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Volume 3
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Preface

Speech and Language: Advances in Basic Research and Practice is a serial publication concerned with contemporary research in speech and language processes and pathologies. It provides contributors with the opportunity to review literature, discuss unresolved issues, offer suggestions for future research directions, relate accumulated data to theoretical discussions, and, whenever appropriate, apply the evidence and theories to clinical issues in speech and language pathology. As a vehicle for the publication of papers that are too lengthy for journal articles, it offers a much-needed comprehensive forum for the discussion of studies in a variety of related fields.

Contributions to this publication present critical reviews, theoretical syntheses, new principles, and/or the integration of recent findings. Because of the diversity of topics included in this publication, no volume is restricted to a single theme. The contents should prove useful to researchers, clinicians, and graduate students in a number of disciplines, including speech and language pathology, speech science, experimental phonetics, linguistics, clinical and experimental psychology, anatomy, and physiology.

Volume 3 contains nine articles on a wide variety of topics. Mowrer presents a detailed discussion of early and recent theories of phonological development. He believes that “through an understanding of theories of phonological development . . . we may be able to discover answers that will drastically change our approach to articulation therapy.” Tatham describes phonology and phonetics as subcomponents of the language encoding/decoding system and distinguishes between the rules that govern the operation of the system and the system’s actual usage. The application of phonological universals in speech pathology is discussed by Ohala. His thesis is that general human phonological universals can help us understand the speech production and speech perception processes in persons with normal or abnormal speech and hearing. Adler and Tims present a position paper on the contemporary role of the speech-language clinician. The authors propose that the clinician should not only treat clients with communicative disorders, but also teach developmental language skills to preschool children. They suggest certification for pediatric language specialists and discuss an innovative pediatric language program as well as a job description for such specialists. Massaro and Oden offer a psychological framework for the study of speech perception, “a model of
the intervening mental processes and memory structures between the presentation of the acoustic input at the ear of the listener and the phenomenal experience and interpretation of that input." Dickson and Maue-Dickson contribute a detailed historical and critical review of the literature on the human velopharyngeal mechanism and use this review in their formulation of a model for biomechanical analysis of velopharyngeal structure and function. A contemporary view on how speech control may operate in skilled and nonskilled speakers is presented by Borden. She provides discussions of control mechanisms for speech, the effects of altered feedback on speech during speech acquisition, and control of established speech. Leith and Chmiel present a clinical rationale for the use of the delayed auditory feedback (DAF) effect in the treatment of stuttering that follows research findings more closely than most of the existing DAF treatment programs. They also describe variations in the clinical use of the DAF effect and suggest areas for further research. Finally, Davis and Drichta discuss biofeedback as related to speech pathology. The authors review clinical applications, describe limitations, and provide suggestions for future research of this intervention technique based on cybernetic theory that interprets activity and learning as self-regulated processes.

It is our intention that the contents of this volume in particular, and of this serial publication in general, will stimulate discussion and investigation of a number of unresolved contemporary issues in speech and language processes and pathologies that will lead to their ultimate resolution.

NORMAN J. LASS
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I. INTRODUCTION

Theories concerning children's phonological development have fascinated linguists for well over a century. Only recently have speech and language pathologists shown an interest in this subject. Speech and language pathologists have been more concerned with the order of sound acquisition, drawing from the early work of Poole (1934) followed by similar studies by Wellman, Case, Mengert, and Bradbury (1931), Templin (1957), and more recently Prather, Hedrick, and Kern (1975). These studies were important because they helped the pathologist to determine the order in which sounds were supposed to be acquired by young children. With this information, the pathologist could then follow this same orderly sequence in teaching speech sounds to children who were delayed in articulation development.
These studies have since come under sharp criticism (Halliday, 1973; Lorentz, 1976; Olmstead, 1971). No longer can we be certain that /r/ should be taught after /l/ or training on /s/ should be delayed until the child is 6 or 7 years old because 90% of the children are reported not to have mastered this sound until that age. In addition, the statistical procedures, sampling methods, and examiner qualifications used in these studies have been challenged.

What does the speech and language pathologist have to fall back on if unable to rely upon traditional studies of age guides and the phonological acquisition process? Since most pathologists have had but a brief exposure to theories of phonological development, many are unable to explain why children acquire sounds in a particular order (assuming that children do follow an orderly process while acquiring sounds). Through an understanding of theories of phonological development, we are in a better position to ask more relevant questions, the answers to which may have important implications for developing more effective therapy procedures. Some questions may be asked, such as: Do some children follow different processes of sound acquisition and, if so, what are the differences; are there certain times when children are more susceptible to learning certain sounds or sound combinations; what role does sound position in words play in the acquisition of sounds; and what causes so-called functional articulation problems. By asking these questions, we may be able to discover answers that will drastically change our approach to articulation therapy.

Without a theory to guide us in formulating possible answers, we are likely to flounder in a trial-and-error process that is extremely costly and time-consuming. At the same time, theory unsupported by factual data about how children actually acquire a phonological system does not provide us with any practical information. Fortunately, attempts are being made to bring these two areas together, that is, the theory and data from the speech of children who are actually in the process of acquiring their phonological systems.

There have been several attempts to establish theories of phonological development. The purpose of this chapter is to provide the speech and language pathologist with an understanding of four current theories as identified by Ferguson and Garnica (1975) that attempt to explain phonological development. These theories fall under the following four headings: (1) biological determinism and (2) behavioral, (3) structural, and (4) prosodic theories. Before presenting each of these theories let us briefly review some of the early theories of phonological development prevalent almost a century ago.
II. EARLY THEORIES OF PHONOLOGICAL DEVELOPMENT

During the late 1800s, many linguists and psychologists thought that children learned sounds according to the principle of least physiological effort. Physiological effort was defined as the amount of nerve and muscle energy required to position the articulators for the production of sounds. This principle of least effort, known as Schultz's law, was first described by Fritze Schultz in his 1880 text, *Die Sprache die Kinder*. Schultz reasoned that different sounds require different amounts of energy to produce. Those sounds easiest to produce appear early, whereas those sounds requiring most effort appear at a later time.

In 1900, the noted psychologist Wilhelm Wundt, although accepting Schultz's idea that easiest sounds occur first, believed that more than just physical ease was responsible for the order of sound acquisition. Vision, hearing, and coarticulation were also important factors. Wundt found it hard to believe that children substitute easy sounds for more difficult sounds since they seemed to have the capacity to produce all sounds during babbling.

Much later, Jakobson (1941/1948), agreeing with Wundt, also rejected the theory that some sounds are easier to produce than others since, according to his observations, the infant is capable of producing all conceivable sounds in any language during the babbling stage. Today, the principle of least physical effort, as an explanation of the orderly sequence in which sounds are learned, has little if any support from phonological theorists. The major criticism is that it ignores the roles played by auditory perception, neurological development, and socioenvironmental factors. Moreover, this theory does not explain many of the unique aspects of phonological development that occur during later stages in the child's life.

A second early theory, one that still persists and will be discussed under the heading of Biological Determinism (Section III,A), was that sound acquisition was determined genetically by certain innate factors. Franke, in 1899, was the first to suggest that sounds simply unfold as a series of sequential developmental stages as a function of some internal growth-determined factors. Leopold (1953) opposes this concept; but, as we shall see, there are many theoreticians who support this theory that the sound-acquisition process is innate.

Since these early observations, which were made at the beginning of the twentieth century, many other theories about phonological development have been proposed. In the following section, some of the major theories that have been presented during the last 30 years will be discussed.
III. CURRENT THEORIES OF PHONOLOGICAL DEVELOPMENT

It is important to note that a discussion of phonological theory can be complex and difficult to understand unless one is well acquainted with this particular area of linguistics. Usually, speech and language pathologists have had only a brief encounter with concepts involved in phonological theory. Frequently, phonological theory is presented as fact, but we must keep in mind that there are insufficient data to allow us to arrive at conclusive decisions about how children acquire sounds. I will try to make this discussion of the four current phonological theories meaningful and clear for the reader who has but a limited background in phonological theory. For those who desire further information about this subject, it would be helpful to refer to some of the original source material found in the reference section of this chapter.

A. Biological Determinism

No doubt most readers are familiar with the unresolved nature versus nurture arguments that purport to explain the presence or cause of various aspects of human behavior. It is also common knowledge that, in many cases, it is very difficult to isolate the respective contributions made by hereditary and/or environmental factors. Do humans develop a phonological system because they are neurologically wired for this function, or does this system result solely from our interaction with environmental factors?

There are a number of phonological theorists who believe that heredity plays an important, but not necessarily the sole, role in the child's acquisition of sounds (Abbs & Sussman, 1971; Brosnahan, 1961; Menyuk, 1968; Stampe, 1969). Stampe (1969) gave the title the Natural System of Phonological Development to what he believed to be a universal, innate system of phonological processes. As the infant’s phonological processes unfold, the adult phonological system places restrictions on this unfolding process. The adult phonological system impinges upon, molds, and changes the child’s naturally developing system toward the adult system. The adult sounds and rules for using them represent only what remains from the child’s innate and complete phonological system. The child’s inherent system is suppressed, limited, and ordered as a result of the interaction with the selective system used by adults of the community. Consider the following analogy: suppose one poured various-sized grains of sand through a fine-mesh wire screen. Only small grains of sand would be passed. All the sand grains might represent the sounds produced by the child innately, whereas only those grains that pass through the screen could represent those sounds of the adult sound system.
Ferguson and Garnica (1975) provide an example of Stampe’s principle that bears directly on the child’s production of consonants. Normally, obstruent consonants (those that block the air stream either totally, as in the case of stops, or partially, as with fricatives or spirants) in infant vocalizations tend to be voiceless. This is because the oral constriction needed to produce them impedes the laryngeal constriction at the vocal cords required to provide voicing. This is the innate, natural tendency, that is, the tendency to produce unvoiced obstruents. But as the child first learns to say words, often an obstruent will occur between two voiced sounds, usually vowels (VCV). By assimilation, the two voiced sounds will cause the voiceless obstruent to become voiced. Thus, the adult system, a system containing many artificial types of sound combinations, changes the child’s natural sound production tendencies, that is, the child’s innate system. If the child makes errors, it is because the older, more natural, innate system prevails. Proponents of this theory believe that the child’s progress at each stage of phonological development can be explained in terms of how these two sound systems, the child’s innate sound system and the adult community sound system, interact.

Brosnahan (1961) takes a similar position in that he assumes that speech-sound development stems primarily from a genetic component. He maintains that each child passes through a sequence of distinct stages of maturation with regard to unique abilities and maturation of the vocal apparatus. These stages determine the nature, rate, and course of sound-acquisition development. This development is directed toward the sound system of the child’s community; the community sound system becomes the norm to which the child adapts, depending upon his or her own individualistic, inherited growth patterns. From this adaptation of the two systems, the inherited articulation patterns plus the environmental influences of the community sound system, each child acquires a unique complement of sounds. At first, a child only approximates the sound system of the community, but gradually, he or she is able to communicate with others by approximating the sound system of the adult community.

This view, that the sound system of the child unfolds as the child’s innate sound system interacts with the sound system of the community, appears periodically in the literature. The process is often referred to as plasticity. Chase (1965) refers to this plasticity concept as he discusses the developing nervous system, that is, the ability of the developing nervous system to replicate features of the sensory environment.

Menyuk (1968), in her comparative study of the early phonological development of English and Japanese children, implied that there may be innate factors that could explain the similarity she found in the sound-acquisition process of the two groups of children. She suggested that
developing perceptive and production capabilities of the child may ac-
count for these similarities. Her hypothesis was that certain sound attri-
butes are universally related to the physiological capacities of humans,
regardless of gene group. Although Winitz (1969) pointed out many lim-
itations of this study, he concluded that certain aspects of phonological
growth may be innate aspects of the child’s development.

Based upon an interpretation of Menyuk’s (1968) study, Abbs and
Sussman (1971) postulated that infants possess special sensory receptor
fields or feature detectors. These detectors are considered to be innate
capacities that allow infants to detect and respond to various features of
the speech sounds in their environment. Biological determinism plays a
key role in their explanation of how sounds are acquired. They postulate
that an individual has a set of built-in templates or models that allow
processing of the distinctive features of phonemes. The features of each
phoneme detected by the infant are compared with the infant’s built-in
templates and, subsequently, are categorized according to the best fit.
Glucksburg and Danks (1975) point out several pitfalls of this theory:
chiefly, there is no one-to-one correspondence between acoustic cues and
distinctive features. Decoding a speech signal requires much more than
just a knowledge of the sound system: it involves semantic and syntactic
information as well.

The theory that sounds are acquired through some preprogrammed bio-
logical determinant has been questioned by many linguists. Jakobson
(1941/1968) for one, believes that a biological explanation for sound acqui-
sition may contain only a partial explanation of this process. For Jakob-
son, the only important biological component in sound acquisition is the
child’s ability to differentiate between sounds. Support for Jakobson’s
position regarding innate discrimination processes is provided from data
gathered by Eimas, Siqueland, Jusczyk, and Vigorito (1971). They con-
ditioned 4-week-old infants to suck on a nipple in the presence of /bae/ but
not to suck in the presence of /pæ/. Since voicing is the chief difference
between these two syllables, and the infants demonstrated an ability to
discriminate between these two sounds, this finding indicates that the
voicing distinction may be a direct function of the neural apparatus.

A number of psycholinguists hold that the broader aspects of language
acquisition are tied to unfolding processes of biological maturation. Len-
neberg (1969) believes that much of our ability to speak and understand a
language is due to our genetic makeup. He states, “Children begin to
speak no sooner and no later than when they reach a given stage of
physical maturation” (p. 635). He points out that the development of a
language correlates consistently with motor development and matura-
tional indices of brain development.

The innateness of language is also discussed by Chomsky (1969) who
believes that humans have developed an innate capacity for dealing with the linguistic universals common to all languages. Experience and learning serve only to provide information about specific instances of those universal aspects of language needed for the child to communicate with a specific community. For Chomsky, the child possesses an innate kind of language construction theory that is not dependent upon any explicit instruction, intelligence level, or outside information.

In summary, the thrust of the biological determinism or natural phonology theory is to identify the phonological processes that account for both language change and child phonological development as a function of an innate process unaffected by environmental factors.

B. Behavioral Determinism

The behavioristic school of thought considers language as an operant behavior learned in much the same way that other operant behaviors are learned. Language skills are gradually acquired as the child is reinforced for producing closer imitations of adult sounds.

1. *Skinner's Principle of Reinforcement*

According to principles of learning theory formulated by Skinner (1957), behaviors followed by favorable consequences are strengthened and occur more frequently than do behaviors followed by no consequences or by unpleasant consequences. As infants babble, their parents recognize certain sounds as being similar to those that they, the parents, produce. The parents attach positive consequences to these sounds, usually in the form of attention, smiling, or coddling. They tend to disregard sounds that do not resemble those made by the adult community. Thus, certain sounds or sound combinations produced by the infant are selectively reinforced, whereas others are ignored and eventually extinguished. The infant tends to retain and produce with greater frequency those sounds that parents reinforce, whereas sounds not resembling adult sounds are lost, since they do not result in pleasant parent reaction. Thus, the infant gradually acquires the phonological system of the adult community by a process of selective reinforcement. Of course, this is a gross oversimplification of Skinner's model; only the principal tenets of his theory have been presented. With this general perspective of reinforcement theory, let us consider in more detail Mowrer's autism theory based upon principles of reinforcement.

2. *Mowrer's Autism Theory*

The autism theory, formulated by Mowrer (1952, 1958, 1960) in the early 1940s, represents an attempt to explain, in terms of learning theory,
how children learn speech sounds. Basically, Mowrer was concerned with how children learn to imitate speech sounds. Observing how trainers taught myna birds to talk, Mowrer decided that the most efficient procedure for teaching these birds was to put a caretaker in charge of administering their primary reinforcer, food. When presenting food to the bird, the caretaker also talks to the bird. Thus, the primary reinforcer (food) becomes paired with the words spoken by the caretaker. Following many such pairings, the caretaker’s words take on some of the reinforcing properties of the food. These words become secondary reinforcers in that they serve to remind the bird of food; that is, the bird anticipates receiving food when certain words are spoken by the caretaker. Once the connection is made between the caretaker’s words and receiving food (i.e., when the words become conditioned reinforcers), the bird may accidentally produce a sound that resembles one of the caretaker’s sounds or words. Since this sound is a secondary reinforcer, the bird is reminded of the pleasant state of receiving food; it is a kind of food substitute. The likelihood that the bird will produce more of these sounds that resemble the caretaker’s sounds is increased. Also, the more accurate the bird’s imitations of the caretaker’s words, the more these reproductions will be reinforcing to the bird. Soon, the bird learns to reinforce itself independent of the caretaker’s presence.

In developing his autism theory, Mowrer stated that infants learn to produce sounds like those produced by the parents in much the same way as birds learn to imitate sounds of their caretakers. That is, they produce certain sounds because these sounds take on self-reinforcing (autistic) properties. Mothers talk to their children during feeding periods as well as when performing other pleasure-producing care duties (changing diapers, bathing the baby, and so on). Since the infant vocalizes many sounds while engaging in reflexive behaviors, vocalizations that approximate those produced by the mother (i.e., secondary reinforcers) also become pleasure-producing to the infant because of their indirect association with comforting and food-intake situations. The infant continues to produce these sounds (self-stimulation) that resemble the mother’s sounds. It is also likely that the mother will respond positively to sounds that resemble those she uses, and consequently she selectively reinforces these sounds. On the other hand, she will probably not attend to sounds that do not resemble those produced by the community.

Although Mowrer’s theory explained, in terms of conventional behavioristic learning theory, how children learn sounds, Mowrer provided no empirical data to substantiate his theory. As a test of Mowrer’s theory, Foss (1964) sought to discover if myna birds could be taught different types of whistles when paired with primary reinforcement. The myna
birds were divided into two groups: birds in Group A were kept in a cage that was exposed to sights and sounds of humans, whereas those in Group B were isolated from human contact. A whistle of ascending pitch was sounded when food was presented to birds in Group A during feeding. After 5 weeks of this exposure, there were no differences in the frequency of whistle types produced by the two groups of birds. According to Mowrer's theory, there should have been a difference in the frequency of whistles between the two groups. Foss concluded that myna birds simply have an innate tendency to imitate anything in their environment.

In another attempt to validate Mowrer's theory, vocalizations of normal-hearing infants whose parents were deaf were compared with vocalizations of infants who had normal-hearing parents (Lenneberg, Rebelsky, & Nichols, 1965). The deaf parents vocalized very little during care activities and rarely responded to infant vocalizations. According to Mowrer's theory, one would expect, infants of deaf parents to vocalize sounds that would be quite different from those produced by infants of normal-hearing parents. Vocalizations analyzed from the time infants were 2 weeks of age to the time they reached 3 months of age failed to show any significant differences between sound types produced by the two groups. This finding led the investigators to conclude that sounds the infant produces during the first 3 months are not dependent upon environmental stimulation.

Mowrer's theory was also studied in conditions in which speech therapy was administered to two groups of children. Rigrodsky and Steer (1961) compared a traditional type of articulation therapy with a therapy method based upon Mowrer's autism theory. They failed to find a difference between the groups in the ability to produce the two test consonants that were misarticulated by both groups of children.

Siegel (1969) points out several problems in the design of all three studies that reduce their credibility. He maintains that none of the three studies offers conclusive evidence disproving Mowrer's theory. However, neither are there empirical data to support the autism theory.

Finally, Wahler (1969) investigated the types of infant vocalizations that mothers reinforced and found that they were nondiscriminatory in their reinforcement of infant vocalizations. Despite the fact that they reinforced speech and nonspeech sounds alike, the children still learned to make appropriate sounds resembling adult sounds.

While the autism theory makes sense from a theoretical viewpoint, there are too many gaps between the theory and the evidence from studies of children who are in the active process of acquiring sounds. One important fact that Mowrer's theory does not explain is why infants acquire sounds in an orderly pattern. Why do some sounds occur early in infant
vocalizations and others appear late? Imitation seems to be inadequate as
the sole explanation of sound acquisition.

3. Extension of Mowrer's Theory

Winitz (1969) elaborates upon Mowrer's theory. He presents a detailed
discussion of three early stages of phonological development, each over-
lapping the other. Winitz reasons that the first two stages occur before the
child is 1 year old; the third, after the first year. During the first stage,
fractional anticipatory goal response, the infant produces vocal sounds
associated with food intake. These include the sounds made while chew-
ing, sucking, swallowing, lip-smacking, as well as various clicking-like
sounds. These sounds, occurring during the second and third months,
frequently precede feeding and become associated with the pleasurable
act of eating. Thus, since they are reinforced, they should occur with
greater frequency as the infant matures. Winitz cites Irwin's (1947) data to
support this observation in that velars and glottals, sounds similar to
mastication and deglutition, comprise 90% of all sounds occurring during
the first 4 months of life. The percentage would have been even greater if
nonphonemic lip-smacking and clicking sounds had been included in Ir-
win's data.

The second stage focuses primarily on sounds that occur during infant
babbling. Frequently, the mother's vocalizations precede and accompany
feeding as well as other pleasure-producing activities. These vocalizations
take on secondary reinforcement characteristics and gradually come to
resemble adult words in such characteristics as phoneme, syllable, loud-
ness, and stress features. Although Winitz is not entirely satisfied with this
concept as an explanation of why the infant gradually produces sounds
similar to adult speech, he believes that the principle of conditioning
comes close to explaining how sound acquisition develops.

The third stage begins when parents recognize some of the child's vocal
productions as word approximations and directly reward these attempts
with social praise. This occurs shortly before or after the child's first
birthday. Gradually, the child refines the articulation of these word at-
ttempts until they closely approximate the adult speech model. Winitz uses
Skinner's (1957) concept of shaping through successive approximation as
descriptive of this process. Winitz also states that the phonological system
is not acquired in isolation but as part of the acquisition of syntactical
aspects of language as well as of perceptual abilities.

The appeal of Mowrer's theory lies in the fact that so many other
operant behaviors can be explained using the behavioral model. But op-
ponents of this theory are quick to point out differences between the
acquisition of human language and other kinds of behavior that may oper-
ate under a different set of principles (Chomsky & Halle, 1968; Milisen, 1966).

C. Structuralist Theories

The central theme of the structuralistic theories of phonological development is that sounds are acquired by children in an orderly and predictable sequence regardless of the type of language spoken by the adult community. The implication is that an underlying structure exists in the sound-acquisition process. Undoubtedly, the best known among the structuralist theories was originated by Jakobson (1941). His theory will be presented first, followed by consideration of a recent modification.

1. Jakobson's Theory

In 1941, Jakobson wrote a monograph about how children acquired sounds (Jakobson, 1941/1968). Published in a little-known Swedish publication and written in German during the time when the world was in a turmoil of war, it is surprising that his manuscript had an impact. Certainly, not many American linguists read it. Some who did claimed that it was utter nonsense; there were no laws for the acquisition of sounds. But others accepted Jakobson's theory as fact despite the lack of data to support it. Even today, some authors discuss Jakobson's theory as though it were factual information [see Wood's (1976) discussion]. Generally, most linguists today feel that Jakobson made one of the most significant contributions to our understanding of how children acquire sounds. Those who have compared his predictions with data from observations of children's speech as they acquired sounds report that many of his predictions were accurate (Ferguson, 1977).

First, let us examine the principal tenets of this unique theory; then we will consider the criticisms that have been leveled against it.

a. Jakobson's Laws. Jakobson began by looking for a commonality shared between the sounds acquired by children and those of adult phonological systems. He discovered three commonalities for consonants and one for vowels. These he called the laws of implication. In the initial report of his study of many languages, Jakobson (1939/1971) noted that every language that had back consonants (velars and palatals) also had front consonants (labials and dentals). Front consonants could exist without back consonants, but no language had back consonants alone. From this observation, he concluded that the child acquires front consonants first followed by the acquisition of back consonants. Thus, place of articulation (front and back) plays an important role in sound acquisition. Re-
lated to this observation is the belief that forward stops were first used by primitive people and, as the need arose for an increased vocabulary, back stops emerged.

His second observation pertained to manner of articulation. Whereas all languages have stops, not all have fricatives. Thus, if a language has a fricative, it is a certainty that stops are also present. But it cannot be inferred that fricatives exist if it is known that stops are used in the language. He believed then that stops were acquired first, followed by fricatives.

Third, affricatives may exist only if stops and fricatives are present. Furthermore, no language can have more affricates than it has fricatives. Therefore, in order for affricatives to exist, both stops and fricatives must already be present. Affricatives should be the last sounds to be acquired.

The fourth observation pertained to vowel development. He stated that the existence of back vowels implies the existence of front vowels of corresponding height. Vowels develop vertically first, followed by a corresponding horizontal development. Jakobson was not as concerned with vowel development as he was with the development of consonants.

The basic principle of each law might be explained best by a simple analogy. Suppose one has some chickens. One may or may not have eggs. But if one has eggs, one may be certain that chickens have been around (somewhere) to lay them. Chickens can exist without the presence of eggs, but the presence of eggs demands the existence of a chicken. Chickens are like back consonants, stops, consonants plus fricatives, and front vowels. Eggs are like front consonants, fricatives, affricatives, and back vowels. Jakobson's answer to which came first, the chicken or the egg, would certainly be chickens.

Three preliminary observations formed the basis for what Jakobson called the laws of irreversible solidarity, which play an important part in his theory. Simply stated, an irreversible relationship exists among sounds when one sound must be present before another sound can exist. To see how this principle works, consider the example cited by Ferguson and Garnica (1975). Jakobson stated that no language will have nasal vowels unless it also has one or more primary nasal consonants. Thus, unless a child has a nasal consonant, it would be impossible for a nasal vowel to exist.

Jakobson went on to state that the first sound to disappear, whether through historical change or in the speech of an aphasie, would be the sound that developed last during the acquisition process. In the example used previously, nasal vowels would disappear before nasal consonants, and fricatives would be lost before stops.

Jakobson claimed that no matter what language a child was acquiring,
no matter where the child lived, or when the child acquired language, the
order of phonological acquisition would be the same; indeed, it would
follow the phonological organization of the adult language. This is an
astonishing claim. Jakobson further stated that a sound is acquired in
direct relation to how widely the sound occurs in other languages. For
example, /t/ occurs in practically every language in the world. It follows
then that /t/ would be acquired by the child at a very early age no matter
what language was being learned. A sound that occurs rarely among lan-
guages would therefore be acquired last. The Czech fricative sound /ɹ/, for
example, is one of these sounds that rarely occurs in languages and should
be acquired last by the child who is learning the Czech language.

As mentioned before, Jakobson felt that the same universal principle
holds for the loss of sounds whether one is considering the loss of certain
sounds by an individual who has aphasia or loss through historical change.
Thus, /t/ would be the last sound an aphasic would lose, and the Czech /ɹ/
would be the first. Jakobson’s laws of irreversible solidarity could explain
the underlying set of principles regarding both the order of acquisition and
the order of loss of the sounds in an individual’s phonological system.

b. Role of Babbling. For Jakobson, babbling played no part at all in the
acquisition of sounds. He considered babbling simply as a stage that in-
fants pass through when they randomly vocalize sounds; there was no
order or structure to the sounds they produced. All sounds would be
equally possible, although he would consider some sounds more likely to
occur than others. Mastery of sounds could only occur during the pur-
poseful and consistent use of these sounds in meaningful speech.

It is important to understand that, for Jakobson, the acquisition of the
child’s phonology begins with meaningful speech, not before. This belief
is in sharp contrast with views of other theories stressing the importance
of prelinguistic utterances.

c. Distinctive Features. Before we consider the specific order in which
sounds are acquired in Jakobson’s theory, we need to understand his
concept of phonemes as a bundle of distinctive features (Chomsky &
Halle, 1968). Each sound is composed of a number of features. Some
features are related to acoustic properties of the sound; some are related
to the position of the lips, tongue, or velum. English consonant sounds can
be described in terms of nine features; the vowels can be described by five
features. The system is a binary one in that a feature is either present
(indicated by a +) or absent (−). Thus, there is a total of 28 features to
describe English sounds: 14 to indicate the presence of a feature, 14 to
indicate its absence. A description of all 28 features can be found in any
one of the following sources: Winitz (1969, pp. 82–84); Weston and Leonard (1976, p. 18); Wood (1976, pp. 82–89); and McReynolds and Huston (1971, pp. 157–158).

Some examples will be used to clarify this feature concept. The sound /f/ consists of a bundle or group of features; that is, four different features are present (+). They are: (1) consonantal; (2) grave; (3) tense; and (4) continuant. Three features are absent (−): (1) Vocalic; (2) compact; and (3) nasal. Two features, flat/plain and strident/mellow, do not apply to this sound. By changing one of the features, the −vocalic to a +vocalic, the /f/ becomes /v/. This is just another way of saying that when voicing is added to /f/, it is changed to a /v/ sound. The /f/ is changed to /p/ when the +continuant is changed to a −continuant (interrupted) since /p/ contains all the features of /f/ with the exception of the continuant feature. Each sound can be described in terms of a distinct number of features that are either present, absent, or do not apply, hence the term, distinctive features. All sounds in all languages can be described according to this system. This is, of course, one of the first hallmarks of a science, the classification of phenomena.

Returning to Jakobson's theory of the development of sounds: he noted that the first words the child utters are mama and papa in reference to the parents (see Bar-Adon & Leopold, 1971, pp. 212–217). No matter what language is investigated, children's pronunciation of these two words is quite close, phonemically, to mama and papa. This first stage, the use of the [m] and [p], was labeled the labial stage. Each consonant is paired with another sound, the vowel /a/, that is the exact opposite of /m/ or /ml/. The vowel /a/, formed in the back of the mouth, involves complete opening of the vocal tract and has a maximum amount of acoustic energy. On the other hand, /p/ is almost the opposite of /a/ in that it is formed in the front of the mouth, involves closing of the vocal tract at the lips, and has a minimal amount of acoustic energy. We therefore have two sounds of maximum contrast, both containing features that are easy to produce.

Recall that Jakobson believed that phonemes were not acquired until the child produced meaningful utterances. To verify that [pa] was a meaningful utterance, it had to be contrasted with another syllable. This contrast could be made with the nasal /m/ resulting in [ma]. Thus, we have an oral–nasal contrast that could result in two possible words when each syllable was duplicated: [mama] and [papa]. When the child uses mama only in the presence of the mother and papa only in the presence of the father, then, according to Jakobson, we have the beginning of phonemic development of consonants.

From this point onward, the child progresses through a series of regular and invariant stages as new sounds are acquired, although the rate of
progression differs according to the individual. The stages are regulated by an inherent universal hierarchy of structural laws. These laws were what Jakobson called the laws of irreversible solidarity. Each new stage involves the use of more complex feature contrasts than did previous stages. Thus, the child learns to make finer feature contrasts as the phonological system develops. Maximum or simple contrasts are learned first, followed by the learning of minimum feature contrasts. The phonological system is composed of layers superimposed one upon the other and will be the same regardless of the adult language used.

Jakobson provides only a bare outline of his universal order of acquisition from this point onward. The general order of consonant acquisition is shown in Fig. 1.

An outline for the mastery of vowels is shown in Fig. 2. Jakobson is not nearly so specific in this description of vowels as he is about consonants.

**Figure 1.** An outline of consonant acquisition according to Jakobson's theory. (Adapted from Blache, 1978, p. 83.)

**Figure 2.** Vowel mastery according to the distinctive-feature approach. (Adapted from Wood, 1976, p. 98.)
2. Criticisms of Jakobson’s Theory

As was mentioned before, whereas Jakobson’s theory was totally rejected by some linguists, others accepted it in toto. Almost 40 years have elapsed since the introduction of his revolutionary theories, and since then many have put his theories to the test. An increasing body of data has been accumulated that allows us to compare his theory with actual observations of children who are in the process of acquiring a phonological system. It is much easier to verify or refute parts of his theory now than it was in the 1940s or 1950s.

One of the most thorough criticisms of Jakobson’s theory is provided by Ferguson (1977). While engaged in longitudinal studies of children who are in the process of acquiring sounds, Ferguson has had an opportunity to compare what actually happens as the child acquires sounds with what Jakobson predicted should happen. Ferguson is in agreement with what he called “Jakobson’s vision.” This vision was that at the bottom of the phonological acquisition process in any language or in any historical period, there are some general principles that underlie the acquisition process. He is in agreement with Jakobson that there is a universal structure to the sound-learning process. This structure is apparent in the phonological system of both the normal speaking child and the one who deviates from the system (i.e., the child who misarticulates sounds).

However, there are many details of Jakobson’s theory that do not match what has been found actually to occur. First, Ferguson questions Jakobson’s position on babbling. We are quite sure now that infants do not babble all possible sounds in random fashion. For example, studies of infant babbling show that they rarely babble voiceless fricatives (Cruttenden, 1970). The study by Oller, Wieman, Doyle, and Ross (1976) indicates that babbling plays an important role in the type of sounds acquired by children after the age of 1 year. In addition, certain sounds occur more frequently in babbling just before they occur in true speech (Kaplan & Kaplan, 1971).

Ferguson believed that Jakobson was wrong about the order in which aphasic individuals lose sounds. Phonological loss among aphasics is quite unpredictable and follows no orderly pattern, as any speech-language pathologist who has worked with aphasics knows.

Jakobson avoids talking about some aspects of sound combinations that have been found to be very important. He does not mention the role that the position of a sound in a word plays in sound acquisition. Acquisition of sound clusters also turn out to follow some specific kinds of rules that Jakobson failed to take into account. Another important pointJakobson avoided was the role that perception plays in learning sounds. Finally,
Jakobson never defined what he meant by the word “acquired.” When he says stops are acquired before fricatives, we do not know whether he meant all stops in all positions, and whether or not all clusters are mastered perfectly before the first fricative appears.

In spite of these criticisms, Jakobson was correct about several things. For one thing, there is a surprising amount of order in the way children acquire sounds and this is reflected in all languages. This was one of Jakobson’s major points. Second, he also was correct about the fact that sounds that are used by the majority of languages are those that occur earliest in child phonology and sounds that occur rarely, like the Czech /\iri/ mentioned earlier, are acquired last.

Let us look at the predictions Jakobson made about stops and fricatives. He said that stops would be acquired before fricatives and that this would be true in each place of articulation. This prediction has been found by Ferguson to be correct. Second, Jakobson predicted that voiceless fricatives would be acquired before voiced ones since voiceless fricatives exist in greater abundance in the world’s languages. This also proved to be generally true. Third, he claimed that /s/ would be among the first fricatives to be acquired based upon its widespread use in all languages. Whereas some English-speaking children do acquire /s/ first, Ferguson found that /\ili/ is usually acquired before /s/; in fact, /\ili/ is usually acquired first, followed by /s/ and /\i/. Next /\i/ and /\z/ are acquired, followed by /\v/, /\v/, and /\v/. This order agrees only in part with Jakobson’s predictions.

We conclude our discussion of Jakobson’s theory with the comment that this theory has, and probably will continue to have, a profound effect upon our understanding of phonological development. When compared with data from phonological acquisition processes of children, too many of Jakobson’s predictions have proved to be correct to allow us to discount his theory. Of course, more data will be needed before definite conclusions can be reached about the validity of his theory, but it offers much promise in helping us to comprehend the phonological processes.

3. Moskowitz’s Theory

Moskowitz (1970, 1971, 1973) not only expanded and modified Jakobson’s original theory but also adopted parts of Chomsky and Halle’s (1968) theory of generative grammar in formulating her theory of phonology. Rather than viewing phonological development as a part-to-whole (analytic) process, she sees it more as a whole-to-part (synthetic) process. The child first discovers the rules governing the arrangement of phonological units, not separate sounds, from listening to the speech of others and from listening to his own babbling. Later, the child identifies smaller sound units and eventually masters speech production.
Unlike Jakobson, Moskowitz viewed babbling as an important period of the sound acquisition process. During this period, the child forms the hypothesis that adult speech contains a number of contrasting sounds bound together in sentence units that have definite intonation contours. This is evidenced by the fact that infants imitate adult intonation contours during (and even before) babbling. Once the infant develops the ability to imitate the basic contour patterns almost at an automatic level, attention focuses upon an analysis of the phonetic elements of the sentence. This does not imply that the infant knows the meaning of sentences, only that sentence form is recognized.

Syllables are then isolated from the sentence unit, and they soon acquire meaning: the syllable-word. Although parents may not recognize the child's syllables as words, they are used by the child as the first meaningful utterances. With practice, the child's accuracy of sound production increases and phonetic differences among syllables begin to resemble adult forms. Moskowitz believes that the child does not learn sounds as isolated units but as parts of syllables. This is a point also made by others who have studied child speech (Ferguson, Peizer, & Weeks, 1973; Fudge, 1969).

The first syllable types are consonant-plus-vowel (CV) combinations and duplications (mama, papa, byebye, etc.), followed shortly thereafter by CVC, VC and V syllables as more words are added to the child's vocabulary (book, mine, up, I, etc.). At this stage, the child discriminates between different syllables, not between different sounds.

When CVCV syllable types are added, it is possible for the child to contrast two syllables, each containing a different consonant and/or vowel sound. At the earliest stage of full duplication, there is no contrast (dada, mama); but as one sound element is changed in the CVCV series, the child learns contrasts ([kiti], [babii]) by this partial duplication. In this way, the child learns the individual sounds, both consonants and vowel, that make up the syllables. An increasing variety of sounds is added and, although there are wide differences among children with respect to the order of sound acquisition, Moskowitz believes that, for the most part, children follow the pattern described by Jakobson (1941/1968) with respect to the general order of sound acquisition. But at any given stage, the child may be engaged in several different processes; that is, he may be analyzing whole syllables of some words and isolated sounds of syllables in other words.

Whereas Moskowitz is able to explain some of the gaps left unexplained by Jakobson, it is difficult to prove what the child is or is not analyzing during the sound-learning process. Nevertheless, Moskowitz's theory does have some appealing features.