended to support their assumptions; in order to see whether those assumptions are warranted in the case of the present sample, we now consider the acquisition of phones as a function of position in the utterance.

The basic data are displayed in Tables 38 through 46. Across the top of each are the letters 'A' through 'F', representing the age-groups described in Chapter 5. Under each letter are three columns, headed with the symbols —,O, +; these represent, respectively 'not tried', 'not passed' and 'passed'. A child is put in the 'not tried' column if he failed to attempt the phone in the position in question; he is listed as not passed if he tried the phone in the position in question but got fifty percent or less correct; he is listed as 'passed' if he tried the phone and got more than fifty percent of his attempts correct. The criterion for passing is thus a demanding

TABLE 38
Initial Consonants

Phone	A			B			C			D			E			F		
	–	0	+	–	0	+	–	0	+	–	0	+	–	0	+	–	0	+
p–	5	4	8	12	10	10	9	4	12	2	2	9	3		3	3	1	1
t–	6	7	4	7	5	20	6	8	11	4	4	5		1	5	3		2
k–	2	4	11	2	4	26	2	6	17	1	2	10	2		4		3	2
b–	1	1	15	2	1	29	4		21	2		11	2		4	3		2
d–	1	3	13	2	5	25	5	1	19	7		6	1		5	4		1
g–	10	1	6	16	2	14	10	5	10	4	1	8	2		4	3		2
f–	10		7	14	4	14	7	4	14	7	1	5	1		5	3		2
v–	17			29	1	2	23	2		12		1	5	1		5		
θ–	14	3		21	10	1	20	3	2	11	2		2	3	1	5		
ð–	7	10		4	28		3	19	3	1	10	2		4	2		3	2
s–	6	7	4	10	17	5	5	9	11	4	3	6	1	1	4	3	1	1
z–	16		1	27	3	2	25			10	2	1	4	2		5		
š–	6	8	3	16	11	5	12	5	8	6	4	3	1	2	3	1	1	3
ž–	17			32			25			13			6			5		
tš–	11	6		17	9	6	19	3	3	10	2	1	3	2	1	4		1
dž–	11	3	3	22	6	4	16	6	3	6	4	3	3	2	1	2	2	1
l–	10	3	4	11	14	7	10	8	7	5	3	5	1	1	5	2	2	1
m–	4	1	14	9	5	18	7		18	2	1	10	1	1	5	4		1
n–	7	2	8	13	7	12	12	1	12	6		7	1		5	3		2
ŋ–	17			32			25			13			6			5		
r–	17			32			25			13			6			5		
ʔ–	17			32			25			13			6			5		

TABLE 39
Medial Consonants

Phone	A			B			C			D			E			F		
	–	0	+	–	0	+	–	0	+	–	0	+	–	0	+	–	0	+
–p–	2	7	8	9	8	15	3	5	17	4	1	8	3	1	5	2		3
–t–	1	15	1	4	17	11		18	7		7	6		5	1	1		4
–k–	7	4	6	6	7	19	3	8	14		1	12			6		1	4
–b–		4	13	4	2	26	7	2	16	1	1	11			6	2		3
–d–	3	7	7	2	11	19	1	10	14		3	10		2	4		1	4
–g–	7	2	8	3	6	23	2	8	15	1	2	10	1	1	4	2		3
–f–	10	3	4	14	4	14	9	2	14	3	2	7	3		3	1		4
–v–	15	1	1	22	7	3	10	7	8	4	5	4	4	1	1	2	1	2
–θ–	17			27	5		12	11	2	3	4	6	3	1	2	2	1	2
–ð–	10	7		17	13	2	7	14	4	3	7	3	2	3	1		1	4
–s–	9	4	4	4	7	21	3	7	15	2	3	8	2	1	3		2	3
–z–	13	1	3	12	10	10	7	8	10	3	4	6	1	1	4		1	4
–š–	13	3	1	19	7	6	11	10	4	8	3	2	3	1	2	4	1	
–ž–	17			29	2	1	24	1		13			6			5		
–tš–	13	4		18	9	5	17	4	4	9	2	2	4	1	1	2	2	1
–dž–	16	1		30	1	1	19	3	3	8	1	4	3	1	2	2	3	
–l–	3	13	1	1	26	5	1	21	3		10	3		5	1		1	4
–m–	9	4	4	5	6	21	6	5	14	2	2	9			6	1	1	3
–n–	5	5	7	4	6	22	1	3	21		1	12			6			5
–ŋ–	9	5	3	14	12	6	9	10	6	4	5	4	3	2	1		1	4
–r–	13	2	2	18	9	5	15	2	8	8	1	4	4	1	1	3		2
–ʔ–	17			29	2	1	20	1	4	12		1	5		1	2	1	2

TABLE 40
Final Consonants

Phone	A			B			C			D			E			F		
	−	0	+	−	0	+	−	0	+	−	0	+	−	0	+	−	0	+
–p	8	3	6	22	2	8	12	1	12	5	3	5	1	4	1	5		
–t	1	9	7	3	15	14	1	7	17	1	3	9		3	3	1	1	3
–k	5	2	10	4	8	20	5	2	18	2	1	10	1	1	4	2		3
–b	16		1	30		2	25			13			6			5		
–d	9	7	1	9	18	5	7	7	11	2	8	3	1	2	3	2		3
–g	7	7	3	17	4	11	13	4	8	6	1	6	2		4	1		4
–f	15		2	26	3	3	17		8	9		4	3	2	1		1	4
–v	17			30	1	1	18	3	4	7	3	3	3	1	2	5		
–θ	11	6		24	7	1	21	4		10		3	3	1	2	4		1
–ð	17			32			23	2		13			6			5		
–s	2	8	7	10	7	15	4	5	16	4	4	5	1	1	4	2	1	2
–z	13	9	5	9	12	11	1	7	17	3	3	7		2	4	1	2	2
–š	14	2	1	21	5	6	15	4	6	7	3	3	3	2	1	4	1	1
–ž	16	1		32			25			13			6			5		
–tš	16		1	29		3	23	2		10	1	2	4		2	4	1	
–dž	17			31	1		17	5	3	11	1	1	4		2	4	1	
–l	6	11		8	20	4	8	11	6	4	7	2	1	3	2		4	1
–m	12	3	2	19	5	8	13	3	9	1	2	10	3	1	2	3		2
–n	6	5	6	4	8	22	1	6	18	3	3	7			6			5
–ŋ	12	3	2	16	11	5	8	10	7	5	7	1	1	5		1		4
–r	17			32			25			13			6			5		
–ʔ	17			32			25			13			6			5		

TABLE 41
Initial Vowels

Phone	A			B			C			D			E			F		
	–	0	+	–	0	+	–	0	+	–	0	+	–	0	+	–	0	+
i–	15		2	25	2	5	22	1	2	11		2	5		1	5		
I–	9	2	6	14	3	14	9	3	13	3	3	7	1		5	2	1	2
ε–	16		1	29		3	22	3		8		5	5	1		5		
æ–	14	1	2	24	1	7	13	3	9	2		11	3	2	1	3	1	1
ə–	16	1		31		1	23		2	10		3	6			5		
ʌ–	11	2	4	9	5	18	11		14	4		9	1	1	4			5
a–	16		1	28		4	24	1		11		2	6			4		1
u–	15	1	1	30		2	22		3	12		1	6			5		
U–	17			32			25			13			6			5		
ɔ–	15		2	25		7	21		4	8	1	4	5		1	5		
ɔw–	15	1	1	28	1	3	20		5	12		1	6			5		
aw–	16		1	26	1	5	22	1	2	11		2	5		1	5		
εy–	17			28	1	3	23		2	11		2	6			5		
ay–	8	1	8	16	4	12	10	2	13	1	4	8	1	1	4	1		4
ɔy–	17			32			24		1	13			6			5		

TABLE 42

Medial Vowels

Phone	A			B			C			D			E			F		
	–	0	+	–	0	+	–	0	+	–	0	+	–	0	+	–	0	+
–i–	6	1	10	2	4	26	23	2		1		12		1	5			5
–I–	1	4	12		10	22	1	7	17		4	9		3	3		1	4
–ɛ–	5	11	1	4	15	13	4	7	14	1	2	10			6	1	1	3
–æ–	2	1	14		7	25		2	23		2	11	1	1	4		1	4
–ə–	11	4	2	21	7	4	16	4	5	7	3	3	3	1	2	4	1	
–ʌ–	1	8	8	1	12	19			25		1	12		2	4			5
–a–	5	1	11	5	4	23	5	3	17	1	2	10		1	5		2	3
–u–	7	5	5	6	5	21	9	4	12	4	6	3		3	3	1		4
–U–	6	4	7	7	11	14	11	3	11	3	4	6	3		3	2	1	2
–ɔ–		7	10	2	7	23		8	17		1	12		1	5		1	4
–ɔw–	5	4	8	8	6	17	4	1	20	11	1	1	5	1		1	2	2
–aw–	9	4	4	10	6	16	8	5	12	3	4	6	3	2	1		2	3
–ɛy–	3	9	5	7	9	16	4	3	18	4		9		2	4	1	2	2
–ay–	4	6	7	5	5	22	2	1	22		2	11			6			5
–ɔy–	17			31	1		23		2	13			6			5		

TABLE 43
Final Vowels

Phone	A			B			C			D			E			F		
	−	0	+	−	0	+	−	0	+	−	0	+	−	0	+	−	0	+
–i	17				1	31		1	24		1	12	6			1		4
–I	17			30	1	1	22	2	1	12	1		1	4	1	5		
–ɛ	17			31	1		25			13			5		1	5		
–æ	15	1	1	31	1		23	1	1	13			5		1	5		
–ə	16	1		30	1	1	24	1		10	1	2	6			5		
–ʌ	13	2	2	24	3	5	18	4	3	9	1	3	1	2	3	5		
–a	15		2	25	2	5	25			10	1	2	4		2	5		
–u	9	2	6	15	4	13	9		14	6		7	1		5	3		2
–U	17			32			25			13			6			5		
–ɔ	15	2		31	1		24	1		13			5	1		5		
–ɔw	6	2	9	16	1	15	13	1	11	4	1	8	2		4	1		4
–aw	11	1	5	26	2	4	19	1	5	13			5	1		1	2	2
–ɛy	17			28		4	20		5	7	1	5	5		1	2		3
–ay	10	2	5	20	1	11	16		9	8	1	4	3	1	2	3		2
–ɔy	17			25	2	5	25			13			6			5		

TABLE 44

Initial Semivowels

Phone	A			B			C			D			E			F		
	–	0	+	–	0	+	–	0	+	–	0	+	–	0	+	–	0	+
h–	5	4	8	5	8	19	2	5	18	1		12			6	2	1	2
w–	9	4	4	16	1	15	10	4	11	4	1	8	2	1	3	2		3
y–	16	1		21	6	5	17	2	6	6	3	4	1		5	2	1	2
w̥–	15	2		22	3	7	16	3	6	7		6	3	1	2	4		1
į–	17			29	2	1	24	1		12		1	6			5		
Į–	17			32			24	1		12	1		6			5		
ę–	16	1		26	4	2	20	2	3	12		1	3	1	2	4		1
æ̨–	15	2		26	5	1	21	3	1	11	1	1	6			4		1
ə̨–	17			30	2		25			11	1	1	6			5		
ʌ̨–	17			32			24	1		11	1	1	5		1	5		
ą–	15	2		21	5	6	18	7		11	2		5	1		3	1	1
ų–	17			31	1		24	1		10	2	1	6			5		
Ų–	17			32			25			13			6			5		
ɔ̨–	17			31		1	24	1		12	1		6			4	1	

TABLE 45

Medial semivowels[a]

Phone	A			B			C			D			E			F		
	−	0	+	−	0	+	−	0	+	−	0	+	−	0	+	−	0	+
-h-	14		3	16	7	9	7	4	14	5	3	5	3		3	1		4
-w-	9	5	3	10	13	9	5	5	15	1	4	8	2	1	3		1	4
-y-	15	1	1	23	3	6	17	3	5	6		7	1	2	3	1	1	3
-w̥-	17			32			19	1	5	10	1	2	5		1	4	1	
-i̧-	15	2		16	11	5	11	8	6	6	5	2	3	3		3		2
-I̧-	10	6	1	19	10	3	20	3	2	9	2	2	4	2		3	2	
-ɛ̧-	11	6		8	19	5	3	16	6	2	5	6	1	2	3		3	2
-æ̧-	14	3		24	5	3	17	5	3	5	3	5	4	1	1	4		
-ə̧-	5	12		8	16	8	1	11	13	1	6	6	1	4	1	2	2	1
-ʌ̧-	14	3		22	9	1	16	8	1	8	4	1	4	1	1	3	2	1
-ɑ̧-	10	7		16	10	6	9	9	7	2	7	4	2	2	2		2	3
-ų-	17			28	3	1	19	4	2	11	2		5		1	5		
-U̧-	17			32			25			13			6			5		
-ɔ̧-	8	7	2	7	18	7	5	12	8	3	5	5		3	3	2	2	1

a The data in this table do not include semivowels found as part of the diphthongs treated in Table 42.

TABLE 46

Final Semivowels [a]

Phone	A –	A 0	A +	B –	B 0	B +	C –	C 0	C +	D –	D 0	D +	E –	E 0	E +	F –	F 0	F +
–h	17			32			25			13			6			5		
–w	16	1		30		2	25			11	1	1	6			5		
–y	15	1	1	30	1	1	25			13			6			5		
–w̩	17			32			25			13			6			5		
–i̩	17			32			23	1	1	13			6			5		
–I̩	12	3	2	25	5	2	21	2	2	8	3	2	3	1	2	5		
–ɛ̩	13	1	3	18	7	7	3	16	6	8	2	3	3	2	1	3	1	1
–æ̩	17			31	1		25			13			6			5		
–ə̩	12	4	1	14	9	9	4	4	17	2	5	6		2	4		3	2
–ʌ̩	17			32			24	1		13			6			5		
–a̩	15	1	1	21	8	3	19	3	3	8	3	2	4	1	1	4	1	
–u̩	17			32			25			13			6			5		
–U̩	17			32			24		1	12		1	6			5		
–ɔ̩	14	3		24	3	5	19	5	1	10	1	2	2	2	2	4	1	

[a] The data in this table do not include semivowels found as part of the diphthongs treated in Table 43.

one. The number in each cell represents the number of children in the age-group who met the standard indicated. The numbers of children in the various age groups were 'A', 17; 'B', 32; 'C', 25; 'D', 13; 'E' 6; and 'F', 5.

The data in Tables 38 through 46 may be roughly summarized as follows, beginning with the initial consonants (Table 38). Not tried by children of any age were [ŋ r ʔ ž]; the first two are non-existent in these dialects of English in initial position and the last two are extremely rare. Very rarely attempted by children of any age were [z] and [v]. We therefore restrict ourselves to the other 16 consonants and combinations; since children who do not try a given phone in a given position provide no information about the correlation of learning with age-group, we ignore the 'not tried' column. A rough approximation of the relation between age-group and learning may then be obtained by comparing the 'not passed' and 'passed' columns. The age-group at which the number of children in the 'passed' cell exceeds the number in the 'not passed' cell may be considered some kind of milestone of acquisition. For example, [b-] is passed by fifteen of the sixteen children attempting it as early as age-group 'A'; for convenience, we may term 'A' the AGE-NORM of [b-]. Similarly, [s-] has the age-norm 'C', and [t-] has the age-norm 'B'.

In Table 47, below, we display the age-norms of consonants in all three positions. Phones such as [ŋ-] which were not tried by anyone are left out, but others, such as [θ-] — which have no age-norm within this sample because there is no age-group showing mastery of the phone — are listed in an extra column headed 'Older'.

Table 47 reveals a definite pattern in the acquisition of consonant phones. At time 'A' (roughly the second half of the second year of life), members of this sample had acquired the labial and velar stops in all positions (except -g) and [n] in all positions. The only spirants in the 'A' group are [f] — in all positions — and [-z-]. Initial [m] and initial [d] complete the group. At time 'B' (roughly the first half of the third year of life), [m] is added in the other two positions, and other loose ends from the previous period are tidied up (-g, -d-, t-); three spirants are added at this time (-s-, -s, -š). Time 'B'

TABLE 47

Age-Norms of Consonants by Position in Utterance

A		B	C		D	E	F	Older	
p–	k–	t–	s–	š–	l–		tš–	θ–	ð–
b–	d–							dž	z–
g–	f–								
m–	n–								
–p–	–k–		–v–		–θ–		–t–		
–b–		–d–					–ð–		
–g–	–f–	–s–		–r–			–ŋ–		
–z–	–n–	–m–		–ʔ–	–dž–	–š–	–l–	–ž–	–tš–
–p	–k			–t					
–b(?)		–g		–d					
–f		–s		–v	–θ			–ð	
–n		–š		–z	–tš		–ŋ	–ž	
		–m						–dž	
								–l	

marks the beginning of apicoalveolar skill, which is extended in period 'C', when [s-, -r-, -t, -d, -z] are acquired, in addition to [š-, -v-, -v, -ʔ-]. Period 'D' (the first half of the fourth year) sees the addition of difficult items like the initial lateral, medial and final [θ] and two affricates: [-dž-, -tš]. Since the affricate is flanked by vowels in medial position and precedes silence in final position, it is not surprising that the voiced one is learned earlier in medial position while the voiceless one is acquired at the same time in final position. In contrast, initial and final [dž] (both flanked by silence), and [-tš-] (flanked by vowels) are not mastered by children in this sample. Medial [š] which is not firmly controlled until period 'E' (the second half of the fourth year) stands in contradiction to the usual assertion that medial consonants are acquired before initial or final ones: [-š] and [š-] were acquired by these children in periods 'B' and 'C', respectively. Illustrating the same point are [-t-] and [-l-], both of which are not acquired until the first half of the fifth year of life, though the initial varieties were learned much earlier in both cases. Also picked up in period F are other difficult phones and combinations [tš-, -ŋ-, -ŋ, -ð-].

TABLE 48

Age-Norms of Vowels by Position in Utterance

A	B	C	D	E	F	Older
I- æ-	i- ə-		ε-(?)			
ʌ- a-	u- εy-					
ɔ- aw-	ɔw-					
ay-						
-i- -I-		-ε-				
-æ-	-ʌ-	-ə-				
-a-	-u-	-ɔy-				
-U-	-aw-					
-ɔ-	-εy-					-ɔ
-ɔw-	-i	-ʌ	-ə	-ε(?)		-I(?)
-ay-	-εy					
-a -u	-ɔy					
-ɔw						
-aw						
-ay						

Comparison of Tables 47 and 48 shows that the learning of vowels is much more concentrated in the two earliest periods, whereas that of consonants is spread out over the whole range of the sample, and, indeed, beyond. Table 48 does not support Jakobson's notion that the vowels are learned first at the extremes of the dimensions of the mouth with progressive differentiation into finer and finer distinctions. Thus, in his scheme, the first three phones to be learned ought to be [a i u], with [a] first and the other two in either order, but definitely before such intermediate types as [I æ ɔ]. The evidence from this sample suggests that he is right about [a], which is learned in the earliest period in all positions. However, [u] and [i] do not seem to be acquired conspicuously earlier than other, intermediate, vowels. For example, [-U-] is earlier than [-u-]; of course, it might be argued that, since Jacobson's rules apply to phonemic distinctions, not phones *per se*, that [-U-] represents the high back position in the earlier period. This argument would be persuasive if, where the model had [-u-] in the earlier period, the child substituted [-U-] for it. Inspection of Table 22 demolishes this line of thought, since, in the entire sample, [U] was a substitute for [u] only four times in any position at any age. In contrast, the most frequent (35 times) substitute for [u] was [ʌ]. The case of [i] and [I] is also instructive. Leaving aside [-I], which can only rarely be attributed to any of the models in this study, [I-] and [-I-] are acquired in period 'A', whereas [i-, -i] are acquired only in period 'B'. Only [-i-] of the highest front vowels is learned in period 'A'. Since [-I-] is acquired at the same time as [-i-], it is a fair assumption that they are in phonemic contrast or opposition, though one cannot be sure without performing phonemic analyses of the corpora of the children involved. At any rate, Table 22 reveals that [I] was not a very frequent substitute for [i], as the Jakobsonian argument might suggest; on the contrary, the reserve substitution was much more frequent; [i] substituted for [I] 67 times, while [I] substituted for [i] 17 times. These data are not decisive for Jakobson's theory, since we cannot be sure that the same children have learned [-i-] and [-I-] in period 'A'. In any event, the many vowels (other than the ones suggested by Jakobson's theory) acquired in period 'A' (and thus earlier than [i-, -u-, -i]) generate considerable doubt concerning the applicability of any hard-and- fast ordering of phenomena like those of children's phonological acquisition which are evidently characterized by a good deal of individual variability. Moreover, the postulates of the Jakobsonian theory in this respect appear to ignore the factor of frequency. Even if it were so that children tend to find the learning of vowels characterized by maximal differences easier at first than of those differentiated by finer distinctions, the results in any given language, or for any given child, might be for him influenced by (1) the relative proportions of morphs modeled greatly containing the types of vowels in question and (2) the actual text frequencies of such items.

Table 49 shows the relative ease and sureness with which the

TABLE 49

Age-Norms of Semivowels by Position in Utterance

A	B	C	D	E	F	Older
h–	w–	y–	į–(?)		æ̨–	ɪ̨–
–h–	w̥–	ɛ̨–			–į–	ə̨–
	–y–	–w–	–ɛ̨–		–ą–	ʌ̨–
	–w	–w̥–	–æ̨–			ą–
	–ɔ̨	–ə̨–(?)	–ɛ̨	–ɪ̨		ų–
		–ə̨				ɔ̨–
						–ɪ̨–
						–ʌ̨–
						–ų–
						–ɔ̨–
						–ą

common semivowels [h w y w̥] are learned. The picture can be clarified still further by comparing Table 48, where additional instances of [w] and [y] in medial and final position are seen as parts of various diphthongs. There, too, they are learned early.

The retroflex vowels, also displayed in Table 49, show a different pattern. The ones acquired within the age-range of this sample are mostly those in final position, while the medial and final retroflex vowels and semivowels are acquired later than the first half of the fifth year if at all. The situation is complicated by the rarity of attempts and the data are, in several cases, contradictory.

In Table 50, the material in Tables 38-49 is summarized. The data are pooled for consonants, vowel and semivowels. After summing the material in the three columns ('not tried, 'not passed', 'passed') for each age-group, the results are expressed as percentages of the total number of children in the age-group. It is important to recognize that, since some phones (e.g. [ŋ-]) are not occurrent in English) and others are very rare (e.g. [Ų]) the percentages in the 'not tried' columns are artificially inflated. However, they may safely be ignored, since the percentages in the two remaining col-

TABLE 50

Indices of Acquisition

	Initial				Medial				Final			
Consonants												
	—	0	+	IA	—	0	+	IA	—	0	+	IA
A	54	19	27	1.5	55	24	19	.8	67	20	14	.7
B	51	20	28	1.4	41	25	33	1.3	62	18	19	1.1
C	58	15	31	2.1	34	29	36	1 3	53	15	28	1.8
D	53	14	31	2.2	30	23	46	2	53	17	28	1.6
E	40	16	41	2.5	33	20	46	2.3	45	21	33	1.6
F	66	14	20	1.4	28	16	56	3.8	58	12	30	2.5
Vowels												
A	85	3	11	3.6	33	29	40	1.4	82	5	11	2.2
B	78	3	17	5.6	22	22	55	2.5	75	4	20	5
C	77	4	18	4.5	29	13	57	4.3	76	3	19	6.3
D	66	3	29	9.6	24	16	59	3.7	73	3	22	7.3
E	75	6	18	3	23	20	56	2.8	68	8	23	2.8
F	80	2	18	9	20	20	60	3	74	4	22	5.5
Semivowels												
A	88	6	5	.8	73	22	4	.19	90	5	3	.6
B	76	8	12	1.5	58	27	14	.5	85	7	6	.8
C	78	8	12	1.5	49	27	24	.9	82	9	8	.9
D	73	6	20	3.3	44	26	29	1.1	82	8	9	1.1
E	75	5	23	4.6	48	25	26	1.1	78	8	13	1.6
F	80	6	14	2.3	46	24	30	1.3	86	10	4	.4

umns will still reflect the proportions of success and error characteristic of the phones of a given type tried in the various age-groups. The ratio of those two figures for each age-group (expressed as the percentage in the 'passed' column taken as a decimal fraction of the percentage in the 'not passed' column) is the INDEX OF ACQUISITION, abbreviated as IA. Thus, the IA's for age-group A for initial, medial and final consonants are 1.5, .8 and .7, showing that, on the average, members of age-group 'A' who tried initial consonants were half again as likely to 'pass' as to 'not pass', whereas they were somewhat more likely to be in the 'not passed' column if they tried medial and final consonants.

Comparison of the three IA's on each horizontal line reveals that initial position confers a distinct advantage upon phones of all three types at all ages; i.e., the IA for initial position is higher than those for medial and final position in every case except two: age-group 'F's handling of consonants, and age-group 'C's handling of vowels. Medial position seems to be next most advantageous for consonants and semivowels, but the least advantageous for vowels.

The correlation of acquisition with age is seen in the generally rising IA's as one reads downward within each group of phones from age-group 'A' to 'F'. The main exceptions are those drawn from age-groups 'E' and 'F', whose small samples of children (only six and five, respectively) are not too reliable statistically.

Though the medial phones in all three groups do not have the highest IA's, they have the lowest percentages of children in the 'not tried' column. Attempts at medial phones, though more frequent than attempts at initial ones, meet with less success. Attempts at medial consonants and semivowels result in more successes than attempts at final ones, but the same cannot be said of vowels, where the less-frequently attempted final vowels have greater IA's than the medial ones.

8

LEARNING CONSONANT CLUSTERS

"In this connection [the shortening of consonant clusters], one did not even meet with individual differences among children"

A. N. Gvozdev

As Gvozdev has pointed out, the study of the child's production of consonant clusters provides a fertile field in which to trace his linguistic development. In particular, since it is true (as has long been noted, cf. Jakobson 1941) that the child experiences difficulty in the correct production of phones in clusters, even when he pronounces them well intervocalically, such a study may lead us to some estimates of articulatory difficulty. The latter notion has long been intuitively used in linguistics as an explanatory device, but it presents formidable problems of measurement. In the study of the learning of consonant clusters, we may perhaps be able to make an approach to the problem by assuming that articulatory difficulty may at first be charted by regarding it as a property of CLUSTERS rather than of phones. Then, after finding that some clusters seem to present more trouble than others, we may check to see whether certain phones occur in them more than usually frequently. Thus, it might turn out that certain phones, pronounced well enough intervocalically and in some clusters, have nonetheless a latent articulatory difficulty that appears only in combination with certain other phones.

A first question one might want to ask is: how many clusters does the child attempt at such an age? Since the first few glances at the data sufficed to show that the same cluster was handled very differently depending upon its position (initial, medial or final in the utterance), clusters occurring in different positions were regarded as separate entities for certain purposes. Likewise, since erroneous attempts to pronounce certain clusters showed characteristic patterns, it was assumed that the articulatory task presented by a given cluster in a given position could change through time, or could be handled differently by different children at the same age. Thus, different outcomes of attempts to pronounce the same cluster in the same position were regarded as separate entities for purposes of analysis. We thus arrive at the notion of a consonant cluster TYPE: there is a separate type for every different outcome of attempts to pronounce the same cluster in the same position. For example, in initial position, attempts to pronounce [gl] had four different outcomes in this sample: [gl] (correct), [g], [ž], and zero (omission). These represent four different cluster TYPES. Each occurrence of a cluster type is a cluster TOKEN. For example, the four types listed above occurred once, five times, once and once respectively. The cluster [gl] thus participates in four types and eight tokens in initial position.

For the sample used in the analysis of clusters[1], the numbers of types and tokens were as follows:

TABLE 51

	Cluster types	Tokens attempted
Initial position	40	85
Medial position	425	1020
Final position	66	127

[1] Clusters were specially recorded for only 54 of the children. In the cases of the four or five oldest children, whose texts were long, fluent and mostly correct, the scoring of errors proceeded as follows: After recording an adequate sample of both correct and incorrect attempts, only errors were noted. The remaining correct phones were counted and added to the total, but no record was kept of the additional tokens of correct clusters. As a result, one cannot reach any conclusion as to correct-incorrect cluster token ratios for the oldest ('D') age-group. A rough estimate suggests that the fluent speakers whose protocols were handled in this way were producing about twenty correct cluster tokens for every erroneous one.

It may be seen from the table above that the token/type ratio of about two to one characterizes all three positions.

8.1. GENERAL CHARACTERISTICS OF CLUSTER TYPES

The 531 cluster types noted in the sample were classified depending upon whether the cluster characteristic of the type was (1) correct (2) omitted (3) same length, but with one or more members changed (4) shortened by one member (5) shortened by two members and (6) lengthened by one member (usually an epenthetic vowel). These were distributed as follows:

TABLE 52

	Initial	Medial	Final
Correct	7	142	26
Omitted	3	12	8
Same length, changed	4	53	6
Shortened by one	25	187	23
Shortened by two	1	28	1
Lengthened by one		3	2

Until we consider the age groups involved, it would be idle to speculate on the extent to which shortening (by one) is favored, even over correct production. The small number of types shortened by two members in initial and final position is no doubt a function of the small frequency of occurrence, in English, of clusters having three or more members in those positions, since unless the cluster attempted had at least three members to begin with, it would not be scored as shortened by two, i.e., a two-member cluster shortened by two was scored as omitted. The one finding suggested by the table is that these children did not generally react to the articulatory difficulties of consonant clusters by retaining the consonants and separating them with epenthetic vowels.

Before we can go further in interpreting the data of the table, we need to know (1) whether the different characteristics of the cluster types have any correlation with the ages of the children, and (2) the frequencies of the different types. We now proceed to these topics.

The children in the sub-sample used in the study of clusters were divided into four age groups as follows:

TABLE 53a

Group	Age Range	Number of children
A	15-25 months	11
B	26-30 months	16
C	31-37 months	16
D	39-54 months	11

The age groups were arranged so as to have comparable numbers of children in groups ‘A’ and ‘D’ and ‘B’ and ‘C’, since a preliminary view of the data seemed to suggest that much of the heterogeneity in cluster types was concentrated in the first and second halves of the third year of life (roughly groups ‘B’ and ‘C’), whereas the other two groups seemed, respectively, to be only beginning to grapple with the complexities of consonant clusters (group ‘A’), and to be substantially in control of the clusters of the language (group ‘D’). This preliminary view was not entirely supported by the closer look at the data reported below.

8.2 CLUSTERS PRONOUNCED CORRECTLY

Although there are seven types in this classification, it is clear that correct initial clusters are extremely rare, since there are only eleven tokens in all. The 27 children of groups ‘A’ and ‘B’ produced only two correct attempts in all their texts, and the 16 in ‘C’ only four. The correct tokens for group ‘D’ are not complete, for the reasons

TABLE 53b

Initial position	Number of tokens/type group			
Cluster	A	B	C	D
gl	1			
pl		1		
sp			2	
kl			1	
fl			1[a]	1
bl				2
sl				2

[a] This cluster was the only correct consonant cluster in the text recorded in any position from this child — a curious fact in view of its evident difficulty (as the table shows, only one other child — an older one — got it right, and that on only one occasion).

specified in footnote 1 of this chapter. It should be remembered that the same clusters are being pronounced erroneously by members of these groups (sometimes the same children) in the same texts, cf. the other tables displaying initial cluster types below.

TABLE 54

Medial Clusters Made Correctly

Cluster	A	B	C	D
bl			1	2
db			1	
dd				1
ddž				1
df				

Cluster	A	B	C	D
dg				1
dl				1
dm				3
dð			1	
fk				1

Table 54 (continued)

Cluster	A	B	C	D
fl				1
ft			1	
fð				1
ftð				1
kk		1		
kl			1	
kll				
klt			1	
ks		2	4	
ksm			1	
kst				1
kt	1		1	2
ktš		1		
kð				3
ld			1	
lg		2	1	1
ls			1	2
lt			1	
θd			1	3
θð				1
mb	1	1		2
mds			1	
mf			1	2
mg		1		
mp			1	
mt		1		
mtš			1	
mz		3		
nð			1	
nt		1		
nd			4	5
ndb			1	
ndh				1
ndhw			1	
ndl				3
ndt			1	
nf				
nm		2	3	1

Table 54 (continued)

Cluster	A	B	C	D
np			1	
ns				1
nt			1	4
ntb			1	
ntd				1
ntf			1	
ntg				1
ntk				1
ntn			5	8
ntnð				
nt		1		
ntsk			1	
nˀn				
nz			3	
ntð				1
ŋb				1
ŋbl			1	
ŋd				1
ŋf				3
ŋg			3	

Cluster	A	B	C	D
ŋk	1	1		3
ŋkf				3
ŋkl			1	
ŋkm		3		
ŋkt				1
ŋkð				1
ŋn				1
ŋp				1
ŋð			1	2
pθ				1
ps				1
pst				6
pt			4	1
pð		1		3
sb			1	
sg		1		2
sk		1	4	5
sm		1	1	2
sn			1	

Table 54 (continued)

Cluster	A	B	C	D
sp		1	3	1
st		1	4	2
sd				1
ss				1
sst				1
sθ				1
tð		1	3	6
tb		2	1	
tk			3	2
tdž				1
tf			1	4
tg			1	4
tk				4
tl			1	5
tlb			1	
tm	1	1	3	2
tn		1		3
ts	1	1	5	5
tsb		2	3	2
tsd				3
tsf				1
tsg				
tsh				1
tsk		2	1	
tsl				1
tsm				3
tsp	2		1	
tst		2	1	3
tsð				7
tsw				1
tsdž				3
tskl				1
tt			1	
vs				3
vt				1
vð				5
vz				1
zb				3
zč			1	

Table 54 (continued)

Cluster	A	B	C	D	Cluster	A	B	C	D
zd				5	znts				1
zdz					zs				4
zdž				3	zš			3	
zf			3		zsk	1			
zg				1	zsl			3	
zk		2	1		zst				1
zl				1	zt			1	
zm			6		ztš	1			
zn				1	zð			3	2
zntn				1	zp			4	2

The 142 types are represented by 375 tokens. By group, these are:

A	B	C	D
9	45	121	200

If we remember that group 'D' is incompletely represented with regard to correct tokens, it is clear that medial clusters show, much more decisively than initial ones, the progress of phonological learning through the third and fourth years of life. If some of the clusters listed above look impossible, the reader should recall that the unit of classification is the utterance, not the word. Thus, a cluster such as [zš], not found within the word in English, is not at all strange in utterance-medial position, e.g., 'his shoes' [hIzšuz] (the use of junctures would be question-begging at this stage, and, of course, the morphemic boundaries of adult utterances are irrelevant to the present investigation).

TABLE 55

Final position	Number of tokens/type/group			
Cluster	A	B	C	D
ps			3	1
pt			1	
pl		1	1	
plz			1	
bl				1
ts	1		3	3
dz			2	
ks	1	2	4	3
gz			1	2
ˀn			1	
mz			1	1
mps			1	1
nt		1	5	
nd			5	
ns			1	
nz		3	5	1
ntš	1			
nts				1
ndžn			1	
ŋz			1	2
ŋk			1	
fs				1
vl			1	
st	1	1		
št				1
lz				2
	4	8	39	20

The 26 types are represented by 71 tokens, and groups ‘A’, ‘B’, and ‘C’ show the progression of improvement clearly. The figure for group ‘D’ is not indicative of the true state of progress for the reasons previously given.

8.3 OMITTED CLUSTERS

The clusters omitted in initial position are distributed as follows

TABLE 56

Cluster	A	B	C	D
dž			1	
gl		1[a]		
sn		1		

This same speaker also handled the same cluster differently in the same position.

The three types have only one token apiece.

Medial position: the clusters omitted in medial position are distributed as follows:

TABLE 57

Cluster	A	B	C	D
ts	1	2	3	1
tm			1	
tl			1	
kð			1	
mp			1	
mθ				1
nt	1			
nd			2	1
nz			1	
fl				1
fr				1
tsz			1	
Totals	2	2	11	5

The twelve types are represented by twenty tokens. It is difficult to account for the larger number in group 'C', since omission of a cluster would, *a priori*, seem more likely to be a characteristic expedient of the younger children from groups 'A' and 'B'. Possibly the answer is to be found in the fact that the texts from the older children are significantly longer and more complex syntactically so that there is much greater likelihood that medial clusters would be ATTEMPTED. Thus, if the increase in total clusters attempted were great enough, the larger total of group 'C' omissions might even turn out to be a decrease in the percentage of times omission was resorted to as a means of handling clusters. As a matter of fact, the numbers of clusters attempted (tokens) were distributed among the groups as follows:

A	B	C	D
121	232	489	387

Thus, *ceterus paribus*, one might expect group 'C' to have about four times as many clusters of any given type as group 'A' and twice as many as group 'B'; in fact, the 11 omissions recorded from group 'C' is still too high to be explained in this way, though the relationships between groups 'A', 'B' and 'D' are not beyond the realm of possibility, when seen in the light of the proportions of the samples.

Final position: the clusters omitted in final position follow.

TABLE 58

Cluster	A	B	C	D
ks		1		
gn		1		
dz	1			
nd			1	
ns		1		
ŋz	1			
st			1	
ndž		2		
	2	5	2	

These numbers more nearly reflect what one would expect: group 'B' about twice as likely as 'A' to omit, with the larger expectancies for groups 'C' and 'D' reduced by their greater age (and consequent opportunity to learn enough about the cluster to be able to do SOMETHING with it other than omit it).

Clusters kept the same length, but with one or more members changed. The study of clusters of this variety promises to turn up direct evidence concerning processes of change long postulated in historical linguistics. For example, one can specify the member or members of a cluster that are correct and those that reveal error. The errors can be classified as to type (place, place-and-friction, nasality, etc.) and process (assimilation, dissimilation, etc.) The types of errors are those we have been discussing in the foregoing chapters, while the processes may be defined as follows: an error of ASSIMILATION occurs in those instances where the erroneous phone is more similar in some phonetic dimension to the neighboring correct phone or phones than was the target phone. For example, when the child says [nt] for [ŋt], [t] is the neighboring correct phone, [ŋ] is the target and [n] the erroneous phone. The error is one of place, and the process is assimilation because [n] is identical in place of articulation with [t], whereas [ŋ] is not. On the other hand, an error of DISSIMILATION occurs when the erroneous phone is less similar to the neighboring correct phone or phones than the target would have been. E.g., when the child says [bs] for [ds], the error is again one of place. However, the erroneous phone [b] is LESS similar to the neighboring correct phone [s] in place than is the target [d], which, like [s], is apicoalveolar. METATHESIS is reversal of order, e.g. [sk] for [ks].

Of course, if all members of the cluster are erroneous, then these processes may be impossible to identify; in such cases the slot under 'process' will be left blank. Sometimes, even when all phones are erroneous, a kind of assimilation can still be identified. For (a hypothetical) example, if the child says [st] for [fk], there are two errors of place and the resulting cluster is composed of members more similar to each other (as regards place) than the members of the target cluster. Conversely, if the child said (again the example is hypothetical) [fk] for [st], the process would be dissimilation.

(In the following tables, the following symbols will be used: ‘P’ = place, ‘O’ occlusion, ‘F’ = friction, ‘V’ = voicing, ‘N’ = nasality, ‘L’ = laterality, ‘A’ = assimilation, ‘D’ = dissimilation, ‘M’ = metathesis, ‘a’ = first member erroneous, ‘b’ = second member erroneous, ‘c’ = third member erroneous, ‘d’ = fourth member erroneous.)

TABLE 59

Initial Position

Model	Child	A	B	C	D	type of error	process	members affected
st	fw			1		P V		a,b
fl	st			1		P L	A	a b
sl	ts			1		L	M	a b
fl	fw		3			L		b
Totals			3	3				

TABLE 60

Medial Position

Model	Child	A	B	C	D	type of error	process	members affected
tsð	tsz			1	1	P	A	c
θp	fp			1		P	A	a
ŋt	nt		1	2		P	A	a
pst	psk			1		P	D	c
ds	bs			1		P	D	a
ŋs	ns			1	2	P	A	a
ms	mf			1		P	A	b
pldž	pldz		1			P	A	d
ktš	kts		1			P	A	c
zð	zz		1			P	A	b
tg	kg		1			P	A	a
tn	ʔn		1			P	D	a

Table 60 (continued)

Model	Child	A	B	C	D	type of error	process	members affected
tlb	ʔlb		1			P	D	a
ŋl	nl	1				P	A	a
zn	ðn				1	P	D	a
ksd	kθd				1	P	D	b
θš	fš				1	P	D?	a
tg	ʔg				1	P		a
šð	šd			1		P F	D	b
kð	kd			3	2	P F	A	b
vð	vd			1		P F	D	b
tð	td			3	7	P F	A	b
dð	dd			1		P F	A	b
št	kt			1		P F	A, D [a]	a
ŋg	ŋw			1		O	D	b
tšð	tsd			1	2	P F	A	b c
pð	pd			1		P F	A, D	b
pst	psθ			2		P F	A, D	c
tsb	fsb			1		P F	A, D	a
ntð	nʔd			1		P F	D	b c
nð	nd				2	P F	A	b
sð	sd				1	P F	A, D	b
zð	zd				1	P F	A, D	b
ŋð	ŋd				1	P F	A?	b
td	dd			1		V	A	a
vs	fs			1		V	A	a
tsð	tsθ			1		V	A	c
tsk	dzk			1		V	D	a b
sm	zm				1	V	A	a
zf	zb			1		F V	A, D	b
kf	kw				1	F V	D	b
ksp	ŋsp			1		N V	D	a
tð	dd			1		P F V	A, D	a b
mv	mb			1		F	A	b
vt	bt			1		F	A	a
vw	mw			1		N F	D?	a
zs	ms			1		N F	D	a
fl	fw		2	1		L		b
tkl	tkw				1	L		c
kl	kw				1	L		b
kt	lt				1	P L	D	a
sk	ts				1	P	M, A	a b
	Totals	1	9	37	29			

[a] Both processes are at work here: [k] is a stop like [t] and thus is assimilated to it, but [k] is farther away than [š] in place of articulation and thus is dissimulated from [t] in that respect.

Considering the tokens of medial clusters of this type, we note that types of errors are represented as follows:

Place	58	Nasality	2
Friction	39	Laterality	6
Voicing	9	Occlusion	1

Again taking tokens into account, and ignoring those process symbols marked as doubtful, we see that the most frequent process is assimilation (52 occurrences), followed by dissimilation (24) and metathesis (1). The member most frequently affected is the second (b), (42 occurrences), followed by the first (a) (30 times). In longer clusters, the third member is affected 12 times and the fourth member once.

In medial position, this type of error is most characteristic of the older children, since those from groups 'A' and 'B' more often handle clusters by omitting one of the members. The composite typical cluster of the sort under consideration here is made by a member of group 'C' or 'D' and has the place of articulation of the second member changed by assimilation. Considering all the clusters and not just those made by members of groups 'C' and 'D', we find that the composite type ('P', 'A', 'b') occurs in fact in 28 tokens.

Final position: clusters found in this position handled by changing one or more members while retaining the same length are distributed as follows.

TABLE 61

Final Position

Model	Child	A	B	C	D	type of error	process	members
št	tš			1			M	a b
ks	ps			1		P		a
ts	tθ				1	P	D	b
lk	wk				1	L	A?	a
ps	bz	1				V		a b
ks	ts		2			P	A	a
	Totals	1	2	2	2			

As in the case of the initial clusters of this type, the numbers are too small to permit conclusive findings, except to note that place of articulation is the type of error represented in four of the seven tokens.

8.5. CLUSTERS SHORTENED BY ONE MEMBER

Clusters shortened by one member may be classified according to the member lost. Thus two-member clusters shortened by one are of three kinds: those retaining the first member, those retaining the second member, and those represented by a single phone which is not either of the two original members.

Initial position: all initial clusters attempted in this class are two-member clusters.

TABLE 62

First Member Retained

Model	Child	A	B	C	D
sl	s	1	2	2	
bl	b	3		1	
fl	f	5	3	4	2
kl	k	1	3	3	
sn	s			2	
nd	n			1	
gl	g	3	1		
pl	p	1			1
sp	s	1			
st	s	1			
	Totals	16	9	13	3

Thus, it may be seen (cf. Table 63) that [sp] and [st] may retain either of the members, though the more common pattern is retention of the stop and loss of [s]. The bulk of the tokens (36 out

TABLE 63

Second Member Retained

Model	Child	A	B	C	D
sp	p	1	2	2	
st	t	2			1
	Totals	3	2	2	1

TABLE 64

Neither Member Retained

Model	Child	A	B	C	D	Remarks
pl	f			1		Labial position retained
kl	s			1		
kl	š			2		
st	d	1		1		Apical position retained
gl	ž		1			
sp	v	1				Friction of (a), place of (b) retained
pl	w	1				
sm	f	2				Friction of (a), place of (b) retained
fl	w	1				
bl	p	1				
	Totals	7	1	5	–	

of 41) in those cases where the first member is retained, involve the loss of [l] as the second member.

The substitution of voiceless spirants for [pl], [kl] is not too surprising since in some idiolects the [l] in those initial clusters is often voiceless. The difficulty of [l] as a second member of an initial cluster is revealed by the fact that 44 out of the 62 tokens in this class (initial clusters shortened by one) have [l] as the second member.

Medial position: medial clusters shortened by one member are considered in order of increasing number of members: two-member, three-member and four-member.

Two-member clusters:

TABLE 65

First Member Retained

Cluster	A	B	C	D	Cluster	A	B	C	D
bl			2		dð	1	3	3	2
kð	2	3	2		dl				1
kt			3		sl		3	2	
ks			1		st			5	
kf		2			tš	1			
fl	2	3	7	4	tð			5	1
ft			1		ts		2		1
pl	3	3	2		ŋk	1			
pt		2			ŋg			1	
nd	2	3	20	12	θð				1
nð	1	2	6	5	gl				1
nt		1	3	2	zð	2		1	
nm			1		zt				1
nz			1		mb	1			
lð		1							
ld			1		Totals	16	28	67	31

The 30 types are thus represented by 142 tokens.

TABLE 66

Second Member Retained

Cluster	A	B	C	D	Cluster	A	B	C	D
ŋg			1		tb		5		2
ŋk	1				tg			3	
ts	4	33	33	9	tf			1	

Table 66 (continued)

Cluster	A	B	C	D	Cluster	A	B	C	D
tp			1		zn			2	
td	1		2		zk		1		
tð		1			zð		1		
tm		2	1		zd		1		
tš		1			zt				1
tn	2		1		vs			2	1
tl	1				vb		1		
ks	2		1		vn			1	
kf			1		vm		1		
ps		1			dt			1	
mb	1				dg		1		
mt	1				dm		1		
nk			1		dp				1
ns	2		1		dð				1
nt		1			db				1
nm		1		2	ʔt			2	
lf			2	1	ʔn	1			
lb		2	2		sp	1			
ld	1	2	3		sm			1	
lg		1		3	sk			3	1
lð				1	sb			1	
zf			1		st	1			
zš			1		θp			1	
					θd			1	
zg			2	2					
zb		2		1	Totals	19	59	74	29
zm			2	1					

In order to calculate the tendencies of phones to be retained or lost, it is useful to compare the two-member clusters where the first member is retained with those where the second member is retained. In the tables below the numbers represent tokens.

TABLE 67

As first member	Retained	Lost
k	14	4
f	17	

Table 67 (continued)

As first member	Retained	Lost
n	59	8
p	10	1
d	10	6
s	10	8
b	2	
ŋ	2	2
g	1	2
θ	1	2
m	1	2
l	2	18
z	4	18
t	10	107
v		6

Thus it appears that 'k', 'f', 'n', 'p' are very likely to be retained when they are first member, while 'l', 'z','t','v' are very likely to be lost in that position. The others are about equally likely to be retained or lost.

TABLE 68

As second member	Retained	Lost
k	7	1
f	5	2
n	7	
p	4	
d	11	38
s	89	4
b	19	1
g	13	1
ð	4	35
m	13	1
l		36
z		1
t	7	22
š	2	1

Comparison of the two tables shows that 'k','f','n','p','s','b' are likely to be retained in either position, and that 'l','z','t' are likely to be lost in either position. The tendencies of the others are less clear, except that 'ð', which occurs only as second member, tends to be lost.

Medial two-member clusters shortened by one, miscellaneous: this type comprises those two-member medial clusters represented by one phone which is neither of the two original members; reduced geminates are thrown in here also.

TABLE 69

Model	Child	A	B	C	D	Model	Child	A	B	C	D
kð	d			4		gk	γ	1			
kl	š			1		dd	d	2		1	
tð	d		5	10	3	ŋk	g	2			
tð	s			1		ŋk	m	1			
ts	θ		1			ŋð	n	1	2	1	
ts	z	1				nk	d		1		
td	b		1			nt	~		1		
pl	f		1			ns	θ				1
fl	z		1			nd	~				1
fð	y			1		zk	g		1		
sk	θ				1	zš	ž		1		
sk	f			1		zð	d			1	
sk	t			1		zn	y			1	
sp	b	1				vð	d			4	
sl	t		1			lθ	f		1		
sl	š		1								
st	š				1		Totals	9	18	27	7

In the apparent heterogeneity of the above class, one can discern some trends. In the four cases (seven tokens) where the child has a nasal (including nasalization), the model has a nasal as first member. In four of the cases where the child has [d] (27 tokens) the model has [ð] as second member; the other two types giving [d] (four tokens) are [nk] and [dd], the latter classified here because it could not be assigned unambiguously either to those with first member retained or those with second member retained. Those with [l] as second member are represented by a spirant in four cases and by a stop in one. Clusters of spirant + stop turn up three times as spirants and equally often as stops; in either case these are not necessarily the same ones found in the model cluster.

Final position:

TABLE 70

First Member Retained

Cluster	A	B	C	D
pt			1	
pl			1	
ks		1		
gz				1
st		2	1	2
nt				1
nd		3	4	
nz			1	
Totals	—	6	8	4

TABLE 71

Second Member Retained

Cluster	A	B	C	D
ts		2	1	
ks			1	
dz			1	
gz			1	
st		3	1	
ŋk		2	1	
lf		1		
lz			2	
Totals	—	8	8	—

Comparison of the two tables reveals that both processes are mostly found in groups 'B' and 'C'. While 'ks', 'gz', 'st' are handled either way, [p] and [n] are retained when first member and [t], [ŋ] and [l] are lost in that position.

TABLE 72

Final Two-Member Clusters Shortened by One, Miscellaneous

Model	Child	A	B	C	D
dz	f			1	
nd	m		1		
lz	t		1		
gz	θ	1			
nd	—	1			
ns	—	1			

Three-member clusters shortened by one.

Initial position: none.

Medial position: medial clusters of this variety either retain two of the original members or do not. The latter cases are listed as miscellaneous. The former have three possibilities: retention of the first two, the last two, or the first and third.

TABLE 73

Three-Member Medial Clusters Retaining the First Two

Cluster	A	B	C	D
ntn			1	
ndð		3	1	
mpt			2	
tst			1	
tpl			1	
dpl			1	
fkl		1		
šbl				1
Totals		4	7	1

The first two clusters listed above are usually handled differently, particularly at the older ages, cf. the tables below. In the other clusters above, the lost member is always [t] or [l], both of which have a tendency to disappear when clusters are shortened; compare the previous treatment of two-member clusters of this type.

TABLE 74

Three-Member Medial Clusters Retaining the Last Two

Cluster	A	B	C	D	Cluster	A	B	C	D
tlt			1		tlg	2		1	
tsð			1		tlb			1	
tst			2		tsb		1		
tsd			2		tss				1
tsl			1	2	mtš			1	
tsg	2		1		nts				1
tsk			2		ktš				1
tsm		1	2		Totals	4	2	15	5

Again, [t] figures prominantly as the member lost. In addition, one of the clusters above ('nts') in which it is retained is usually handled by another way, cf. below.

TABLE 75

Three-Member Clusters With the First and Third Members Retained

Cluster	A	B	C	D	Cluster	A	B	C	D
ndm			1		ndl				1
nts			2	1	ndk				1
ndz			1		ŋks			1	
ntk	1				ksd				1
ntn			1	7	kzð			1	
ndð				21	tsð			1	
nds			1		tsb				1
ntm	3	1			tsm	1			
ndp				1	lzd			1	
ntð				1					
nzm				2	Totals	5	1	10	37

Comparison of the three tables above makes it clear that retention of the first and third members is the favored pattern (53 tokens), followed by retention of the last two (26 tokens) and retention of the first two (12 tokens). It should be noted that much of the preponderance of the most favored pattern is concentrated in the 21 tokens from group 'D' for [ndð]. Even without these, retention of the first and third seems to be the favorite method of group 'D'.

TABLE 76

Miscellaneous Three-Member Clusters Shortened by One

Model	Child	A	B	C	D
kdž	kg	1			
mpt	ŋk		1		
tsð	ss			1	
tšð	ts		1		
tpl	pw		1		
tld	wd		1		
tsð	sd		2		
tsð	šd		1		
tst	tf				1
tsk	sg				1
tsð	šð	1			
	Totals	2	7	1	2

It appears that the results above may be traced in part to attempts, usually by members of group 'B', which amount to shortening by loss of one of the members, complicated by some further phonetic change, e.g., replacement of [l] by [w].

Final position: there is only one final three-member cluster shortened by one.

TABLE 77

Model	Child	A	B	C	D
nts	ts		1		

TABLE 78

Four-Member Clusters Shortened by One (all are medial)

Model	Child	A	B	C	D
stsl	stl				1
ndbl	nbl				1
ndst	nst				1

8.6. CLUSTERS SHORTENED BY TWO MEMBERS

Three-member clusters:
Initial position: none.
Medial position:

TABLE 79

First Member Retained

Cluster	A	B	C	D
ntd			1	
ndð			3	
mpt		1		
tsð		1		
ndl	1			
Totals	1	2	4	—

TABLE 80

Second Member Retained

Cluster	A	B	C	D
ldð	4		1	
tsð	5		1	
pfl		1		
mpt		1		
gbl		1		
mtš	1			
Totals	10	3	2	—

TABLE 81

Third Member Retained

Cluster	A	B	C	D
gzf			1	
tsg			1	
tsm			1	
ntd		1		
ndb				1
ntn		1	3	1
Totals	—	2	6	2

The last cluster listed could, of course, just as well be classified as one retaining the first member.

TABLE 82

Miscellaneous (*No Member Retained*)

Model	Child	A	B	C	D
spl	f			1	
tsð	d			3	
nds	z			1	
zdž	y			1	
ksk	g			1	
ntn	~			1	
tšt	b		1		
tsð	z	1			
	Totals	1	1	8	—

It is clear from the above four tables that shortening three-members clusters by two is a practice largely abandoned by children in group D.

Final position: there is only one type.

TABLE 83

Model	Child	A	B	C	D
nts	s		2		

Four-member clusters shortened by two or more members: these occur only in medial position.

TABLE 84

Model	Child	A	B	C	D
ʔnts	ns		1		
tlbl	lb		1		
mzdž	y			2	

The two examples of the last are from children other than the one who (cf. above, miscellaneous) had [y] for [zdž].

8.7. CLUSTERS LENGTHENED

The lengthened clusters are as follows:
Initial position: none.

TABLE 85

Medial Position

Model	Child	A	B	C	D
st	stš		1		
nš	nsy		1		
tsg	tsəg				1

TABLE 86

Final Position

Model	Child	A	B	C	D
s	ts		1		
pl	pəl				1

TABLE 87

Summary of Consonant Clusters

		A		B		C		D		Total	
		n	%	n	%	n	%	n	%	n	%
	I	1	3.7	1	5.6	4	14.3	5	55.6	11	13.4
correct	M	9	11.4	45	24.1	121	30.9	200	56.8	375	37.1
	F	4	40.0	8	22.9	39	65.0	20	74.1	71	53.8
	*	14	12.1	54	22.5	164	34.2	225	58.0	457	37.3
omitted	I			2	11.1	1	3.6			3	3.7
	M	2	2.5	2	1.1	11	2.8	5	1.4	20	2.0
	F	2	20.0	5	14.3	2	3.3			9	6.8
	*	4	3.4	9	3.8	14	2.9	5	1.3	32	2.6
same	I			3	16.7	3	10.7			6	7.3
length,	M	1	1.3	9	4.8	37	9.4	29	8.2	76	7.5
changed	F	1	10.0	2	5.7	2	3.3	2	7.4	7	5.3
	*	2	1.7	14	5.8	42	8.8	31	8.0	89	7.3
	I	26	96.3	12	66.7	20	71.4	4	44.4	62	75.6
short,	M	55	69.6	119	63.6	201	51.3	115	32.7	490	48.5
by 1	F	3	30.0	17	48.6	17	28.3	4	14.8	41	31.1
	*	84	72.4	148	61.7	238	49.6	123	31.7	593	48.4
	I										
short,	M	12	15.2	10	5.3	22	5.6	2	0.5	46	4.6
by 2	F			2	5.7					2	1.5
	*	12	10.3	12	5.0	22	4.6	2	0.5	48	3.9
	I										
length-	M			2	1.1			1	0.3	3	0.3
ened	F			1	2.9			1	3.7	2	1.5
	*			3	1.2			2	0.5	5	0.4
	*I	27	(23.3)	18	(7.5)	28	(5.8)	9	(2.3)	82	(6.7)
attempts	*M	79	(68.1)	187	(77.9)	392	(81.7)	352	(90.7)	1010	(82.5)
	*F	10	(8.6)	35	(14.6)	60	(12.5)	27	(7.0)	132	(10.8)
	**	116	100.0	240	100.0	480	100.0	388	100.0	1224	100.0

9

CONCLUSIONS

"Exactly how children learn to speak is not known"

Leonard Bloomfield

9.1. CONSONANTS, ALONE AND IN CLUSTERS

The data presented in Chapter 8 concerning the fate of consonant clusters may be compared with our information concerning the acquisition (and non-acquisition) of consonants in general.

TABLE 88

Frequently retained in clusters	Mean Percent Correct	Mean Residual Difficulty
k	80.4	.105
f	81.9	.038
n	75.3	.146
p	75.5	–.059
s	61.4	.017
b	90.4	.094
Frequently lost in clusters		
l	33.5	not applicable
z	57.6	–.014
t	52.2	–.135
ð	20.3	–.009

The Mean Percents Correct are from Table 28. The data concerning residual difficulty are from Table 37; a negative number in this connection indicates that the phone in question was more difficult than would be predicted from the amalgamation of the various factors involved in its production (cf. Table 33) when corrections are made for frequency of occurrence). A positive number indicates that the phone is less difficult than would be expected.

It is clear from these data that frequently-retained members of consonant clusters are consonants that are usually gotten correct when they stand alone, since the Mean Percents Correct range between 61.4 and 90.4. In addition, all of the frequently-retained members — save only [p] — have positive Mean Residual Difficulty, i.e., are less difficult than would be predicted given their places and manners of articulation.

In contrast, the four consonants most frequently lost from clusters are all difficult to produce correctly, even when they stand alone. The Mean Percents Correct of this group range from 57.6 down to 20.3. Residual difficulty could not be calculated for [l]; the Mean Residual Difficulty for the other three is in every case negative, i.e., all were more difficult than one would predict upon the basis of their components.

Overall, it appears that, while consonant clusters present particularly difficult problems of articulation, the resolutions of those problems are consistent with, and partially predictable from what is known about the children's ability to pronounce phones in other positions.

9.2. SUMMARY OF FINDINGS

The results of such a study as this are of two kinds. First, there are the implications for the postulates of the theory that prompted the investigation. Second, there are the empirical findings which ought to be useful to other investigators whether or not they have any interest in the theory advanced here.

The postulates of the present study include the following:

1. That the child's acquisition of language — and of phones in particular — is fruitfully regarded as a problem in learning responses rather than as the unfolding of innate capabilities.
2. That the concept of secondary reinforcement is useful in explaining the persistence of babbling and the 'latent learning' of certain articulatory behavior.
3. That certain articulatory components (e.g. voicing, nasality) contribute more to the discriminability of phones than do others (e.g. friction, place of articulation).
4. That the phones of the language are modeled for the child in about the same proportions as they occur in ordinary speech.
5. That, in the face of partial or complete masking by other sounds in the environment, the more discriminable phones have a selective advantage — with respect to potential for success and resistance to error — over the less discriminable ones.

The postulates listed above are a mixed bag, as far as their position within the theory is concerned. The third and fourth are susceptible to direct empirical test and may thus be theorems in some theory, though in the present one they are postulates. The third postulate was, in fact, a theorem of Miller and Nicely's study (1955). The first postulate is really more a declaration of investigatory style than a postulate, strictly speaking. It would hardly have been necessary to include it, had it not been denied so vigorously and frequently and aprioristically. That language-acquisition could fruitfully be studied as learning would have come as no surprise to earlier workers such as Bloomfield, Sapir and Esper. That such a basis has resulted in a theory of considerable predictive power (in a limited area) will confirm the productivity of the approach in minds not closed by dogma. The results obtained here, of course, do not suggest that the present postulates are the only ones which will give positive results, or that this is the only orientation which can be adopted in studying the acquisition of language by the child.

The notion of secondary reinforcement is not directly tested in this study. However, none of the results of this study are inconsistent with the role postulated for secondary reinforcements in the learning process, and alternative explanations of those results (e.g., dependence on the concept of biological maturation) appear to be less satisfactory, inasmuch as they do not, so far, lead to successful predictions.

The fifth postulate is partly confirmed (with respect to resistance to error) and partly disconfirmed (with respect to successes). It is clear that the postulate was too crude in bracketing successes and errors together, since the factors that make for success in pronunciation learning by the child evidently include resistance to error AND ALSO SOME OTHERS (including possible articulatory difficulty) not investigated in this study.

Whether or not the reader agrees with the approach adopted in this study, he may, when constructing his own theory, want to take account of the observations and relationships that came to light as a result of this investigation. The principal ones are as follows:

1. For the sample as a whole, the theory predicts the relative frequency of errors correctly, except that the resistance of the nasality component to error was under-predicted.
2. With respect to the performance of individual children, the theory predicted successfully more than 90 per cent of the time.
3. Errors are not reciprocal: voiced stops are most frequent substitutes for voiceless ones, but not vice versa; in general, the phones most frequently substituted for consonants differ by either voice or place; in general, the phones serving as the most frequent model for erroneous productions differ by both place and friction.
4. In general, labials tend to be the most frequent substitutes for labials, while the most frequent substitutes for models in all other positions are errors of place of articulation.
5. Errors are not reciprocal: voicing is lost less often than chance would suggest; nasality is added less frequently than chance would suggest; friction has been lost (i.e., the model's fricative has been replaced by the corresponding stop) much more often than chance would suggest.
6. The different positions of articulation are vulnerable to errors of place at different rates: labial position is most resistent to such

errors; the alveolar and velar positions are about 3.7 times as vulnerable, while interdental position is about 11 times as vulnerable and postalveolar position is about 13 times as prone to such errors.

7. There is a centralizing tendency in place errors among consonants: erroneous attempts at labial, interdental, post-alveolar and velar phones are all very much more likely to turn up in alveolar position than in any other. On the other hand, place-erroneous attempts at alveolar phones are relatively evenly represented in all the other four positions.

8. The classes of phones differ in their vulnerability to error. The semi-vowels are least likely to be mispronounced, turning up in error about 9% of the time. Non-retroflex vowels are next, with about 22% of errors, followed by consonants (about 26 per cent), diphthongs (about 29%) and retroflex vowels (about 58%).

9. The most frequent substitutes for vowels are [ʌ] and [a], showing a tendency to concentrate errors of place — as regards vowels — in low central position.

10. A phone is not learned once and for all. In fact, the usual course of development appears to consist of a mixture of successes and errors in successive attempts at a given phone, with gradual increases in the percentages of successes and decreases in the relative numbers of errors.

11. In this sample of children, coexistence of success and error is the most frequent pattern among phones.

12. In this sample of children, coexistence of success and error is the most frequent pattern among children.

13. Coexistence of success and error is, for these children, more frequent as a function of the representativeness of the sample, i.e. as a function of the frequency of attempts of a given phone by a given child.

14. Success in pronunciation depends on more than frequency of attempts: some of the most frequently-attempted phones have relatively poor mean percents correct.

15. The presence of voice as a component of a phone appears to give some advantage in acquisition at the earlier ages, but the effect

is reversed among the older children. The data are not inconsistent with the views of Templin (1957) but do not agree with the theory of Jakobson, who postulated that /p/ would be the first consonant (rather than /b/) because its voicelessness would make it maximally different from (voiced) vowels. In fact, in this sample, [b] with a mean percent correct of 90.4 has a considerable advantage over [p] (75.5).

16. Both friction and nasality contribute negatively to acquisition. The effect of the former is not unexpected, but that of the latter flatly contradicts the theory found in Olmsted (1966), where it was assumed that predictions of error and success would be simple opposites of each other. This crude notion must now be abandoned.

17. The various positions of articulation confer advantage in acquisition in the following decreasing order: labial, velar, alveolar, postalveolar, and interdental.

18. Subtraction of the calculated component scores appropriate to each phone from its mean percent correct yields the concept of RESIDUAL DIFFICULTY, i.e., the extent to which the performance of any phone agrees with what would be expected from the sum of its components' effects.

19. More difficult than expected are [p t d v ð z ž ŋ].

20. Less difficult than expected are [k b g f θ s š m n].

21. (When at least half of a child's attempts at a given phone result in successes, he is defined as having ACQUIRED that phone.) The labial and velar stops in all positions (except '-g') and [n] in all positions were acquired by the second half of the second year of life. The only spirant acquired in all positions by this time is [f].

22. During the first half of the third year of life, members of this sample completed acquisition of [m] in all positions and acquired about half the possible apicoalveolar phones in the various positions, the rule being that those in initial position are acquired earlier than those in other positions, except for [-s-] and [-z-] where the medial phone is the first mastered.

23. The second half of the third year of life sees the completion of the acquisition of most of the apicoalveolar phones, plus non-initial [v].

24.The first half of the fourth year is marked by the successful extension of the apex to positions others than alveolar, i.e., interdental and postalveolar, plus mastery of the initial lateral.

25. Certain difficult consonantal phones are acquired by children in this sample only at the beginning of the fifth year of life. Among these are the initial postalveolar affricate, medial [-t-,-ŋ-, -l-, -ð-] and final [-ŋ].

26. The most difficult consonant phones have still not been mastered by the middle of the fifth year: initial [θ-, ð-, dž-, z-] medial [-ž-, -tš-] and final [-ð, -ž, -dž, -l].

27. Vowels, unlike consonants, were acquired by these children almost entirely in the first two periods, i.e., by the end of the first half of the third year. The order of acquisition does not support Jakobson's contention that the vowels are learned first at the extreme dimensions of the oral cavity with progressive differentiation into finer distinctions.

28. The non-retroflex semivowels are, for the most part, acquired as early as the vowels, whereas initial and medial retroflex semivowels are acquired very late, generally beyond the age range included in this sample.

29. When the number of phones PASSED is expressed as a decimal fraction of the number of phones NOT PASSED for any age-group, the resulting number is the INDEX OF ACQUISITION (IA).

30. Inspection of the IA's reveals that initial position confers a distinct advantage upon phones of all three types at all ages.

31. Medial position is next most advantageous for consonants and semivowels, but the least advantageous for vowels.

32. Medial phones are most frequently attempted, though they are successfully handled less often than initial ones.

33. Errors made in the pronunciation of consonant clusters reveal the same proportions as those characteristic of single consonants, viz. errors of place are most frequent, followed at some distance by those of friction, with errors of voice still fewer and those of nasality nearly non-existent.

34. The most frequent process involved in erroneous cluster tokens is assimilation, which is represented about twice as often as dissimilation.

35. In two-member clusters, the member most frequently affected (by error) is the second, which predominates over the first by a proportion of about 4 to 3.

36. The incidence (in clusters) of metathesis is negligible.

37. When three-member clusters are shortened by one, the first and third members are most likely to be retained. About half as frequent is the retention of the last two and about a quarter as frequent is the retention of the first two.

38. Lengthening of clusters by the insertion of an epenthetic vowel is, among these children, quite infrequent.

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INDEX