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THE ACQUISITION OF MORPHOPHONOLOGY

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ABSTRACT

MacWhinney, Brian. The Acquisition of Morphophonology. *Monographs of the Society for Research in Child Development*, 1978, **43**(1–2, Serial No. 174).

A model is presented which details the ways in which children in different language communities acquire the morphophonological structure of their languages. In this model, the processes of rote, combination, and analogy are integrated into a single processing goal stack. The model views learning as a cyclical process in which acquisition leads to application, application leads to correction, and correction leads to renewed acquisition. The processes of acquisition, application, and correction are formulated in relatively precise terms. The empirical aspects of the model are then summarized as a series of 16 claims. The validity of these 16 claims is evaluated in the light of experimental and diary data on the acquisition of Arabic, Chinese, English, Finnish, French, German, Hungarian, Latvian, Russian, and Spanish. Experiment 1 examines the acquisition of nine patterns in Hungarian morphophonology by children between 2 and 6 years of age. It indicates that the sequence of acquisition of morphophonological productions is determined chiefly by applicability as defined by the model. Experiment 2 indicates that preschoolers tend to avoid acquisition of synonymous inflections. Experiment 3 gives some evidence that Hungarian 5-year-olds can use information on allomorphic variations to determine the use of allomorph selection productions. Experiment 4 examines the learning of the German plural formation by children between the ages of 3 and 11. The order of acquisition of strategies in plural formation was determined by the interaction of applicability and correctness, as suggested by the model. Experiment 5 gives evidence for the ordering of rote, combination, and analogy as a goal stack in the formation of German gender. The concluding chapters review the success of the model in accounting for the available data on the acquisition of morphophonology. In general, the model constitutes an advance in our ability to account for the acquisition of complex linguistic structures in terms of specific cognitive processing.

Every normal newborn is, in a sense, a subject in a vast experiment of nature. Each of these newborns brings to this experiment some set of abilities

that will allow him to master his native tongue. Nature has so arranged things that different groups of subjects learning different languages will have to use these abilities to acquire widely differing sets of target language structures. By studying the ways that children come to control these structures, we can hope to make inferences about the universal set of language-learning abilities common to all children.

The present report seeks to provide a detailed characterization of the acquisition of the linguistic system called morphophonology. It attempts to do this by describing a set of universally human abilities which are involved in the acquisition of morphophonology. Some writers (Chomsky 1965; Lenneberg 1967; Stampe 1969) have underscored the importance of specifically linguistic abilities in the acquisition of language. Others (Anderson 1975; Braine 1963) have stressed the importance of general cognitive mechanisms. The present model makes no a priori assumptions regarding the ultimate source of the abilities evidenced by the child. Rather, it attempts to focus on the construction of an explicit description of these abilities.

The description to be offered here relies heavily on the many important insights achieved by Slobin (1973) in his investigations of universal abilities in language acquisition. The hope is that, once such explicit descriptions become more generally available, the discussion regarding the ultimate source of these abilities could be rejoined with a new clarity and purpose. The strategy is to focus on a single, well-defined, and easily researched content area: the acquisition of morphophonology. There may be those who will feel this restriction of focus to the area of morphophonology vitiates the applicability of the findings to language acquisition as a whole. However, it must be recognized that, in order to achieve precision in model construction, it is often necessary to sacrifice generality. Moreover, the limits of the applicability of the present approach have not yet been fully tested and the model may well apply to other areas. In particular, an extended version of the model is now being used to describe much of the development of word order and lexical semantics. Such extensions will not be examined in this report but will be discussed in subsequent publications.

This report is divided into seven major chapters. The first chapter briefly examines the role of rote, analogy, and combination in earlier characterizations of language acquisition. The second chapter develops these characterizations into an account which will be called the "dialectic model" because of the emphasis it places on the continuing resolution of opposites. Chapters III–V examine data from Hungarian, Finnish, and German, respectively. Chapter VI examines data from English, French, Latvian, Russian, Spanish, Arabic, and Chinese. The final chapter summarizes and evaluates the successes and failures of the substantive claims deriving from the model. Appendix A expresses the details of the model as a set of flow charts. Appendix B presents a glossary in which the technical terms used in the report are explicitly defined. Appendix C lists and defines the symbols and abbreviations used in both the text and the production notations.

I. THREE CENTRAL ABILITIES

Discussions of the abilities underlying language acquisition have focused on three central constructs: rote memorization, productive combination, and analogical formation. Some writers have stressed the importance of rote; others have attributed language learning to analogy; still others have viewed language learning as the acquisition of the ability to produce forms by combination. The model to be presented in the next chapter claims that all three abilities are involved in language acquisition. The present chapter briefly reviews some earlier suggestions regarding the status of these three abilities.

Rote.—The central characteristic of rote processing is the absence of any form of analysis. Forms that are learned by rote and applied by rote are never broken up into their component pieces or decomposed in any way. This type of nonanalytic learning was viewed by classical rhetoric and Koranic instruction as one important way of acquiring literary skill. Within linguistics, the Anomalists (chiefly the ancient Stoics and Skeptics, like Crates and Sextus) presented the argument that language is essentially irregular and that rote serves to support this irregularity. More recently, this argument has been echoed by generative phonologists such as Skousen (1974) and Vennemann (1974). Within psychology, theorists have related learning by imitation or rote to secondary reinforcement (Allport 1924, esp. chap. 8; Mowrer 1960), autoclitic frames (Skinner 1957), stimulus generalization (Mowrer 1960), and identification (Guillaume 1925/1971; Prandtl 1910). MacWhinney (1975, 1976) has shown that rote is a powerful mechanism in the hands of the young child. By using rote, children at the very beginning of language learning can correctly produce both regular forms like *horses* and *jumped* and irregular forms like *feet* and *ran*.

Analogy.—However, there is evidence that rote cannot be the only device in the child's arsenal of acquisitional abilities. If the child produced all forms by imitation or rote, errors would seldom occur. But, in fact, child speech is full of errors. Moreover these errors are of a systematic type, not evenly distributed across forms. MacWhinney (1975, p. 75) notes that forms obeying

regular patterns are seldom incorrect, whereas forms based on irregular patterns are often incorrect. Thus, errors like /dɔrs/ (i.e., *doors* with a final /s/) are rare, whereas errors like *wifes* are common.

These arguments were clearly articulated by Guillaume (1927/1973), Paul (1920), and Saussure (1915/1966) during the earlier periods of linguistic structuralism. However, these earlier researchers felt that all phenomena that could not be attributed to rote could be ascribed to analogy. In fact, this emphasis on analogy lay at the very heart of the rise of structuralism in the twentieth century. The central importance of analogy to early structuralism makes all the more curious the fact that the structuralists never gave linguistic analogy a proper psychological definition. For example, Stern (1931, pp. 207–210) attacked Delacroix's (1924, p. 250) view of analogy as proportion without providing an acceptable definition of his own. Psychologists like Spearman (1923) and Sternberg (1977) have examined the processes involved in solving analogies like *Red* : *Stop* : : *Green* : *X*. However, such analogies involve forced choices which depend on information that fairly completely determines the response. The situation in morphophonological analogy is quite different. For example, formation of the plural of **wug* by analogy would seem to require, at a minimum:

a) a formulation of the fact that the target form should be the plural of **wug;*
b) the availability of some pair of rote-memorized forms such as *bug-bugs* (this is a precondition rather than a process);
c) a process which locates *bug* as that form most analogous phonologically (i.e., in terms of its sound) to **wug;*
d) a process to locate the item, *bugs*, which relates to the proposed analog found in (*c*) in the way required in (*a*);
e) a process capable of comparing *bug* to *bugs* in phonological terms; and
f) a process capable of creating a form, **wugs*, which applies the difference isolated in (*e*) to **wug*.

Although it might well be possible to generate detailed descriptions of morphophonological analogy that are quite unlike the one given above, no such detailed descriptions exist in the literature. The above description is offered as a plausible first attempt at a precise characterization of analogy. Further details of the processing involved can be found in the flow diagram called "expressive analogy" in Appendix A.

Combination.—The very emphasis on analogy that led to the flowering of early structuralism also led to a transcendence of the Analogist thesis. Once researchers had begun to focus on regular patterning, they soon became interested in the ways in which structural classes could combine. In regard to acquisition, the question was no longer, "How do children learn words?" Rather, the question became, "How do children learn to put units together?" In syntax the question was, "How do children build up sentences by com-

bining words?" In morphology the question was, "How do children build up words by combining morphemes?" The present report deals only with this latter question.

Generative phonologists (Anderson 1974; Chomsky & Halle 1968) have tended to maximize the role of combination in description. However, generative phonologists are generally not interested in formulating performance models. On the other hand, those researchers who are interested in performance models (Fromkin 1973; Moskowitz 1973) have recognized that the human information processer (Newell & Simon 1972) does not necessarily produce all morphological formations through combination. In particular, as MacWhinney (1975) has suggested, morphological formations may be based on rote, analogy, or combination. This *Monograph* illustrates ways in which we can assess the relative contributions of rote, analogy, and combination to a body of data.

Once one has determined that at least some words are formed by the combination of separate morphemes, a second issue arises: How do children learn which allomorphs go with which other allomorphs in combinations? For example, an allomorphic pair in English is /waIf/ (which appears in the singular *wife*) and /waIv/ (which appears in the plural *wives*). Together, /waIf/ and /waIv/ constitute two allomorphs of the same morpheme. Similarly, the English plural morpheme has the allomorphs /s/, /z/, and /ɨz/. If the form /waIvz/ is produced by combination, then it is a combination of the allomorphs /waIv/ and /z/.

The selection of one allomorph over another can be determined by the application of an allomorph-selection production. Such productions are of the general form of context-sensitive productions, as defined by Levelt (1975). Productions are here considered to be the psycholinguistic counterparts of what linguists call rules. The fundamental difference between a production and a rule is that productions are viewed as formalized expressions of operations conducted by the human information processor, whereas rules make no claims regarding psychological reality or productivity. The choice of /waIf/ or /waIv/ can be determined by a production like (1).

$$\left\langle \begin{matrix} \text{waIf} \\ \text{waIv} \end{matrix} \right\rangle \rightarrow \text{waIv} \,/\, \_\_\_ + \text{X} \qquad (1)$$

This production would select /waIv/ before any suffix. In more general form, the pattern would be expressed as (2).

$$\left\langle \begin{matrix} \text{f} \\ \text{v} \end{matrix} \right\rangle \rightarrow \text{v} \,/\, \_\_\_ + \text{X} \qquad (2)$$

This production would choose the allomorph ending in /v/ out of any allomorph pair with either /f/ or /v/. Here the wedged brackets indicate sounds that differ between allomorphs. Productions like (1) and (2) can be

simplified by using an asterisk to mark the allomorphs to be selected. Using the asterisk, (2) is equivalent to (3).

$$\left\langle \begin{matrix} f \\ v* \end{matrix} \right\rangle + X \tag{3}$$

In effect, the production determines the selection of an allomorph in a given context. A similar suggestion can be found in Hudson (1974).

Not all choices between allomorphs can be specified so simply. For example, in German, the nominative singular definite article has three allomorphs: *der* (masculine), *die* (feminine), and *das* (neuter). A production using only phonological information to determine the selection of *die* would look like (4).

$$\left\langle \begin{matrix} der \\ die* \\ das \end{matrix} \right\rangle \quad \# \quad \left\{ \begin{matrix} Sonne \\ Mutter \\ Butter \\ Küh \\ Spielerei \\ etc. \end{matrix} \right\} \tag{4}$$

A production that would avoid such extensive listing would use an abstract category like [+feminine] or [+class 2] as in (5).

$$\left\langle \begin{matrix} der \\ die* \\ das \end{matrix} \right\rangle \quad \# \quad [+\text{class } 2] \tag{5}$$

The productions described in (1)–(5) above are allomorph selection productions. Not all morphophonological productions are selections. In the case of very general patterns, allomorph modification productions may be formulated. An example of a modification production is given in (6).

$$a \rightarrow \acute{a} \ / \ \_\_\_ + X \tag{6}$$

This production lengthens all final [a]'s before suffixes.

Which ability is the real one?—Theories of language acquisition have often tried to stress the importance of one of these three major abilities over the others. The Anomalists attempted to view all language learning as rote learning. The Analogists tried to view all formations as analogical. Generative phonologists have tried to view all morphological formations as products of a system of context-sensitive productions or rules. Linguists and psychologists working within the mediational framework have attempted to view all combinations as the concatenation of classes. The model to be outlined in the next section takes a somewhat different approach. It recognizes the importance of all of these abilities and attempts to relate their operation in terms of a single model.

II. THE DIALECTIC MODEL

The model presented in this chapter is called the "dialectic model," because it views development as the continuing resolution of the opposition between thesis and antithesis. The model makes a series of 16 substantive claims regarding ways in which children should learn languages. These 16 claims will be presented in the course of the discussion below. They will also be summarized in table 3 at the end of this chapter. Chapter VII examines the successes and failures of these 16 substantive claims in light of the data presented in Chapters III, IV, V, and VI. The dialectic model has three major aspects: application, correction, and acquisition. These three aspects are linked together in a cyclic fashion as shown in figure 1. There are two

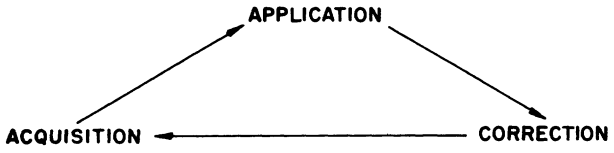

FIGURE 1.—The dialectic cycle

modes of language functioning in the child: expression, and reception. The child is engaged in expression whenever he talks. He is engaged in reception whenever he listens. The model holds that the dialectic cycle given in figure 1 is relevant to both expression and reception.

APPLICATION

When the child is engaged in expression, application is called expressive application. In expressive application the child begins with a set of things he wants to say. This will be called the intention (Schlesinger 1977). The child's task is to map his intention onto a series of conventional words or forms. The end product of this mapping will be called the expression. For example, a child with the intention [+object, +animate, +four-legged,

+furry, +number, −singular] may be able to use expressive application to map his intention onto the expression *dogs*.

When the child is engaged in reception, application is called receptive application. In receptive application the child begins with an auditory form derived from some discourse he has heard. This form will be called the audition. The child's task is to map the audition onto an understanding of the communication. The end product of this mapping will be called the reception. For example, a child with the audition *dogs* may be able to use receptive application to map his audition onto the reception: [+object, +animate, +four-legged, +furry, +number, −singular].

Both expressive application and receptive application involve use of the three basic processes: rote, combination, and analogy. Moreover, the model holds that combination only applies when rote fails and that analogy only applies when both rote and combination fail. This is to say that the three basic processes are ordered as a habit-family hierarchy (Hull 1938) or, more precisely, a pushdown goal stack (Newell & Simon 1972). These observations are summarized as claim 1 of the model.

> Claim 1 (goal stack): children will only apply analogy when rote and combination fail, and they will only apply combination when rote fails.

How can one tell from a child's behavior which of the three basic processes he has applied? Several criteria can be used. When the child produces correct real forms without problems but cannot generate nonce forms even when given maximum contextual support, there is evidence for rote. When the child produces erroneous real forms and regularized nonce forms, there is evidence for combination. Use of combination may also show somewhat longer response latencies. When the child produces correct real forms and nonce forms of many different shapes, there is evidence for analogy. The use of priming should serve to increase the use of analogy.

Expressive application first attempts to lexicalize the child's intentions through a single rote expression. When this fails, the child turns to combination to express himself by piecing together a set of morphemes that will express his intention. In doing this he makes use of three types of information. These three types will be called by their file numbers as used in Appendix A. File 1 items are words; file 2 items are affixes; and file 3 items are roots. When the child uses combination, he first chooses an item from file 1 or file 3. Then he attaches one or more affixes from file 2. The semantics of the file 2 affix items may overlap the semantics of the file 1 or file 3 items. For example, having retrieved the file 1 form *feet*, the child may get /s/ from file 2 and end up with the expression *feets*. Redundancies such as *wanteded* and *lefted*, however, are prevented by a process of affix checking. If the child finds the file 2 item already on the file 1 or 3 item, he refrains from applying it. Slobin (1971) has noted that children avoid attachment of the regular past tense suffix to forms like *left* and *bought*. In such cases, the child seems to be

checking file 1 items for the presence of a file 2 form. Derwing and Baker (1977) and Solomon (1972) found that preschoolers tend to treat words like *church* or *glass* which end in sibilants as if they were already pluralized. Here also, the child seems to be checking file 1 items for the presence of a file 2 form. In this case, however, his checking leads him into making an error. Data from Labov (1972) indicate that this process of affix checking is operative even in adults. The tendency to delete final /t/ in English has less impact on words like *missed* which use /t/ as an affix than on words like *mist* which use /t/ as an integral part of the root. These facts suggest the second claim of the model.

> Claim 2 (affix checking): irregular rote forms which appear to contain a desired affix will resist redundant affixing more than rote forms which do not appear to contain the affix. At the same time, children will have trouble learning to add affixes to roots that appear to already contain the affix.

Once the child has selected a set of morphemes, he must then apply allomorph selection productions like (3) and (5). After this, he linearizes the items and then applies allomorph modification productions like (6). Allomorph modifications will apply vacuously if their input allomorphs are not actually selected. The end result of this processing is an expression produced by combination. At the earliest stages of development, the child may have no productions such as (1)–(6) above. However, he can still apply combination, even though the result often will be in error.

In reception, the relation between rote and combination is quite parallel. When a form can be located as a single unit, rote can be applied. When no single unit is readily available, the form must be broken down into its components. The details of this processing are given in the flow chart in Appendix A.

CORRECTION

After the completion of application, processing moves on to correction. Correction serves to monitor the accuracy of expressions and receptions in terms of both internal and external data. Whenever a mismatch is detected, it is stored as a disequilibrated pair. In the disequilibrated pair, the reception or expression just produced by the child is the thesis, and the correcting form is the antithesis.

There are four types of disequilibrated pairs: types 1, 2, 3, and 4. Type 1 pairs involve a correction of an expression generated by combination or analogy by a weak form generated by rote. For example, the child may have *wives* as a weak rote form but actually utter *wifes* as the combination. In such cases the weak form is equivalent to a word that is on the tip of one's tongue (Brown & McNeill 1966) and is located only after combination has already yielded an expression. The combination is the thesis, and the rote form is the

antithesis. In such pairs, the thesis differs from the antithesis in sound rather than in meaning. In this type of correction the child remembers how to say something after he has just said it incorrectly. The literature on speech errors (Fromkin 1973) is rich with such self-corrections. In the child language literature, Guillaume (1927/1973), Lindner (1898), MacWhinney (1975), and others have shown that children may have trouble locating rote forms when certain situational supports are absent.

Type 2 pairs involve a mismatch between the semantics of the intention and the semantics of the expression. For example, the child may want to say "dogs" [+object, +animate, +four-legged, +furry, +number, −singular], but only end up saying "dog" [+object, +animate, +four-legged, +furry] with the features [+number, −singular] not being lexicalized. In effect, the child knows what he wants to say and realizes that he has not said it correctly. The material he has not been able to express will be called the "unexpressed." Here [+number, −singular] is the unexpressed.

Type 3 pairs arise when the sound of the audition fails to match the sound of the reception. In this case the child knows that there is some piece of the audition that he cannot understand. This piece will be called the "unknown." If the situation is rich in nonlinguistic semantic cues, the child also may be able to detect a "discrepancy" between what he understands from the verbal message and what he understands from the situation. For example, the child may hear *dogs*, but only be able to understand the part *dog*. At the same time, he may realize that the speaker is not talking about just one dog but is referring to several dogs.

Type 4 pairs involve forms that are repeatedly produced by combination and which eventually are entered into file 1 as rote forms. This occurs because, if we say something often enough, we come to believe it is true. However, reception serves to monitor the correctness of such autoinstruction. When the listener derives a reception from an audition, he then uses the reception to monitor his file 1 forms by checking to see whether the form he would generate from file 1 would have the same shape as the audition. If not, a disequilibrated pair is formed. Although this type of monitoring probably only occurs for a few forms in a given communication, it remains an option available to the child.

According to the model, overt corrections of children's errors by adults can only have an impact when the child is already disposed to acquire the overt correction as a new rote item or if the child monitors his own system by attempting to match the adult form. As Brown and Hanlon (1970) have noted, overt corrections seem to have little immediate impact on the child. However, their long-term impact has not been closely examined. Claim 3 is based on these observations.

Claim 3 (overt correction): children can learn from correction by adults but only in a slow and often delayed fashion.

ACQUISITION

When there is no antithesis, there is no formation of a disequilibrated pair. In this case, both expressive and receptive acquisition serve to strengthen the forms that have been used in the expression or in the reception. Rote appears to be in constant competition with combination and analogy. An example of this is Guillaume's (1927/1973) case of a child who produced the correct irregular French participle *pris* and then corrected himself with the incorrect regular form **prendu*. It would appear that the child had checked *pris* for the presence of the suffix *-u*. Not finding it, he went ahead to produce *pris*, but later generated *prendu* by combination or analogy. Eventually, the child would have to increase the lexical strength of *pris*. By increasing the strength of the rote form, the child would be able to insulate it against the alternative use of combination. Since rote applies before combination, strong rote forms will be very likely candidates for application. Thus, Gregoire (1947, p. 358) notes that, in French, common irregular forms like *ira* quickly suppress regularizations like *allera*. However, the fact that even adults make occasional morphophonological errors when distracted (Meringer 1908) indicates that the strength of rote forms must be actively maintained. Evidence from Miniature Linguistic System learning (Palermo & Eberhart 1968; Palermo & Howe 1970; Palermo & Parrish 1971) indicates that frequent irregular forms generally are learned before infrequent regular forms. This suggests that more frequent forms are more easily memorized. These observations lead to claim 4:

> Claim 4 (insulation): infrequent irregular rote forms will be subject to overregularization more frequently than common irregular rote forms. When children are forced to use forms out of context, this effect will be particularly pronounced.

In cases where correction results in the formation of disequilibrated pairs, more complex processing is required. Type 1 pairs are processed by morphophonological acquisition, type 2 pairs by expressive lexical acquisition, type 3 pairs by receptive lexical acquisition, and type 4 pairs by receptive acquisition. The details of this processing can be traced through five dialectic cycles. Earlier cycles acquire material that then requires processing by later cycles. Later cycles cannot function until this earlier material is available. The acquisitions during each cycle are summarized in table 1.

Cycle 1: Amalgams

Word learning is the simplest form of acquisition. The first step in this acquisition is the establishment of an intention the child wants to express. This occurs during expressive lexical acquisition. Every time the child has something he wants to say with no way to say it, a type 2 disequilibrated pair

TABLE 1

THE FIVE CYCLES FOR MORPHOPHONOLOGY

Cycle	Acquisition	Example
1....	Amalgams	"dogs"=*dogs*
2....	Allomorphs	/z/, /waIv/
3....	Modification productions	/dɔrs/→/dɔrz/
4....	Selection productions	$\langle \begin{smallmatrix} f \\ v^* \end{smallmatrix} \rangle$ +X (as in *wives*)
5....	Implications, class features	*das* (nominative)↔*dem* (dative) for *Wasser* (Class 3)

is formed, and the strength of the unexpressed intention increases. The more important the intention is to the child, the faster its strength will grow.

Acquisition of a form to express this unexpressed intention occurs during receptive lexical acquisition. When some aspect of the communicative situation matches some strong unexpressed intention and when some entire intonational unit (audition) is not processed by reception, a type 3 disequilibrated pair emerges. This pair leads directly to acquisition of a new item. Claim 5 views functionality as the basic factor influencing the acquisition of new lexical items.

> Claim 5 (functional determination): children will learn forms for intentions they very much want to express but for which they do not yet have forms.

The actual acquisition of items is limited by the availability of the required forms in the input. Claims 6, 7, 8, 9, and 10 note several further influences on the shape and nature of the child's early lexical items.

In cycle 1 the forms picked up by the child must be intonational units. Later, in cycle 2, the child will be able to analyze forms into their components. But in cycle 1 he must rely on the segmentation cues provided by intonation. If a language uses relatively unambiguous intonational cues to mark words as basic units, the intonational units acquired by children will be words. In languages with elision and varying accentuation, segmentation will be more difficult. It may be the case, however, that mothers compensate for this by predigesting or presegmenting their own speech to their children and that this segmentation tends to isolate words as units. Moreover, within a string of forms the child is trying to receive, some will stand out more than others. Such perceptual prominence is largely due to intonation. Claim 6 summarizes these observations:

> Claim 6 (intonational packaging): early forms will take the shape of units which are separately packaged by intonation in the input.

A further consequence of claim 6 is that the uninflected form of a root can be picked up as a complete amalgam in cycle 1. However, the oblique form

of a root can only be acquired together with affixes. These observations suggest claim 7:

> Claim 7 (first root allomorph): the first productive uses and the first overgeneralizations of a root will make use of the uninflected or citation allomorph. If the citation form is rare or if there is no citation form, the first overgeneralizations will be of the most frequent allomorph.

For example, Hale (1971) shows how Walbiri verbs are acquired in citation form even though extraction of the oblique root allomorph of the passive would simplify the grammar.

Cycle 2: Allomorphs

The forms acquired in cycle 1 are preanalyzed on the syntactic level by intonation. However, they remain totally unanalyzed on the morphological level. Because of this, they are called amalgams. If an amalgam is composed of more than one morpheme, the morphemes it contains are embedded within it. For example, amalgams like *dogs* and *cats* have the plural morpheme embedded in them. Both Bloom, Hood, and Lightbown (1974) and MacWhinney (1974) have noted that the morphophonological structure of rote forms often is far in advance of the morphophonological structure of productive forms. For example, MacWhinney (1974) found that children produced correctly inflected past-tense forms of both the regular (*megcsiptem*) and irregular (*megettem*) varieties long before there was any evidence for productivity of the past-tense suffix. Diarists (Gregoire 1947, pp. 115–117; Stern & Stern 1928/1965; and many others) have consistently noted that, when affixes first appear, they are not really separate units. Claim 8 is suggested by these and other observations:

> Claim 8 (embedding): when affixes are first acquired, they will be used with only a limited number of roots and will not be generalized to new roots. They will not illustrate errors in morphophonology until they are generalized to new roots.

The child can acquire new affixes through use of receptive lexical acquisition. In this process the child may hear a new word such as *dogs* and try to process it by receptive combination. The reception will be the morpheme *dog* and the unknown material will be /z/. In this example, the unknown is a single segment. However, receptive lexical acquisition can code any number of contiguous segments as unknown. In some cases, the unknown parts of a word or phrase may be separated by known material. Such discontinuous morphemes are hard for the child to encode, as noted by claim 9:

> Claim 9 (discontinuous morphemes): the child avoids acquisition of discontinuous morphemes. Such morphemes will be learned piece by piece, and the first piece learned will be the one with the most easily controlled allomorphic variations.

The child will associate this unknown material with any discrepancy that exists between the semantics of the situation and what he was able to understand of the audition. In other words, if he sees several *dogs*, but only understands *dog*, then the discrepancy is [+number, −singular]. If the discrepancy matches some unexpressed intention, it will be associated to the unknown and added as a new affix or root. In this example, [+number, −singular] will be associated to /z/ and added as a new affix. If there is already a meaning corresponding to the discrepancy, it must be the case that that meaning is associated to another allomorph. In that case the unknown will be added as a new allomorph to file 2 (affixes) or file 3 (roots). The details of this processing are given in Appendix A in the diagram for receptive lexical acquisition.

Each allomorph has a strength counter associated to it. When use of an allomorph leads to the formation of a disequilibrated pair, such as **wifes-wives*, the counter is decremented. When its use does not lead to error, the counter is incremented. Until the child has learned the principles governing allomorph selection or modification he will make the fewest errors by using the most common affix most frequently. This suggests claim 10:

> Claim 10 (first affix allomorph): the first productive uses and the first overgeneralizations of an affix will make use of the most frequent form.

Once the child is able to produce forms by combination, he is able to pick up forms that he himself has created. In expressive acquisition, all combinations that do not lead to disequilibrated pairs are placed in file 1, and their correctness is subsequently monitored against new auditions.

Cycle 3: Modification Productions

Cycle 2 processing leads to the acquisition of several allomorphs for a given morpheme. However, nothing in cycle 2 acquisition tells the child how to select among the allomorphs. Lacking any better guide, he will pick the allomorph with the highest strength. However, this method will lead to errors. Cycle 3 processing works to reduce this error. Unfortunately, it is hard to find a straightforward example of cycle 3 processing in English. Therefore, a simple Hungarian example will be used.

In cycle 1 the child can acquire *pipák* as the plural of *pipa* "pipe." In cycle 2 he can acquire /k/ as one of the allomorphs of the plural. Applying expressive combination in cycle 3, the child may take the root *pipa* and attach the plural /k/. The result is the erroneous form **pipak*. If *pipák* is a weak rote form, correction will lead to the formation of a type 1 disequilibrated pair with **pipak* as thesis and *pipák* as antithesis. Correction then leads to acquisition and, in particular, to acquisition of productions that modify allomorphs.

The synthesis of the production occurs in the following way. The modification $a \rightarrow \acute{a}$ is located by comparing thesis with antithesis. If the two

differ in only one segment, the segment of the thesis is placed on the left of the modification, and the segment of the antithesis is placed on the right of the modification. Next, the antithesis is examined for information regarding the context of the context-sensitive morphophonological production. In this case, the context is the full form *pipák*, and the production thus becomes (7).

$$a \rightarrow \acute{a} \,/\, pip\_k \tag{7}$$

This production is given a strength counter set to some low level. At some later time, the child finds that he has created another disequilibrated pair such as **fam-fám*. This pair shows the same *a* → *á* alteration. The child relates it to the existing production and uses it to refine or "prune" the context of the production. The result of a comparison of the **fam-fám* environment with the **pipak-pipák* environment yields (8).

$$a \rightarrow \acute{a} \,/\, \begin{bmatrix} +\text{consonantal} \\ -\text{vocalic} \\ +\text{anterior} \\ -\text{coronal} \\ -\text{voiced} \end{bmatrix} \_\_ + \begin{bmatrix} +\text{consonantal} \\ -\text{vocalic} \\ \ldots \end{bmatrix} \tag{8}$$

Subsequent comparisons will eventually prune the production down to (9).

$$a \rightarrow \acute{a} \,/\, \_\_ + X \tag{9}$$

With each comparison, a disequilibrated pair is equilibrated, the production is refined, and the strength of the production is increased. As the strength of the production grows, its productivity increases until, eventually, it becomes fully productive. Thus there is a direct relation between the number of disequilibrated pairs used in forming a production and the strength of that production. This relation is expressed in claim 11:

> Claim 11 (production applicability): the earliest productive uses of morphophonological patterns will be for those productions which apply correctly to the largest number of combinations produced by the child. The strongest productions will be those which are the most applicable.

Cycle 4: Selection Productions

If use of a cycle 3 production leads to error, it must be because the pattern it expresses is not general to all allomorphs of a given phonological shape. As an example, take the alternation between /waIf/ and /waIv/ in English. This can be expressed as a cycle 3 production with a /f/ → /v/ modification occurring in a certain context. However, this production would also serve to produce *sherives* from *sheriff* and *strives* as the plural of *strife*. Type 1 disequilibrated pairs like **fives-fifes* lead to a further type of morphophonological acquisition. In this further acquisition the child replaces the cycle 3 production with a cycle 4 selection production.

In the case of this /f/ → /v/ alteration, the cycle 4 production would be

$$\left\langle \begin{matrix} f \\ v* \end{matrix} \right\rangle + X \qquad (10)$$

This production states that, when there is an allomorph pair with an /f/-/v/ alternation followed by a suffix, then the allomorph with the /v/ should be selected. The wedged braces indicate allomorphic variations.

It often happens that a cycle 4 pattern can be controlled by a cycle 3 pattern with very few errors. When errors do occur, they decrease the strength of the cycle 3 pattern. But, since errors are rare, this decrease is slow. In such cases the cycle 4 production will remain in cycle 3 form for some time. These observations are expressed in claim 12:

> Claim 12 (cycle 4 strength): cycle 4 productions for which a cycle 3 form applies correctly in a large percentage of combinations will initially be used in a cycle 3 form.

However, once enough exceptions have been encountered, the allomorph condition becomes strengthened, and the production is limited in ways noted in claim 13:

> Claim 13 (cycle 4 productivity): productions that have many exceptions will only generalize to new morphemes when they are presented in two allomorphic forms.

Cycle 5: Implicational Table

If the child has exhausted all possible ways of controlling allomorphic selection through phonological principles and still encounters disequilibrated pairs, he must finally resort to lexical principles to determine the choice of allomorphs. In effect, he must acquire a system of lexical implications and a way of marking which lexical items relate to which implications. Because there is no full system of lexical implications in English, an illustrative example will be taken from the German system of article declension (table 2).

When the German child wants to express the intention [+dative,

TABLE 2

AN ILLUSTRATION OF AN IMPLICATION SYSTEM

		Meanings		
		[+nominative, +singular, +definite]	[+dative, +singular, +definite]	[+accusative, +singular, +definite]
Roots	Class	Allomorphs		
Mann, Hammer, etc.	1	der	dem	den
Frau, Butter, etc....	2	die	der	die
Pferd, Wasser, etc...	3	das	dem	das

+singular, +definite] with, for example, a noun like *Frau*, he has to choose between the two allomorphs *dem* and *der*. In order to do this he needs to know whether the following noun is in class 1 (masculine), class 2 (feminine), or class 3 (neuter). If he knows the class of the following noun, he can use an allomorph selection production such as (11).

$$\left\langle \begin{matrix} \text{dem} \\ \text{der*} \end{matrix} \right\rangle \# [+\text{class } 2] \tag{11}$$

In order to make use of this production, the child must have marked the noun *Frau* ("woman") for class 2 membership. The present hypothesis is that acquisition of such markings depends upon the use of a system of implications. If a child has the form *die Frau* (nominative) as a file 1 amalgam, he can examine table 2 and deduce the class membership of *Frau*. Thus the central task facing the child is the acquisition of a well-arranged table of implications.

The raw materials used in building the table are a series of implications. Implications derive from type 1 disequilibrated pairs. For example, the child may produce *dem Frau* by combination and have *der Frau* as a weak form. The result is the pair **dem Frau–der Frau*. The child then searches file 1 for another form with *Frau*. If he finds *die Frau*, he derives an implication such as

die Frau (nominative) ↔ *der Frau* (dative) .

He then looks to see if *Frau* is given as a root in the table. If it is, he looks to see if the implication is already present. If it is, he strengthens it. If it is not, he adds it.

If, on the other hand, *Frau* is not listed as a root in the table, it still may be possible to add the implication to a new row if (*a*) the table is empty, or if (*b*) it is clear that the implication could not fit into any existing row. This method of constructing the table is fairly conservative. However, as we will see in Chapter V, learning of German gender is a slow process.

Productivity of this system can be demonstrated in the following way. If the child is given a nonce form like **der Wug* (dative), he should be able to produce *die Wug* as the nominative of *Wug*. However, such processing could possibly be explained without introducing the notion of a table of implications. For example, *der* and *die* could be viewed as a positional class occurring before a certain group of nouns as in the model of "contextual generalization" proposed by Braine (1963). However, the child must also be able to draw implications between articles which occur before the noun and pronouns which occur at various places in the sentence. Such implications between noncontiguous elements cannot be controlled by a system based exclusively on positional patterns. Claim 14 focuses on this difference between a general system of implications and one based on positional classes.

Claim 14 (implication position): children who can use affix information to judge the class membership of a root will also be able to use informa-

tion not directly affixed to the root. Acquisition of the use of such classes will be slow.

The construction of a system of implications depends on the generation of disequilibrated pairs that bear some relation to file 1 information. The exact shape of the implications therefore depends on the child's choice of allomorphs. If the German child always uses *dem* for the dative, his implications will all be based on the use of *dem*. Eventually, the child will have learned as much as he can about the use of *dem*. In order to learn more about the dative article, he must then work on use of *der* for the dative. At this point, overgeneralization of *dem* may be replaced for a short time by overgeneralization of *der*. In effect, the child starts by attempting to delimit the application of the strongest allomorph until he reaches a point of diminishing returns. He then pushes application of another allomorph. Slobin (1966; 1973, p. 205) has called this "inflectional imperialism." Claim 15 summarizes this phenomenon:

Claim 15 (inflectional imperialism): when allomorphic variation cannot be controlled by cycle 3 or 4 productions, children initially overgeneralize the strongest allomorph. At some later time, overgeneralization of weaker allomorphs will occur.

DETERMINANTS OF THE SEQUENCE OF ACQUISITIONS

The dialectic model makes several claims about the sequence of acquisition of morphemes, allomorphs, and morphophonological productions. This subsection is devoted to a comparison of these claims with several somewhat different claims made by Brown (1973) in his recent book on the first stages of language. Brown devotes a great deal of attention to the sequence of acquisition of grammatical morphemes. The conclusion he reaches is that "there is an approximately invariant order of acquisition for the 14 morphemes we have studied, and behind this invariance lies not modeling frequency but semantic and grammatical complexity" (p. 379). The order of acquisition observed by Brown was based on the use of morphemes in "obligatory" contexts. If the child failed to use a plural when a plural was needed, he was judged to have omitted a plural form from an obligatory context. However, Brown never attempted to separate rote use of affixes in amalgams from productive use of affixes in combinations.

According to the dialectic model, the sequence of initial acquisition of affixes as nonproductive units will be determined largely by the functional importance (claim 5) of the amalgams within which the affixes are embedded (claim 8) as well as the intonational packaging of these units (claim 6). The sequence of acquisition of affixes as productive devices will be determined largely by the functional importance (claim 5) of the affixes themselves. The identity of the first productive allomorph of a given morpheme will be determined by the frequency (claim 10) of the allomorph within existing

amalgams, with the most frequent allomorph being acquired first. If a morpheme is discontinuous, the first form acquired will be the piece of the morpheme subject to the fewest allomorphic variations (claim 9). Finally, the sequence of acquisition of morphophonological productions will be determined by the number of productive combinations to which the production may apply. Application to rote forms is not a factor.

Nowhere in this model is there a role for either semantic or grammatical complexity per se. Rather, the emphasis is on functionality as a determinant of morpheme acquisition, frequency in amalgams as a determinant of allomorph acquisition, and applicability to productive combinations as a determinant of production acquisition. Since this *Monograph* is concerned only with the sequence of acquisition of allomorphs and productions, there will be no need to evaluate the role of functionality as a determinant of morpheme acquisition. If, at some later time, reliable criteria for measuring functionality become available, the dialectic model will be able to address the issue of the sequence of morpheme acquisitions.

Brown, on the other hand, has not yet turned his attention to the sequence of acquisition of allomorphs and productions. The data to be presented here will indicate that semantic or grammatical complexity bears no obvious relation to these acquisitions and that frequency in amalgams is the chief determinant of allomorph acquisition, while frequency of applicability to combinations is the chief determinant of production acquisition.

PREDISPOSITIONS

Stampe (1969, 1972) has suggested that the shape of early words is heavily influenced by processes such as devoicing of obstruents, deletion of unstressed syllables, or voicing assimilation in consonant clusters. Many of the natural processes or predispositions suggested by Stampe seem to be based on something like the principle of "least effort" offered earlier by Buffon (cited by Jakobson 1941), Ponori (1871), Scallinger (1540, cited by Vértes 1953, p. 6), and Schultz (1880). J. Ohala (1974) has pointed to a number of problems inherent in providing a phonetic basis for a principle of least effort in phonology. Despite these problems, it is clear that the phenomena described by Stampe are real and important. Ingram (1974a, 1974b) and Smith (1973) provide convincing accounts of the relevance of predispositions to the structure of early words and babblings.

Although predispositions are clearly relevant to phonotactics, their relevance to morphophonology is not always so straightforward. Let us take three examples. First, consider a strong morphophonological production which is not obviously related to any predisposition. The Hungarian production given in (13) is the same as the one given in (6) and (9) above.

$$a \rightarrow \acute{a} \,/\, \_\_ + X$$

This production converts *pipa* + *k* to *pipák*. However, there is no clear evidence for a universal predisposition to vowel lengthening in closed syllables. In fact, in uninflected roots with final consonants, Hungarian allows both short final vowels (/pipɑtʃ/, /kulɑtʃ/) as well as long ones (tɑna:tʃ/, /kɑla:tʃ/).

In a second type of case, a strong morphophonological process may combine with a relatively weak predisposition. Hungarian vowel harmony seems to be a case like this. Although the processes of rounding harmony and fronting harmony for vowels are probably related to predispositions, these predispositions seem to be relatively weak. Languages such as English seem to have little vowel harmony, and the role of vowel harmony in child phonotactics seems so far to be marginal. Even in vowel-harmony languages like Hungarian there can be a wide array of exceptions (*kréta*, *írok*, etc.) to vowel harmony. Nonetheless, predispositions probably play some role in the early acquisition of harmony.

In a third type of situation, a morphophonological process may combine with a relatively strong predisposition. The choice of /z/ versus /s/ as an allomorph of the English plural is an example of this type. Articulation of *cat* + *plural* as /kaetz/ or of *dog* + *plural* as /dɔgs/ is clearly problematical, although such forms are found in Caucasian languages and elsewhere. Reduction of these forms to /kaets/ and /dɔgz/, according to the predisposition of voicing assimilation of consonant clusters, is highly likely. In such cases, any attempt to construct a morphophonological account which disregards these phonotactic predispositions would be in error. Chapter VI includes a further discussion of this example. These remarks lead to the positing of claim 16:

> Claim 16 (predispositions): morphophonological patterns that are in accord with natural phonological predispositions will enter early and will seldom lead to errors.

The trade off and competition between predispositions and productions is a topic of clear importance. Unfortunately, given the data presently available, it is also a topic about which we cannot yet say a great deal.

Braine (1974) presents an interesting application of natural phonological analysis to the learning of a cycle 4 pattern. In Southern British English *soar* and *saw* are both pronounced [sɔ:] with no [r]. However, *soaring* has an [r], while *sawing* does not. Combination of the file 1 form [sɔ:] *soar* with the file 2 form [Iŋ] *-ing* would yield [sɔ:Iŋ] rather than the correct [sɔrIŋ]. Braine claims that the child, given a natural predisposition to delete [r] in postvocalic final position, would generalize the sound [r] to all postvocalic final positions in lexical representations. In addition, he suggests that such an automatic generalization mechanism may be of general importance in language acquisition. Because this extension should occur quite auto-

matically and because the deletion of [r] would also be quite automatic, errors such as *[sɔr] for *soar* or *[sɔ:Iŋ] for *soaring* should never occur. Unfortunately, Braine does not provide data on the occurrence of these two crucial forms.

Although the tendency to delete final [r] may be viewed as a natural phonological predisposition, the generalization mechanism proposed by Braine is not really bound to specific articulatory mechanisms. Rather, it seems to be a general processing mechanism. In this regard, it resembles the various processing abilities proposed in the dialectic model rather than the natural predispositions suggested by Stampe. It is, in a sense, a proposal about how processing abilities can interact with motoric predispositions. Slobin (1973) has investigated another processing ability which might well be related to certain perceptual predispositions. Slobin claims that one of the basic operating principles followed by young children is to "pay attention to the ends of words." This operating principle is seen as a reflection of fundamental predispositions to recall recent material better than nonrecent material. A consequence of this principle is that suffixes should be learned before prefixes and postpositions before prepositions. Slobin notes that the article is acquired in the third year in languages where it comes before the noun, but is acquired somewhat earlier in Bulgarian (Gheorgov 1905) where it is a suffix. Similarly, Rūķe-Draviņa (1963, p. 141) holds that Latvian endings, as case markers, generally enter earlier than the corresponding prepositions. Similar observations have been made for Serbo-Croatian by Mikeš (1967) and Mikeš and Vlahović (1966). MacWhinney (1974, 1975, 1976) has argued that these studies only show that affixes are acquired earlier than prepositions or postpositions and that what is needed to support Slobin's claim is evidence that suffixes are acquired before prefixes.

Table 3 summarizes the 16 claims that have been made in this chapter. The remaining chapters of this *Monograph* are devoted to an examination of the validity of these 16 claims.

TABLE 3

SIXTEEN CLAIMS OF THE DIALECTICAL MODEL

1 (goal stack)	Children will only apply analogy when rote and combination fail, and they will only apply combination when rote fails.
2 (affix checking)	Irregular rote forms which appear to contain a desired affix will resist redundant affixing more than rote forms which do not appear to contain the affix. At the same time, children will have trouble learning to add affixes to roots that appear to already contain the affix.
3 (overt correction)	Children can learn from correction by adults but only in a slow and often delayed fashion.
4 (insulation)	Infrequent irregular rote forms will be subject to overregularization more frequently than common irregular rote forms. When children are forced to use forms out of context, this effect will be particularly pronounced.
5 (functional determination)	Children will learn forms for intentions they very much want to express but for which they do not yet have forms.
6 (intonational packaging)	Early forms will take the shape of units which are separately packaged by intonation in the input.
7 (first root allomorph)	The first productive uses and the first overgeneralizations of a root will make use of the uninflected or citation allomorph. If the citation form is rare or if there is no citation form, the first overgeneralizations will be of the most frequent allomorph.
8 (embedding)	When affixes are first acquired, they will be used with only a limited number of roots and will not be generalized to new roots. They will not illustrate errors in morphophonology until they are generalized to new roots.
9 (discontinuous morphemes)	The child avoids acquisition of discontinuous morphemes. Such morphemes will be learned piece by piece, and the first piece learned will be the one with the most easily controlled allomorphic variations.
10 (first affix allomorph)	The first productive uses and the first overgeneralizations of an affix will make use of the most frequent form.
11 (production applicability)	The earliest productive uses of morphophonological patterns will be for those productions which apply correctly to the largest number of combinations produced by the child. The strongest productions will be those that are the most applicable.
12 (cycle 4 strength)	Cycle 4 productions for which a cycle 3 form applies correctly in a large percentage of combinations will initially be used in a cycle 3 form.
13 (cycle 4 productivity)	Productions that have many exceptions will only generalize to new morphemes when they are presented in two allomorphic forms.
14 (implication position)	Children who can use affix information to judge the class membership of a root will also be able to use information not directly affixed to the root. Acquisition of the use of such classes will be slow.
15 (inflectional imperialism)	When allomorphic variation cannot be controlled by cycle 3 or 4 productions, children will initially overgeneralize the strongest allomorph. At some later time, overgeneralization of weaker allomorphs will occur.
16 (predispositions)	Morphophonological patterns that are in accord with natural phonological predispositions will enter early and will seldom lead to errors.

III. THE ACQUISITION OF HUNGARIAN MORPHOPHONOLOGY

This chapter is divided into three parts. The first part introduces nine patterns in Hungarian morphophonology. The second part reviews previous studies of the learning of these patterns. The third part reports a series of three experiments on the development of these patterns.

NINE PATTERNS OF HUNGARIAN MORPHOPHONOLOGY

Before beginning, it may be helpful to take a brief look at the structure of the Hungarian phonological system. The vowel system is given in table 4. It can be seen from this table that the five features of highness, lowness, length, frontedness, and roundedness fully specify the system in phonological terms. Phonetically, however, there is a difference in both tenseness and height between [α] and [a:] and between [ɛ] and [e:]. For the purposes of the present study, there is no need to examine the consonantal system, although the following orthographic peculiarities may be noted: Hungarian *sz* = [s], *cs* = [tʃ], *s* = [ʃ], and *ny* = [ŋ]. Also, the reader should note the diacritics on Hungarian vowels. An umlaut indicates rounding. A single accent indicates a long vowel. A double accent indicates a long rounded vowel.

TABLE 4

HUNGARIAN VOWEL SYSTEM

		−front		+front	
		+round	−round	+round	−round
+high, −low	−long	u [u]	...	ü [y]	i [i]
	+long	ú [u:]	...	ű [y:]	í [i:]
−high, −low	−long	o [o]	...	ö [ɸ]	ë [e][a]
	+long	ó [o:]	...	ő [ɸ:]	é [e:]
−high, +low	−long	...	a [α]	...	e [ɛ][a]
	+long	...	á [a:]	...	...

[a] These two sounds are often in free variation.

With these general phonological observations in mind, we now turn to a consideration of each of the nine patterns. Some of these patterns are controlled by one morphophonological production. Others are controlled by more. Altogether, 15 productions are needed to correctly control these nine patterns. These productions are designed to be applied in parallel, according to the "selectric principle" suggested by Cearley (1974) and MacWhinney (1974). According to this principle, the entire morphophonological component moves in parallel, like a scanner, across the word as it is being formed. When a production finds its structural description fulfilled, it operates. Allomorph modifications may apply vacuously if their input allomorphs are not actually selected.

The nine patterns represent a major subset of the productive morphophonological patterns of Hungarian. Szépe (1969) and Tompa (1970) both provide excellent descriptions of the patterns in question. The 15 productions given here are designed to express these nine patterns in the simplest possible shape. On the one hand, they attempt to formalize all of those aspects of each pattern for which some productivity can be demonstrated. On the other hand, the productions are formulated within the context of the true generalization condition of natural phonology as formulated by Hooper (1976). This condition claims that "the rules speakers formulate are based directly on surface forms and that these rules relate one surface form to another, rather than relating underlying to surface form" (p. 13). As the reader will observe, all lexical forms posited in this *Monograph* are direct concrete reflections of surface structure.

Pattern 1: Final Vowel Lengthening

The pattern of final vowel lengthening can be expressed by productions 1 and 2.

Production 1: $[\alpha] \rightarrow [a:] / \_\_\_ + X$
Example: ora + k → orák

Production 2: $[\varepsilon] \rightarrow [e:] / \_\_\_ + X$
Example: csésze + k → csézék

Production 1 lengthens final [α] before any suffix. Production 2 lengthens final [ε] before any suffix. These productions each apply to a large number of roots. Roots ending in [α] are very numerous in Hungarian; roots ending in [ε] are somewhat less numerous. Both productions apply correctly to all items in their domain. This is to say that production 1 applies correctly to all roots ending in [α] and that production 2 applies correctly to all roots ending in [ε]. Hence both patterns are fully correct and should be acquired in cycle 3. These patterns affect four of the roots used in experiment 1 (*óra*, *tóra*, *csésze*, and *fésze*). Table 5 lists the various stimuli used in that experiment.

TABLE 5

STIMULI FOR EXPERIMENT 1

Real Noun	Allomorph	Meaning	Analog
1. óra.....	órá	clock	13. tóra
2. csésze.....	csészé	teacup	14. fésze
3. könyv.....	...	book	15. önyv
4. bőr.....	...	leather	16. mőr
5. kenyér.....	kenyere	bread	17. kepér
6. hal.....	hala	fish	18. gal
7. szék.....	...	chair	19. mék
8. kabát.....	...	coat	20. kanát
9. ló.....	lova	horse	21. gó
10. kéz.....	keze	hand	22. széz
11. tükör.....	tükrö	mirror	23. fükör
12. kosár.....	kosara	basket	24. mosár

Suffix	Allomorphs	Relevant Productions
plural.....	-k, -ok, -ek, -ök, -ak	6, 8, 9, 10
accusative.....	-t, -ot, -et, -öt, -at	6, 8, 9, 10
superessive ("on")....	-n, -on, -en, -ön	6, 8, 9, 10
allative ("toward")...	-hoz, -hez, -höz	9, 10
instrumental ("with")	-val, -vel, -al, -el	10, 12, 13
possessive.....	-a, -e, -ja, -je	10, 14, 15

Pattern 2: Internal Vowel Shortening

The pattern of internal vowel shortening serves to shorten the vowels of the last syllable of some, but not all, roots of a given shape. The shortening occurs before all suffixes with allomorphs beginning in [a]. For example, the pattern applies to *kenyér* + *t* to yield *kenyeret*, but does not apply to *kabát* + *t* to yield **kabatot* since the correct form is *kabátot*. Furthermore, *kenyér* + *nek* becomes *kenyérnek* and not **kenyernek*.

The child should initially attempt to learn this pattern in terms of cycle 3 productions altering [a:] to [α] and [e:] to [ε]. However, such productions would soon give rise to type 1 disequilibrated pairs such as **kabatot-kabátot*. Such pairs would lead the child to append cycle 4 allomorph conditions. In their final shapes, the productions are

Production 3: $\left\langle \begin{matrix} a* \\ á \end{matrix} \right\rangle$ [+consonantal] + ⟨a⟩

Example: $\left\langle \begin{matrix} \text{madár} \\ \text{madar} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{ak} \\ \text{ek} \\ \text{k} \end{matrix} \right\rangle \rightarrow$ madarak

Production 4: $\left\langle \begin{matrix} e* \\ é \end{matrix} \right\rangle$ [+consonantal] + ⟨a⟩

Example: $\left\langle \begin{matrix} \text{kenyér} \\ \text{kenyer} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{ak} \\ \text{ek} \\ \text{k} \end{matrix} \right\rangle \rightarrow$ kenyerek

The symbols in wedged brackets indicate material that must be contained by some of the allomorphs in that position.

Pattern 3: Internal Vowel Deletion

Like internal vowel shortening, this pattern holds for only some roots of a given phonological shape. Thus, vowel deletion applies to *bokor* + *ok* to yield *bokrok*, but does not apply to *motor* + *ok* since the correct form is *motorok* rather than **motrok*. This pattern is given as

$$\text{Production 5:}\quad \left\langle \begin{matrix} \phi * \\ X \end{matrix} \right\rangle [+\text{consonantal}] + \langle [+\text{vocalic}] \rangle$$

$$\text{Example:}\quad \left\langle \begin{matrix} \text{tükör} \\ \text{tükr} \\ \text{tükrö} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{ok} \\ \text{ak} \\ \text{ök} \\ \text{ek} \\ \text{k} \end{matrix} \right\rangle \rightarrow \left\langle \begin{matrix} \text{tükr} \\ \text{tükrö} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{ök} \\ \text{k} \end{matrix} \right\rangle$$

Pattern 4: Linking Vowel Insertion

There are three productions governing linking vowel insertion. The most general is

Production 6:

$$\phi \rightarrow \begin{bmatrix} +\text{vocalic} \\ -\text{consonantal} \\ -\text{high} \\ -\text{low} \\ -\text{long} \end{bmatrix} / \begin{matrix} (a) \begin{bmatrix} +\text{consonantal} \\ \cdots \end{bmatrix} + \text{——} \begin{bmatrix} +\text{consonantal} \\ -\begin{bmatrix} +\text{anterior} \\ +\text{coronal} \\ -\text{strident} \\ -\text{voiced} \end{bmatrix} \end{bmatrix} \\ (b) \begin{bmatrix} +\text{consonantal} \\ -\begin{Bmatrix} +\text{nasal} \\ +\text{vocalic} \\ +\text{strident} \end{Bmatrix} \end{bmatrix} + \text{——} \begin{bmatrix} +\text{anterior} \\ +\text{coronal} \\ -\text{strident} \\ -\text{voiced} \end{bmatrix} \end{matrix}$$

Examples: ablak + *t* → ablakot, but asztal + *t* → asztalt

Like productions 1 and 2, this is a cycle 3 production. Part *a* applies when the first consonant of the suffix is not [t]. Part *b* applies when it is [t].

The second linking vowel production applies to roots which use the low vowel [α]. It selects the allomorph with [α] before suffixes with allomorphs in [α].

$$\text{Production 7:}\quad \left\langle \begin{matrix} \phi \\ a* \end{matrix} \right\rangle + \langle a \rangle [+\text{consonantal}]$$

$$\text{Example:}\quad \left\langle \begin{matrix} \text{hal} \\ \text{hala} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{m} \\ \text{om} \\ \text{am} \end{matrix} \right\rangle \rightarrow \text{halam}$$

The third linking vowel production applies to suffixes with initial vowels. It selects the allomorphs with initial vowels after roots ending only in consonants.

$$\text{Production 8: } [+\text{consonantal}] + \left\langle \begin{matrix} [+\text{vocalic}]* \\ \phi \end{matrix} \right\rangle$$

$$\text{Example: ház} + \left\langle \begin{matrix} \text{od} \\ \text{ed} \\ \text{öd} \\ \text{ad} \\ \text{d} \end{matrix} \right\rangle \rightarrow \text{ház} + \left\langle \begin{matrix} \text{od} \\ \text{ed} \\ \text{öd} \\ \text{ad} \end{matrix} \right\rangle$$

Pattern 5: Rounding Harmony

A common property of the Ural-Altaic group of languages, of which Hungarian is a member, is the extensive use of vowel harmony. Both within morphemes and within morphological words, Hungarian stipulates that vowels must harmonize for roundedness and frontedness. Rounding harmony is controlled by a cycle 4 production.

$$\text{Production 9: } \begin{bmatrix} +\text{vocalic} \\ +\text{round} \end{bmatrix} [+\text{consonantal}]_n \, ([+\text{vocalic}]) + X \left\langle \begin{matrix} [+\text{round}]* \\ X \end{matrix} \right\rangle$$

$$\text{Example: bőr} + \left\langle \begin{matrix} \text{hoz} \\ \text{hez} \\ \text{hoz} \end{matrix} \right\rangle \rightarrow \text{bőr} + \left\langle \begin{matrix} \text{hoz} \\ \text{hoz} \end{matrix} \right\rangle$$

In other words, the vowel of some suffixes will be round if the last vowel present in all allomorphs of a root is round.

Pattern 6: Fronting Harmony

The second harmony pattern is fronting harmony. This type of harmony is governed by a cycle 3 production.

$$\text{Production 10: } \begin{bmatrix} +\text{vocalic} \\ +\text{front} \end{bmatrix} [+\text{consonantal}]_n + X \left\langle \begin{matrix} \begin{bmatrix} +\text{vocalic} \\ +\text{front} \end{bmatrix}* \\ X \end{matrix} \right\rangle$$

$$\text{Example: kéz} + \left\langle \begin{matrix} \text{ban} \\ \text{ben} \end{matrix} \right\rangle \rightarrow \text{kézben}$$

Pattern 7: V-Insertion

A handful of original Ugro-Finnic roots are subject to production 11 for v-insertion.

$$\text{Production 11: } \left\langle \begin{matrix} \text{v}* \\ \phi \end{matrix} \right\rangle X + \langle \phi \rangle [+\text{consonantal}]$$

$$\text{Example: } \left\langle \begin{matrix} \text{ló} \\ \text{lov} \\ \text{lova} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{as} \\ \text{es} \\ \text{s} \end{matrix} \right\rangle \rightarrow \left\langle \begin{matrix} \text{lov} \\ \text{lova} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{as} \\ \text{es} \\ \text{s} \end{matrix} \right\rangle$$

Pattern 8: V-Assimilation

Two Hungarian suffixes begin with a [v]. These two are the instrumental and the translative-factitive. When these are preceded by roots ending in a consonant, the [v] disappears and the final consonant of the root lengthens. This pattern is controlled by a cycle 3 modification production and a cycle 4 selection production.

Production 12: $[-\text{long}] \rightarrow [+\text{long}] \,/\, \_\_\_ + \left\langle \begin{matrix} \text{v} \\ \phi \end{matrix} \right\rangle$

Example: ház + val → házzal

Production 13: $[+\text{consonantal}] + \left\langle \begin{matrix} \text{v} \\ \phi* \end{matrix} \right\rangle$

Example: ház + $\left\langle \begin{matrix} \text{val} \\ \text{al} \end{matrix} \right\rangle$ → házzal

Pattern 9: J-Insertion

The final two productions involve j-insertion in the possessive. Nouns ending in vowels in all allomorphs take a [j] at the beginning of the possessive. Nouns ending in vowels in some allomorphs never use the [j]. Nouns ending in consonants take [j] only if they end in a stop consonant. These facts are expressed in

Production 14: $[+\text{vocalic}] + \left\langle \begin{matrix} \text{j}* \\ \phi \end{matrix} \right\rangle$

Example: hajó + $\left\langle \begin{matrix} \text{ja} \\ \text{a} \end{matrix} \right\rangle$ → hajója

Production 15: $\begin{bmatrix} +\text{consonantal} \\ -\text{continuant} \end{bmatrix} + \left\langle \begin{matrix} \text{j}* \\ \phi \end{matrix} \right\rangle$

Example: kabát → $\left\langle \begin{matrix} \text{ja} \\ \text{a} \end{matrix} \right\rangle$ → kabátja

Table 6 summarizes the 15 productions as they have been presented in the preceding paragraphs.

These 15 productions differ quite widely in their applicability and productivity. For example, production 10 applies to the majority of morphophonological productions whereas production 11 applies only to a handful of roots. Although production 10 is very high in applicability, it should be limited in productivity. It should apply productively to new roots but not to new suffixes. Production 1, on the other hand, should apply productively to new and old roots ending in [α] in combination with both new and old suffixes. Table 7 summarizes the productivity and applicability of the 15 productions.

TABLE 6

FIFTEEN HUNGARIAN MORPHOPHONOLOGICAL PRODUCTIONS

Production 1—final vowel lengthening:

$[\alpha] \rightarrow [a:]/\_\_\_ + X$

Example: ora + k → orák

Production 2—final vowel lengthening:

$[\varepsilon] \rightarrow [e:]/\_\_\_ + X$

Example: csésze + k → csészék

Production 3—internal vowel shortening:

$\left\langle \begin{matrix} a^* \\ á \end{matrix} \right\rangle$ [+consonantal] + ⟨a⟩

Example: $\left\langle \begin{matrix} \text{madár} \\ \text{madar} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{ak} \\ \text{ek} \\ \text{k} \end{matrix} \right\rangle \rightarrow$ madarak

Production 4—internal vowel shortening:

$\left\langle \begin{matrix} e^* \\ é \end{matrix} \right\rangle$ [+consonantal] + ⟨a⟩

Example: $\left\langle \begin{matrix} \text{kenyér} \\ \text{kenyer} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{ak} \\ \text{ek} \\ \text{k} \end{matrix} \right\rangle \rightarrow$ kenyerek

Production 5—internal vowel deletion:

$\left\langle \begin{matrix} \phi^* \\ X \end{matrix} \right\rangle$ [+consonantal] + [+vocalic]

Example: $\left\langle \begin{matrix} \text{tükör} \\ \text{tükr} \\ \text{tükrö} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{ok} \\ \text{ak} \\ \text{ök} \\ \text{ek} \\ \text{k} \end{matrix} \right\rangle \rightarrow \left\langle \begin{matrix} \text{tükr} \\ \text{tükrö} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{ök} \\ \text{k} \end{matrix} \right\rangle$

Production 6—linking vowel insertion:

$\phi \rightarrow \begin{bmatrix} +\text{vocalic} \\ -\text{consonantal} \\ -\text{high} \\ -\text{low} \\ -\text{long} \end{bmatrix}$ /(see text)

Examples: ablak + t → ablakot, but asztal + t → asztalt

Production 7—linking vowel insertion:

$\left\langle \begin{matrix} \phi \\ a^* \end{matrix} \right\rangle$ + ⟨a⟩ [+consonantal]

Example: $\left\langle \begin{matrix} \text{hal} \\ \text{hala} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{m} \\ \text{om} \\ \text{am} \end{matrix} \right\rangle \rightarrow$ halam

Production 8—linking vowel insertion:

[+consonantal] + $\left\langle \begin{matrix} \phi \\ [+\text{vocalic}]^* \end{matrix} \right\rangle$

Example: ház + $\left\langle \begin{matrix} \text{od} \\ \text{ed} \\ \text{öd} \\ \text{ad} \\ \text{d} \end{matrix} \right\rangle \rightarrow$ ház + $\left\langle \begin{matrix} \text{od} \\ \text{ed} \\ \text{öd} \\ \text{ad} \end{matrix} \right\rangle$

Production 9—rounding harmony:

$\begin{bmatrix} +\text{vocalic} \\ +\text{round} \end{bmatrix}$ $[+\text{consonantal}]_n$ ([+vocalic]) + X [+round]*

Example: bőr + $\left\langle \begin{matrix} \text{hoz} \\ \text{hez} \\ \text{höz} \end{matrix} \right\rangle \rightarrow$ bőr + $\left\langle \begin{matrix} \text{hoz} \\ \text{höz} \end{matrix} \right\rangle$

TABLE 6 (*Continued*)

Production 10—fronting harmony:

$$\begin{bmatrix} +\text{vocalic} \\ +\text{front} \end{bmatrix} [+\text{consonantal}]_n + X \left\langle \begin{matrix} \begin{bmatrix} +\text{vocalic} \\ +\text{front} \end{bmatrix}^* \\ X \end{matrix} \right\rangle$$

Example: kéz + $\left\langle \begin{matrix} \text{ban} \\ \text{ben} \end{matrix} \right\rangle$ → kézben

Production 11—v-insertion:

$$\left\langle \begin{matrix} v^* \\ \phi \end{matrix} \right\rangle X + \phi\,[+\text{consonantal}]$$

Example: $\left\langle \begin{matrix} \text{ló} \\ \text{lov} \\ \text{lova} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{as} \\ \text{es} \\ \text{s} \end{matrix} \right\rangle \rightarrow \left\langle \begin{matrix} \text{lov} \\ \text{lova} \end{matrix} \right\rangle + \left\langle \begin{matrix} \text{as} \\ \text{es} \\ \text{s} \end{matrix} \right\rangle$

Production 12—v-assimilation:

$$[-\text{long}] \rightarrow [+\text{long}]/\_\_\_ + \left\langle \begin{matrix} v \\ \phi \end{matrix} \right\rangle$$

Example: ház + val → házzal

Production 13—v-assimilation:

$$[+\text{consonantal}] + \left\langle \begin{matrix} v \\ \phi^* \end{matrix} \right\rangle$$

Example: ház + val → házzal

Production 14—j-insertion:

$$[+\text{vocalic}] + \left\langle \begin{matrix} j^* \\ \phi \end{matrix} \right\rangle$$

Example: hajó + $\left\langle \begin{matrix} \text{ja} \\ \text{a} \end{matrix} \right\rangle$ → hajója

Production 15—j-insertion:

$$\begin{bmatrix} +\text{consonantal} \\ -\text{continuant} \end{bmatrix} + \left\langle \begin{matrix} j^* \\ \phi \end{matrix} \right\rangle$$

Example: kabát + $\left\langle \begin{matrix} \text{ja} \\ \text{a} \end{matrix} \right\rangle$ → kabátja

The order of applicability given in table 7 was based on estimates of the total number of forms to which a production would potentially apply. The figures for productions 3, 4, 5, 7, and 11 were taken from Bánhidi, Jókay, and Szabó (1965, pp. 62–63). The other percentages were taken from Papp's (1969) inverse dictionary. Such figures provide an indirect measure of the frequency of forms in the child's speech. More precise measures of applicability have not yet been conducted. Such measures would need to be based on extensive sampling of child speech data.

THE RESULTS OF PREVIOUS STUDIES OF THE DEVELOPMENT OF HUNGARIAN MORPHOPHONOLOGY

The numerous diary studies of Hungarian language development include many examples of morphophonological errors judged to be typical of a given age. As Berko (1958), Guillaume (1927/1973, p. 220), Leopold (1949, pp. 76–80), and others have argued, child errors provide important evidence regarding the productivity of linguistic patterns. Correct forms of real words tell us very little, since they can so easily be attributed to rote memorization.

TABLE 7

PRODUCTIVITY, APPLICABILITY, AND ACQUISITION OF THE 15 PRODUCTIONS

Production	Productivity	Applicability	Order of Applicability	Order of Acquisition
1.....	New roots with [α]	All roots ending in [α] (7.2)[a] before all suffixes	3	2
2.....	New roots with [ε]	All roots ending in [ε] (1.7)[a] before all suffixes	6	5
3.....	New roots with correct allomorphs	About 40 roots before most common suffixes	13	12
4.....	New roots with correct allomorphs	About 20 roots before most common suffixes	14	13
5.....	New roots with correct allomorphs	About 110 roots before most common suffixes	11	11
6.....	New suffixes with correct allomorphs	Many common suffixes after roots ending in consonants (80.4)[a]	2	3
7.....	New roots with correct allomorphs	About 70 roots before most common suffixes	12	10
8.....	New suffixes with correct allomorphs	Most common suffixes	4	4
9.....	New suffixes with correct allomorphs	Many common suffixes	5	6
10.....	New suffixes with correct allomorphs	Nearly all suffixes after all roots	1	1
11.....	New roots with correct allomorphs	About 15 roots before most common suffixes	15	14
12.....	New roots with final consonants	All roots in consonants (80.4)[a] before two suffixes	10	8
13.....	New suffixes with correct allomorphs	Two suffixes after all roots in consonants (80.4)[a]	9	7
14.....	New suffixes with correct allomorphs	Two suffixes after all roots ending in vowels (19.6)[a]	8	9
15.....	New suffixes with correct allomorphs	Two suffixes after most roots ending in stops (32.2)[a]	7	15

[a] Percentages of total vocabulary given by Papp (1969, pp. 541–543). The figures for noun roots alone are somewhat lower.

Unfortunately, there is no way to calculate the absolute frequency of a given-error type from the Hungarian diary data. Nonetheless, a comparison of these anecdotal reports does provide a rough indication of the relative frequency of different error types. MacWhinney (1974) compiled all the morphophonological errors reported in the Hungarian literature. From this compilation, six generalizations can be made regarding errors in morphophonological alterations:

a) Errors in productions 1 and 10 are extremely rare. In fact, MacWhinney (1974) reports productivity for these two productions as early as 1-8.6 (1 year, 8 months, 6 days) in one of his subjects. Since these productions are the two most applicable productions of Hungarian morphophonology, this finding lends support to claim 11 (production applicability) of the dialectic model.

b) Where individual suffixes (*-nék*, first-person singular conditional; *-ik*, third-person plural definite; and *-i*, third-person singular definite) resist the overall pattern of fronting harmony given by production 10, there are frequent attempts to create harmonizing allomorphs not provided by the language. Such spontaneous creation of new forms of suffixes is certainly an extreme case of productivity. This finding supports claim 11 which holds that productions that are frequently applied become the strongest and most productive productions.

c) Overgeneralizations of fronting by production 10 are as common as undergeneralizations of fronting by production 10. This finding suggests that front-vowel allomorphs are as strong as back-vowel allomorphs.

d) The vowel [o] is more often overgeneralized as a linking vowel than the vowel [α]. This finding supports claim 11, since production 6 is more applicable and productive than production 7.

e) Overgeneralizations of citation (primary or nominative) root allomorphs exceed overgeneralizations of secondary (oblique) allomorphs by over four to one. This finding supports claim 7 (first root allomorph) which suggests that early roots are usually citation forms.

f) When the selection of an allomorph is governed by class membership, errors abound. Examples are the selection between ϕ and *-ik* in the 3PS Present Indefinite and the selection of a tense-based root for the irregular verbs. This finding supports claim 14 (implication position).

In addition to these six general findings on morphophonological alterations, the Hungarian literature (MacWhinney 1976) includes observations regarding the morphemic and semantic aspects of morphological analysis. There are three lines of evidence indicating that affixes first emerge in morphologically unanalyzed amalgams, in accord with claim 8 (embedding). First, affixes are used correctly before they are used productively, as Brown (1973) has noted. Second, underanalysis is reflected in semantic extensions, affix redundancies, and affix contradictions. Third, the linear ordering of affixes is very seldom incorrect. This suggests that the component morphemes are being produced not by combination but by rote.

These diary data have been supported in Berko-type studies by MacWhinney (1975) and Réger (1974, 1975). Réger tested 32 6-year-olds for their ability to produce plural, accusative, plural-accusative, possessive-plural, possessive-allative, and other forms of real nouns. She also examined the third-person singular and third-person plural past tense forms of a number of real verbs. Unfortunately, she used no nonce-word stimuli. Sixteen of her subjects were Hungarian monolinguals and 16 were Hungarian-Gypsy bilinguals with Gypsy as their first language. In noun morphophonology, both groups showed numerous errors in productions 3, 4, 5, 7, 11, and 15. Both groups showed virtually no errors in productions 1, 2, 6, 9, 10, 13, and 14. In general, Réger's results support claim 11 in that the most applicable

productions are those acquired first (see table 7). For each of the 15 productions bilingual errors exceeded monolingual errors by around two or three to one. Moreover, the bilinguals produced 42 forms with overgeneralized secondary (oblique) allomorphs, whereas the monolinguals only produced three. Also, there were four errors in suffix ordering produced by the bilinguals, whereas none were produced by the monolinguals. These two differences between the bilinguals and the monolinguals could both be attributed to a possible lesser use of amalgams by the bilinguals. These results may have general implications for the role of amalgams in second-language learning.

The only study of Hungarian morphophonology which has compared performance on both real and nonce roots is that of MacWhinney (1975). The results of that study need not be discussed separately, since experiment 1 incorporates and replicates the earlier experiment.

The remainder of this chapter presents three studies of the acquisition of Hungarian morphophonology. The next three chapters deal with further data on the acquisition of Finnish, German, and a number of other languages. Finally, Chapter VII reviews the 16 claims of the dialectic model in the light of the available data.

EXPERIMENT 1: HUNGARIAN NOUN MORPHOPHONOLOGY

This experiment is designed to provide data on two major issues. The first issue is the role of analogy in morphological formations (claim 1) which will be investigated by systematically attempting to induce analogy in nonce formations with the use of real "primes" or analogs. The second major issue is the determination of the order of acquisition of the various morphological productions. Claim 11 of the model holds that the order of acquisition of productions is largely determined by applicability. Productions that are highly applicable will also be strong. However, claim 12 holds that cycle 4 productions that apply only to a subclass of morphemes of a given shape will not be as productive as cycle 3 productions.

It will be helpful to distinguish four levels at which productions may be acquired. Productions will be judged to be *fully productive* if they are applied at least 90% of the time to nonce roots. Productions will be judged to be *moderately productive* if they are applied at least 50% of the time to nonce roots. In this experiment productive productions are, almost by definition, either cycle 3 productions or cycle 4 productions that apply to affixes. Cycle 4 productions that apply to roots or which are limited to a certain root type cannot be shown to be productive unless the child is taught a new inflection. Since no new "nonsense" inflection was taught in this experiment, the limits of productivity of productions 3, 4, 5, 7, and 11 are only partially assessed. For these rules, the data indicate that the production is *fully learned* when it is

applied to at least 90% of the roots for which it correctly applies. The production is moderately learned when it is applied to at least 50% of the rules for which it is correct. There is no intended relation between these criteria and those used by Brown (1973) and Cazden (1968) for the measurement of the acquisition of lexical items. The present study is concerned with the acquisition of morphophonological productions, whereas Brown and Cazden were interested in the acquisition of grammatical morphemes.

Method

Subjects.—This experiment was conducted with 15 children from each of the following age groups: 2-6 to 2-9, 3-0 to 3-8, 4-9 to 5-1, and 6-8 to 7-5. Each group was composed of seven boys and eight girls or eight boys and seven girls. The children in the two youngest age groups came from two Budapest nursery schools for children from 2 to 4 years of age. The children in the two older groups all came from one Budapest nursery school for children from 4 to 7 years of age. Overwhelmingly, the parents of the children were workers or low-level professionals. Most of the families were composed of two parents and one or two children.

Stimuli.—Each child was asked to generate 144 morphological formations. These formations involved six inflections: the plural, the accusative, the superessive (English *on*), the allative (English *toward*), the instrumental (English *with*), and the third-person singular possessive. Children were asked to attach these six inflections to each of the 24 nouns given in table 6. The attachment of six inflections to 24 nouns yielded 144 formations for each child. However, only three of the 30 children in the two youngest groups were able to understand the possessive elicitation task. Thus, the analysis for the two youngest groups is based on 120 forms per child, whereas the analysis for the two older groups is based on 144 forms per child.

All 24 forms of a given inflection were administered in a given block. Within a given block (i.e., the plurals) each subject received a different order of real noun roots. Six nonce analogs were randomly selected for each subject to serve as items to be primed. These to-be-primed forms were ordered immediately after the analogous real nouns. The other six nonce analogs were placed randomly after the six remaining real nouns. Finally, the order of the six blocks was randomized across subjects.

Procedure.—Each of the forms was elicited by the same technique. This technique consisted of 10 steps in which the experimenter (1) exhibited the toy, (2) named the toy, (3) allowed the child to play with the toy, (4) repeatedly named the toy, (5) got the toy back from the child, (6) asked the child "what is this?" (7) repeated steps 1–6 if the child failed to provide the correct name, (8) presented a test question, (9) repeated steps 1–8 if the child failed to attach a suffix to the noun, and (10) proceeded to the next item. Only step 8 was different for each inflection. In the plural block, the experi-

menter presented a second similar toy and said, "Here is another . . . . What are these?" In the accusative block, the experimenter grabbed (or bit) the toy and asked, "What am I grabbing?" In the superessive, the experimenter took a very little doll, seated it on the toy, and then asked, "What is the little doll sitting on?" In the allative, the experimenter rolled a wheeled penguin or a windup toy toward the target toy and asked, "What is the penguin rolling toward?" In the instrumental, the experimenter threw the toy around in the air and asked, "What am I playing with?" Finally, in the possessive, the experimenter said, "This . . . belongs to Uncle Brown (the experimenter's nickname). This is Uncle Brown's what?" (In Hungarian, the possessive follows the thing possessed.) Note that all six inflections appear in Hungarian as suffixes after the word which is an answer to the question "What?" By attaching inflections to the word provided by the experimenter, the child creates a morphological form subject to some of the 15 productions discussed above. In this procedure, the test question includes the suffix to be used by the child. Earlier research (MacWhinney 1974) indicated that the shape of the allomorph in the test question has no influence on the shape of the child's response. For example, children asked question (12) were no more likely to respond with (14) over (15) than children asked question (13).

(12): Melyik barátta*l* játszol? (*-tal*, instrumental)
Which friend-with play-you?
(13): Melyik emberre*l* játszol? (*-rel*, instrumental)
Which man-with play-you?
(14): *Peterral.
(15): Peterrel.

This is not surprising, since there is no necessary relation in the language between the shape of allomorphs used in questions and those used in answers.

All responses were tape-recorded and then transcribed in phonetic notation. When a child produced two different responses to the same item, the response included in the analysis was the response closest to the adult standard.

Results

Analogy.—The first issue to be evaluated in this research is the impact of analogy on morphological production. This impact may be evaluated by examining whether the words using primed nonce analogs were more like the analogous words using real nouns than the words using unprimed nonsense analogs were like their analogous words using real nouns. Nonce words and their analogous real nouns are judged to be "alike" when there is no evidence for differential application of any of the 15 productions discussed above.

The analysis of variance yielded significant effects for treatment, $F(1,72) = 5.64$, $p < .05$, and age, $F(3,72) = 4.745$, $p < .005$. The interac-

tion of treatment and age was barely short of the $p = .05$ significance level, $F(3,72) = 2.44$, $p < .07$. Trend analysis for this interaction indicates a significant linear-by-quadratic interaction, $F(1,72) = 6.96$, $p < .01$. Inspection of the cell means reveals the sources of this interaction trend (table 8). Whereas the numbers of primed analogies peaked at the youngest age, the numbers of nonprimed analogies peaked at the second age. In fact, the second and third groups showed very little effect for priming. Rather, the effect was concentrated at the youngest and oldest ages.

Production acquisition.—The next subsections investigate the second major question in this research: the order of acquisition of the 15 productions. As noted above, productions may be fully or moderately productive for nonce nouns and fully or moderately learned for real nouns. Some of these productions are easily mastered and lead to few mistakes. Other productions are quite difficult and result quite uniformly in errors. As a result, many of the age-by-morpheme cells have no variance, and analysis of variance is inappropriate. Moreover, when there are large numbers of tied ranks, measures of nonparametric correlation are unstable. Unless otherwise stated, the statistic used is Fisher's test of exact probabilities. To minimize type 1 errors, $p < .025$ rejection level is used throughout. The four age groups will be referred to by numbers. The 2-6 to 2-9 group will be group 1; 3-0 to 3-8 will be group 2; 4-9 to 5-1 will be group 3; and 6-8 to 7-5 will be group 4.

1. Final vowel lengthening. Inspection of table 9 reveals that production 1 was fully learned (90% correct on real) and fully productive (90% correct on nonce) even for group 1. However, production 2 was only fully learned by

TABLE 8

MEAN *N* ANALOGOUS RESPONSES

Group	Age	Primed	Not Primed
1.....	2-6 to 2-9	26.9	23.5
2.....	3-0 to 3-8	25.1	25.2
3.....	4-9 to 5-1	22.6	22.8
4.....	6-8 to 7-5	24.6	22.2

TABLE 9

FINAL VOWEL LENGTH
(% Omission Errors)

		PRODUCTION 1		PRODUCTION 2	
GROUP	AGE	*óra*	*tóra*	*csésze*	*fésze*
1.....	2-6 to 2-9	2	1	41	41
2.....	3-0 to 3-8	0	2	8	20
3.....	4-9 to 5-1	0	0	3	17
4.....	6-8 to 7-5	0	0	0	22

3-0 and was not fully productive even by 7-5. Errors on *csésze* significantly exceeded those on *óra* ($p < 10^{-5}$ by exact probabilities). Group 2 did significantly better than group 1 on both the real form *csésze* ($p < 10^{-9}$) and the nonce form *fésze* ($p < .001$). However, the nonce form never quite reached full productivity. There were no significant differences between the six suffixes in use of productions 1 and 2.

2. Internal vowel shortening. Table 10 summarizes the omissions of internal vowel shortening. This pattern is governed by productions 3 and 4. Productions 3 and 4 seem to have been moderately learned by 4-9, but were never fully learned during this period. There were no significant differences between the four roots at the various ages. However, the errors with the plural suffix were significantly fewer than the errors on the accusative or the possessive for group 3 ($p < .01$). In the oldest group, this advantage for the plural disappeared. It would appear that the low degree of error on plural forms for group 3 must have been due to greater strength of plural amalgams and consequently greater use of rote. A test with Wilcoxen's T indicated a significant ($p < .005$) difference between the overall performance of group 2 and group 3 on internal vowel shortening for the plural and accusative.

The overgeneralization data in table 11 indicate four things. First, productions 3 and 4 could not have been productive before 6-8. If they had been productive in the first three groups, overgeneralizations to the superessive and

TABLE 10

INTERNAL VOWEL SHORTENING
(% Omission Errors)

Group	Age	*kenyér*	*ló*	*kéz*	*kosár*	Plural	Accusative	Possessive
1.....	2-6 to 2-9	76	96	93	93	85	95	...[a]
2.....	3-0 to 3-8	80	90	83	96	85	90	...[a]
3.....	4-9 to 5-1	24	66	46	76	23	45	45
4.....	6-8 to 7-5	23	30	20	33	20	18	15

[a] Possessives not administered.

TABLE 11

INTERNAL VOWEL SHORTENING
(% Overgeneralization Errors)

GROUP	AGE	REAL SUPERESSIVES	NONCE PROBES		
			kepér	*széz*	*mosár*
1.....	2-6 to 2-9	20	10	0	3
2.....	3-0 to 3-8	8	1	0	0
3.....	4-9 to 5-1	17	2	0	6
4.....	6-8 to 7-5	44	56	16	53

to nonsense words would have been far more frequent. Second, the few overgeneralizations that did occur before 6-8 might have been based on analogy. The real analogs of *kepér*, *széz*, and *mosár* are subject to production 3, the real analogs of *mék* and *kanát* are not. In fact, only *kepér*, *széz*, and *mosár* underwent any analogical overgeneralizations. In this regard, it is interesting to note that such analogies were most frequent in the youngest and oldest groups—the same groups which were found in table 6 to make the most overall use of analogy. Furthermore the data in table 10 indicate that most of the correct uses of the pattern were based on rote rather than combination.

The third finding indicated by the data in table 11 is that productivity of internal vowel shortening increased markedly in group 4. This was illustrated by a significant increase of overgeneralizations to real superessives over group 3 ($p < .005$) and by a significant increase of overgeneralizations to nonce forms ($p < 10^{-10}$). Such productivity reflects an attempt to acquire a highly applicable cycle 4 production in cycle 3 form. Claim 12 (cycle 4 strength) predicts just this type of acquisitional strategy. There is evidence, moreover, that the cycle 3 production was limited to two-syllable roots, since overgeneralizations to *széz* were significantly fewer in group 4 than overgeneralizations to *kepér* or *mosár* ($p < 10^{-5}$).

The fourth finding is that there were no significant differences between the results for roots subject to production 3 and those subject to production 4. This was probably due to the fact that the two productions apply to roughly equal numbers of roots.

3. Internal vowel deletion. Table 12 summarizes the various failures to apply production 5 to the root *tükör*. The correct forms are *tükrök*, *tükröt*, *tükrön*, and *tükre*. Excluding the possessives, a test of the differences between the total errors for group 2 and group 3 was highly significant ($p < 10^{-7}$). Both group 3 and group 4 showed moderate learning of production 5.

There were significantly more overgeneralization errors (see table 13) for group 3 than for group 2 ($p < .00006$) and more for group 4 than group 3 ($p < .00004$). The increase in overgeneralizations and the decrease in omissions of production 5 in groups 3 and 4 indicates that children were at-

TABLE 12

INTERNAL VOWEL DELETION
(% Omission Errors on *tükör*)[a]

Group	Age	Plural	Accusative	Superessive	Possessive
1.....	2-6 to 2-9	100	93	86	...[b]
2.....	3-0 to 3-8	100	100	80	...[b]
3.....	4-9 to 5-1	33	60	46	33
4.....	6-8 to 7-5	33	46	13	40

[a] Here omissions involve failure to apply a deletion production.
[b] Possessives not administered.

TABLE 13

INTERNAL VOWEL DELETION
(% Overgeneralization Errors on *fükör*)

Group	Age	Plural	Accusative	Superessive	Possessive
1.....	2-6 to 2-9	6	0	6	...[a]
2.....	3-0 to 3-8	0	0	0	...[a]
3.....	4-9 to 5-1	40	13	20	13
4.....	6-8 to 7-5	73	60	66	33

[a] Possessives not administered.

tempting to acquire this fairly applicable cycle 4 production in cycle 3 form, as predicted by claim 12.

4. Linking-vowel insertion. Linking-vowel insertion is determined by the joint operation of productions 6, 7, and 8. All but four of the roots in table 5 require linking vowels. The roots not taking linking vowels are those ending in vowels. However, the source of the linking vowels for three of the roots (*hal*, *ló*, and *kosár*) must be the final vowel of the root allomorph chosen by production 7.

Omissions of linking vowels in the plural and superessive (table 14) were significantly fewer in group 2 than in group 1 ($p < .001$) and in group 3 than in group 2 ($p < .001$). In group 2, part *a* of production 6 was fully productive. The absence of any significant differences between real and nonce roots indicates that the production was acquired in cycle 3 form.

There were far more errors in the use of a linking vowel before the accusative. The overgeneralization errors in table 15 indicate some delay in the acquisition of part *b* of production 6. However, these rates were significantly below the 91%–99% overgeneralization rate which would have derived from use of only part *a* of production 6. Another proof of the productivity of part *b* of production 6 was the tendency (table 16, pt. B) to erroneously omit linking vowels in the accusative of irregular nouns ending in liquids. The data in table 15 indicate significantly more cases of erroneous insertion of a linking vowel in group 2 than in group 3 ($p < .001$). This de-

TABLE 14

LINKING VOWEL INSERTION
(% Omission Errors)

		REAL		NONCE	
GROUP	AGE	Plural	Superessive	Plural	Superessive
1.....	2-6 to 2-9	12	8	18	17
2.....	3-0 to 3-8	5	4	6	8
3.....	4-9 to 5-1	0	0	1	0
4.....	6-8 to 7-5	0	1	1	2

TABLE 15

LINKING VOWEL INSERTION
(% Overgeneralization Errors on the Accusative)

Group	Age	Nonsense Nouns						Real Noun
		mőr	*kepér*	*gal*	*széz*	*fükör*	*mosár*	*bőr*
1.....	2-6 to 2-9	26	7	20	53	0	7	26
2.....	3-0 to 3-8	13	7	26	33	20	10	13
3.....	4-9 to 5-1	0	0	7	20	0	13	0
4.....	6-8 to 7-5	20	53	67	73	46	73	20

TABLE 16

LINKING VOWEL INSERTION
(% Omission Errors on the Accusative)
A. REGULAR NOUNS

Group	Age	*könyv*	*önyv*	*szék*	*mék*	*kabát*	*kanát*
1.....	2-6 to 2-9	26	33	7	0	0	7
2.....	3-0 to 3-8	13	26	7	20	0	0
3.....	4-9 to 5-1	0	7	0	0	0	13
4.....	6-8 to 7-5	0	7	0	0	0	7

B. IRREGULAR NOUNS

Group	Age	*kenyér*	*hal*	*kéz*	*tükör*	*kosár*
1.....	2-6 to 2-9	73	53	20	80	100
2.....	3-0 to 3-8	80	27	33	80	100
3.....	4-9 to 5-1	27	33	40	46	53
4.....	6-8 to 7-5	7	7	7	40	27

crease in erroneous insertions seems to reflect acquisition of full productivity for part *b* of production 6. However, this decrease was accompanied by a marked and highly significant ($p < 10^{-8}$) increase in erroneous insertions in group 4. This increase in group 4 was largely related to increased productivity for productions 3, 4, and 5. Only in the cases of *bőr* and *mőr* could part *b* have been operating alone. For those two roots, the changes between the age groups were not significant. Conclusions regarding the acquisition of part *b* will require more data on the use of roots with regular shapes, such as *bőr* or *mőr*.

Production 7 is the second linking-vowel insertion pattern to be considered. If Production 7 fails to select an allomorph with a final vowel, production 6 will be used to determine the shape of the linking vowel. The errors on the irregular nouns in table 16 resulted from failure to select allomorphs ending in vowels. Performance on these five nouns was significantly better for group 3 than group 2 ($p < .003$). In group 3, production 7 met the criterion

for moderate learning. Height errors in the plural (tables 17 and 18) provide further information on the learning of production 6. Performance on the real plural was significantly better for group 3 than group 2 ($p < .009$). Also, overgeneralizations of [α] in the plural (table 18) were significantly more frequent in group 3 than in group 2 ($p < .00007$). The data on errors in the accusative are not useful, since the vowel is so often missing. In the superessive, the vowel is not inserted by production 6.

Production 8 is the last of the three linking-vowel insertion patterns. Only roots subject to production 7 can give evidence for productivity for production 8. The data on use of [α] for the superessive in table 18 showed that use of production 7 rather than production 6 or 8 was the exception at all ages. Moreover, the data discussed above showed that production 7 was moderately learned only by 4-9 and never fully learned or productive in this period. Thus, only from 4-9 was there also evidence for moderate learning of production 8. However, there is no evidence that production 8 is not acquired even before this, perhaps even by 2-6.

5. Rounding harmony. Overgeneralizations of rounding harmony were confined exclusively to the roots *könyv* and *önyv* (table 19). Although *könyv* and *önyv* have rounded vowels, the shape of their final consonant cluster blocks application of production 9. Control of this pattern was only fully productive by group 4. For group 4 errors on rounding harmony for *könyv* and *önyv* were

TABLE 17

LINKING VOWEL HEIGHT ERRORS
(% Omissions, i.e., Use of [o]) for [α])

		PLURAL		ACCUSATIVE	
GROUP	AGE	*hal*	*kosár*	*hal*	*kosár*
1.....	2-6 to 2-9	26	60	13	0
2.....	3-0 to 3-8	40	73	7	0
3.....	4-9 to 5-1	20	26	0	0
4.....	6-8 to 7-5	7	20	0	0

TABLE 18

LINKING VOWEL HEIGHT ERRORS
(% Overgeneralizations, i.e., Use of [α] for [o])

		PLURAL		ACCUSATIVE		SUPERESSIVE				
GROUP	AGE	*gal*	*mosár*	*gal*	*mosár*	*gal*	*mosár*	*hal*	*kosár*	*ló*
1.....	2-6 to 2-9	13	7	0	0	20	0	20	20	0
2.....	3-0 to 3-8	0	0	7	0	0	0	20	0	0
3.....	4-9 to 5-1	53	26	7	0	0	0	20	10	10
4.....	6-8 to 7-5	53	53	13	0	7	13	30	0	30

TABLE 19

LINKING VOWEL ROUNDING HARMONY
(% Overgeneralization Errors)

		könyv			*önyv*		
GROUP	AGE	Plural	Accusative	Superessive	Plural	Accusative	Superessive
1.....	2-6 to 2-9	13	0	20	40	13	7
2.....	3-0 to 3-8	20	0	40	26	20	26
3.....	4-9 to 5-1	7	13	40	40	40	20
4.....	6-8 to 7-5	0	0	0	13	7	0

significantly less than for group 3 ($p < 10^{-5}$). The most interesting aspect of table 19 is the fact that errors on *könyv* and *önyv* never exceeded 40% at any ages. However, full use of production 9 would have brought the error rate on *könyv* and *önyv* closer to 100%. Moreover, the data given in table 20 indicate that production 9 was fully productive for all the other rounded roots even by 2-6. Moreover, there were no significant differences for the age groups in table 20. It seems possible that there was some natural phonological support for rounding harmony blockage after certain consonant clusters and that this support worked to keep down the overgeneralization rate. If this were found to be true, the results obtained would be in accord with claim 16 (predispositions).

The above remarks deal with rounding harmony for linking vowels. The experiment also examined rounding harmony for the internal vowel of the allative suffix (tables 21 and 22). As noted in table 5, this suffix takes the forms *-hoz*, *-hez*, and *-höz*. Since the only back-vowel allomorph is the rounded allomorph, children make no errors on rounding harmony with back-vowel words. In front-vowel words, however, there are both omission and overgeneralization errors. The large error percentages in tables 21 and 22 reflect an overgeneralization found in certain dialects of [ϕ] for [ɛ] that is known as *özés*. This sociolinguistic option treats front unrounded roots as if they were fronted, rounded roots. The effect is to eliminate the *-hez* allomorph and reduce the allative to the *-hoz* ~ *-höz* contrast. If the only allative allomorphs

TABLE 20

LINKING VOWEL ROUNDING HARMONY
(% Omission Errors)

Group	Age	*bőrök*	*börön*	*mőrök*	*mőrön*
1.....	2-6 to 2-9	26	7	13	0
2.....	3-0 to 3-8	7	7	7	13
3.....	4-9 to 5-1	7	0	7	0
4.....	6-8 to 7-5	7	0	7	0

TABLE 21

SUFFIX VOWEL ROUNDING HARMONY
(% Overgeneralization Errors)

Group	Age	*csésze*	*kenyér*	*szék*	*kéz*	*fésze*	*kepér*	*mék*	*széz*
1.....	2-6 to 2-9	7	26	20	20	13	26	26	33
2.....	3-0 to 3-8	13	33	33	26	26	46	26	26
3.....	4-9 to 5-1	46	60	60	53	53	53	46	73
4.....	6-8 to 7-5	7	7	13	20	26	20	13	20

TABLE 22

SUFFIX VOWEL ROUNDING HARMONY
(% Omission Errors)

Group	Age	*könyv*	*bőr*	*tükör*	*önyv*	*mőr*	*fükör*
1.....	2-6 to 2-9	53	33	20	46	33	20
2.....	3-0 to 3-8	26	40	26	20	33	20
3.....	4-9 to 5-1	13	6	53	6	6	6
4.....	6-8 to 7-5	26	26	20	20	20	0

the child has learned are *-hoz* and *-höz*, then use of *-höz* where *-hez* is required is not an error in production 9 but a gap in the lexicon. Between group 2 and group 3 there was a significant increase in overgeneralization (table 21) of *-höz* ($p < .00002$). This was accompanied by a significant decrease in omission of *-höz* (table 22) between group 2 and group 3 ($p < .001$). However, there was also a significant decrease in overgeneralization of *-höz* between group 3 and group 4 ($p < 10^{-11}$). It is unlikely that this rise in use of *-höz* in groups 3 and 4 is a result of dialect differences since the children came from the same nursery school serving the same area of Budapest. Nonetheless, future studies of rounding harmony must include explicit controls of dialect peculiarities.

6. Fronting harmony. Table 23 lists all the fronting harmony omissions

TABLE 23

FRONTING HARMONY OMISSION ERRORS

Group	Age	Subject ID No.	Omissions	
1.....	2-6 to 2-9	3	kenyérhoz	székhoz
2.....	3-0 to 3-8	4	mőrhoz	...
		5	csészéhoz	fészéhoz
			kenyérhoz	kepérhoz
			székhoz	mékhoz
			kézhoz	szézhoz
		9	őron	...
3.....	4-9 to 5-1	5	csészéhoz	fészéhoz
4.....	6-8 to 7-5	5	szézhoz	...

in the data. The only overgeneralization of fronting harmony was the incorrect form *galhez* for the correct form *galhoz* given by a subject in the youngest group. All the omissions except one (*mőron*) were uses of *-hoz* when *-höz* or *-hez* are required. There is evidence, therefore, that production 10 was fully productive by 2-6.

7. V-insertion. The root *ló* underwent internal vowel shortening by a form of production 3 whenever it underwent v-insertion by production 11. This is because *ló* has only these allomorphs: *ló*, *lov*, and *lova*. Both v-bases also have short internal vowels. However, one has a final vowel, and the other does not. Thus, use of production 11 does not automatically determine use of production 7. The error **lovn* illustrates how production 11 may apply and production 7 not apply. There was a significant improvement in v-insertion from group 2 to group 3 ($p < .001$) and from group 3 to group 4 ($p < .001$) (see table 24). Only in group 4 was there any case of overgeneralization of v-insertion to the nonsense analog *gó*. With 17 such overgeneralizations, group 4 had significantly ($p < 10^{-6}$) more than group 3. These data indicate that production 11 may have begun to emerge as a cycle 3 production in group 4.

8. V-assimilation. Performance on v-assimilation (see table 25) was nearly perfect from 4-9. Group 3 showed significantly fewer failures to lengthen the final consonant of the root than did group 2 ($p < 10^{-6}$). At the same time, group 2 showed significantly fewer failures to delete the [v] than

TABLE 24

V-BASE INSERTION
(% Omission Errors)

Group	Age	Plural	Accusative	Superessive	Possessive
1.....	2-6 to 2-9	93	100	100	...[a]
2.....	3-0 to 3-8	86	93	100	...[a]
3.....	4-9 to 5-1	40	46	46	60
4.....	6-8 to 7-5	20	20	26	20

[a] Possessive data excluded.

TABLE 25

V-ASSIMILATION
(% Omission Errors for Roots Ending in Consonants)

		FAILURE TO LENGTHEN		FAILURE TO DELETE [v]	
GROUP	AGE	Real	Nonsense	Real	Nonsense
1.....	2-6 to 2-9	8	12	12	16
2.....	3-0 to 3-8	11	24	6	8
3.....	4-9 to 5-1	0	2	0	0
4.....	6-8 to 7-5	0	0	0	0

group 1. There were no major differences in performance among the 18 roots ending in consonants.

Production 13 does not apply when the root ends in a vowel. Thus, deletion of the [v] was an error after the six roots listed in table 26. The most common errors were *csészel*, *fészel*, and *tóral*. Less common were *góal* and *gól*. For these same six roots there were 10 errors in the shape of what should have been a [v]. These errors included the types: *gólal*, *lólal*, *tórával*, and *órálal*.

It appears that both productions 12 and 13 were well established in group 3 and that group 2 was involved in a small amount of overgeneralization of production 13.

9. J-insertion. Only the two older groups were able to provide responses to the possessive elicitation task. These two groups do not differ significantly in their overall performance or their performance on particular roots. Thus, in this analysis, their data are pooled. Production 14 specifies use of a [j] after all vowels. The [j] was always correctly inserted after vowels. Production 15 specifies use of the [j] after stop consonants. Judging by binomial probabilities ($p = .50$), performance was better than chance at $p < .0001$ on the six nouns ending with vowels and for *kabát*, *kéz*, and *széz*. It was better than chance at $p < .001$ for *könyv*, *önyv*, *bőr*, *mőr*, *kenyér*, and *hal*. However, for *szék*, *mék*, *kepér*, *gal*, *kanát*, *tükör*, *fükör*, *kosár*, and *mosár*, performance was at chance. The results on the nonce roots reflect both asystematicity and idiolectal variation in the use of production 15. However, the errors on the real possessives indicate that learning of j-insertion after consonants must proceed root by root. On the other hand, j-insertion after vowels was fully productive early on.

Order of acquisition.—Table 27 summarizes the data presented in this section regarding the ages at which the productions become moderately learned, fully learned, moderately productive, or fully productive.

From the data given in table 27 an order of acquisition was estimated. The productions judged to be first acquired were those which were fully productive at the youngest age. The productions last acquired were those which were not even moderately learned at the oldest age, etc. The order derived in this way was given above in table 7 where it can be compared with

TABLE 26

V-ASSIMILATION
(% Overgeneralization Errors for Roots Ending in Vowels)

Group	Age	*óra*	*tóra*	*csésze*	*fésze*	*ló*	*gó*
1.....	2-6 to 2-9	0	0	20	13	0	7
2.....	3-0 to 3-8	0	13	20	33	0	7
3.....	4-9 to 5-1	0	0	0	0	0	0
4.....	6-8 to 7-5	0	0	0	0	0	0

TABLE 27

AGES OF HUNGARIAN PRODUCTION ACQUISITION

Production	Moderately Learned	Fully Learned	Moderately Productive	Fully Productive
1	2-6	2-6	2-6	2-6
2	2-6	3-0	2-6	NDOP
3	4-9	NDOP	N.A.	N.A.
4	4-9	NDOP	N.A.	N.A.
5	4-9	NDOP	N.A.	N.A.
6*a*	2-6	2-6	2-6	3-0
6*b*	2-6	3-0	2-6	?
7	4-9	6-8	N.A.	N.A.
8	2-6	2-6	N.A.	N.A.
9	2-6[a]	4-9[a]	2-6[a]	6-8[a]
10	2-6	2-6	2-6	2-6
11	4-9	NDOP	N.A.	N.A.
12	2-6	4-9	2-6	4-9
13	2-6	4-9	2-6	4-9
14	4-9[b]	4-9[b]	4-9[b]	4-9[b]
15	NDOP	NDOP	NDOP	NDOP

NOTE.—NDOP = not during observational period, i.e., the rule is not acquired at this level before 6-8; possibly it is not acquired at this level even by adults. N.A. = not applicable since productivity was not tested by using new affixes (see text).

[a] Only for children not subject to dialect instability.

[b] No figures before this time since suffix was not yet widely used.

the order of relative applicability of the 15 productions. Agreement between the two orders was high (Kendall's $\tau = 0.75, p < .0001$). This indicated that applicability can be a remarkably good predictor of order of acquisition. However, correctness also seemed to play a role in the delayed acquisition of production 15. This factor thus accounted for nearly all of the deviation from perfect prediction.

Discussion

The first issue addressed by this research was the impact of analogy on morphological formation. The analysis of variance indicated a significant effect of priming and a highly significant effect of age on the number of analogic responses produced. However, these significant main effects must be interpreted in light of the nearly significant age $\times$ treatment interaction effect. The two groups most affected by the priming treatment were the youngest and the oldest group. Group 1, the 2-year-old group, seemed to use analogy as one of a number of strategies to produce new formations. Groups 2 and 3, who were working hard at the refinement and application of general rules, seemed to have temporarily abandoned analogy as a strategy in morphological problem solving. Group 4, however, had reached a point where continued production learning led to diminished returns. They seem to have reinstated analogy as one of several tools in their morphological arsenal. In an earlier study, MacWhinney (1975) found little evidence for the use of analogy in morphological formations. However, the children investi-

gated in that study were mostly 3-year-olds, and the present data indicate that the effect of analogical priming is minimal at that age. A weak effect of priming on analogies has also been reported by M. Ohala (1974) for adult Hindi speakers. Although priming increased the number of analogies produced in Ohala's study, the increase was not statistically significant. In general, these results support claim 1 (goal stack), which views analogy as one of several strategies for word formation and, in particular, as a last alternative when rote and combination have failed.

The second major issue addressed by this experiment involves the determinants of the order of acquisition. The major finding which stands out in table 7 is that applicability is the chief determinant of order of acquisition. This finding directly confirms claim 11 (production applicability). The chief anomaly in table 7 is the very delayed acquisition of production 15 for j-insertion. This production is a good example of a highly applicable production that is very low in correctness. As suggested by claim 11, it is acquired late precisely because it is low in correctness. Thus, highly applicable productions are acquired early only if they are generally correct.

A further finding of this line of research is of importance to certain fundamental issues in the examination of the abilities underlying language acquisition. In her research with English morphophonology, Berko (1958) found correct usage of the three plural allomorphs /s/, /z/, and /ɨz/ in the mid elementary school years. However, the selection of one of the allomorphs could, conceivably, be governed by a selectional production rather than a modification production. For example, the child could learn to use /ɨz/ after roots ending in sibilants. On the other hand, learning of final-vowel lengthening in Hungarian cannot be described by any simple selectional mechanism. Since lengthening is applied automatically to all nonsense roots ending in [α] or [ε], and since the number of such roots has no finite limit, the production could not be a selection between a small class of alternatives. Nor could the production be viewed as a selection between [α] and [a:], since the [a:] on a new word is never given to the child. Rather, the child replaces the [α] that is given him with an [a:] by use of what is best described as a modification production. Moreover, such modificational abilities have been observed (MacWhinney 1974) in children as young as 1-8.10. The emergence of the ability to alter representations through the application of context-sensitive modification productions at such an early age constitutes a crucial fact to be explained by any theory of development.

Four summary conclusions derive from this experiment and from the previous research. First, there is evidence indicating that productions such as those proposed are useful in describing children's behavior. Second, although rote plays an important developmental role in the acquisition of these rules, its contribution to behavior decreases with age. Third, the role of analogy in producing morphological formations is minimal, particularly during the

period when cycle 3 productions are being acquired. Fourth, by using the notions of applicability and correctness it is possible to accurately predict the data here on the acquisitional sequence of the 15 productions.

EXPERIMENT 2: ALTERATIONS OF HUNGARIAN ADJECTIVES

Claim 5 (functional determination) holds that children will learn forms for intentions they very much want to express but for which they do not yet have forms. A corollary of this claim and of claim 10 is that, when two morphemes express the same content and differ only in their context specifications, the child will first acquire the one that is most frequent. Acquisition of the less frequent morpheme will be markedly delayed. Experiment 2 tests these claims.

Hungarian adjectives use the low linking vowels [α] and [ε]. Use of these low linking vowels is the exception for nouns. For adjectives it is the rule. One way of controlling this semantic asymmetry of morphophonological rules would be to encode, for example, the plural for adjectives as below:

$$\left\langle \begin{matrix} \text{ak} \\ \text{ek} \end{matrix} \right\rangle = [-\text{singular}] \,/\, [+\text{modifier}] \,\ldots\ldots\, [\_\_\_] \,,$$

and the plural for nouns as:

$$\left\langle \begin{matrix} \text{k} \\ \text{ok} \\ \text{ek} \\ \text{ők} \\ \text{ak} \end{matrix} \right\rangle = [-\text{singular}] \,/\, [+\text{object}] \,\ldots\ldots\, [\_\_\_] \,.$$

The second solution would be to encode all adjectives with at least two allomorphs, as in *lassú* ("slow singular") and *lassuák* ("slow plural"):

$$\left\langle \begin{matrix} \text{lassú} \\ \text{lassúa} \end{matrix} \right\rangle = \begin{bmatrix} +\text{modifier} \\ +\text{speed} \\ -\text{polar} \end{bmatrix}$$

Choice of *lassúa* would be determined by production 7 as it was given above. The first solution differentiates suffixes with similar meanings on the basis of the meanings of the roots to which they attach. It establishes the adjective plural and the noun plural as separate lexical items. The second solution relies on the phonological environment to determine allomorph selection. Claims 5 and 10 suggest that the second solution will be the one first attempted by the child, since it avoids acquisition of a new form for a function already expressed by an old form.

Method

Upon the conclusion of experiment 1, all subjects proceeded on to experiment 2. The method of experiment 1 was duplicated in experiment 2 with

the same 60 subjects. The stimuli included the four adjectives, *bátor*, *boldog*, *vörös*, and *lassú*, whose plurals are *bátrak* (productions 5 and 7), *boldogok* (production 6), *vörösek* (production 7), and *lassúak* (production 7). Nonce analogs were *nádor*, *bolnok*, *örös*, and *passú*. The analogs were primed half of the time by real forms in a counterbalanced pattern.

Results

Essentially, there was no evidence for use of an independent adjective plural by any of the age groups. The plurals of *lassú*, *passú*, and *bolnok* were always *lassúk*, *passúk*, and *bolnokok*. Except when primed by *bátor*, the plural of *nádor* was always *nádorok*. Thus, the nonce roots *passú*, *bolnok*, and *nádor* were always followed by the mid vowel of production 6 and showed no evidence for an independent adjective plural. There are four adjectives which are exceptions to the general pattern of low vowel harmony. *Boldog* is one of these. However, there were only two cases of overgeneralization of the low vowel (i.e., *boldogak*) in these data. The forms *vörösek* and *vörösök* occurred with equal frequency at all age levels. The same was true of *örösek* and *örösök*. There was significantly ($p < .005$) less use of [ϕ] with the adjectives *vörös* and *örös* than with the nouns *bőr* and *mőr* (cf. table 20). In the back, adjectives sometimes take [ϕ], although they usually take [α]. In the front, they always take [ε] and never [ϕ].

Discussion

The height of the linking vowel for adjective plurals seems to rely on phonological rather than semantic properties. Essentially, children use productions 6 and 7. It is true that their use of [ϕ] with rounded nonsense adjectives is significantly less than their use of [ϕ] with rounded nonsense nouns. However, this semantic contextual differentiation is not fully controlled before age 7-5. The basic finding is, then, that children attempt to preserve the association of one form with one function on the lexical level. In doing so, they maximize the applicability of the noun-plural suffix. They do not establish a separate suffix for the adjective, even though to do so would increase the correctness of adjective pluralization. These findings support claims 5 and 10. Unfortunately, we do not know how often children use adjective plurals in everyday speech. Consequently, we do not know how much incorrectness they actually experience. Further research is needed to determine whether applicability is sacrificed by older children and adults to attain correctness.

EXPERIMENT 3: EXTRACTION OF AMBIGUOUS FEATURES

The majority of the productions presented above are designed to select between allomorphs. This experiment investigated the ability of children to encode and select between allomorphs on the basis of a single exposure to an

allomorph pair in discourse. Claim 13 (cycle 4 productivity) holds that children who use such productions should be able to perform above chance in this task.

Method

After subjects had finished experiments 1 and 2, they began experiment 3. The 60 subjects used in the earlier experiments were shown three additional nonsense objects, called *zomor*, *satár*, and *zű*. They were given irregular plurals for each of these nouns: *zomrok* (production 5), *satarak* (productions 3 and 7), and *züvek* (productions 3, 7, and 11). The children were then asked to give the accusatives (*zomrot*, *satarat*, and *zuvet*) and then restate the singular (*zomor*, *satár*, *zű*). The sequence was as follows: (1) the child was shown an object and told it was a *zomor*, (2) the child was shown a second exemplar and told that the two were *zomrok*, (3) the experimenter pretended to bite the object and the child was asked what he was biting (*zomort* or *zomrot*), and (4) the child was asked to rename the singular object (*zomor*).

Results

In the singular, *zomor*, *satár*, and *zű* assume their primary allomorphs. In the plural and accusative, they assume their secondary allomorphs (*zomro*, *satara*, *züve*). Correct performance (given in the last column of table 28) re-

TABLE 28

INDUCTION OF AMBIGUOUS FEATURES
(% Responses of Each Type)

Group	Age	No Plural	Primary Accusative and Nominative Singular	Secondary Accusative and Nominative Singular	Secondary Accusative and Primary Nominative Singular
			zomor		
1.....	2-6 to 2-9	80	10	0	10
2.....	3-0 to 3-8	60	0	10	30
3.....	4-9 to 5-1	20	0	20	60
4.....	6-8 to 7-5	10	10	0	80
			satár		
1.....	2-6 to 2-9	70	10	20	0
2.....	3-0 to 3-8	60	10	20	10
3.....	4-9 to 5-1	30	10	10	50
4.....	6-8 to 7-5	10	70	10	10
			zű		
1.....	2-6 to 2-9	70	10	20	0
2.....	3-0 to 3-8	60	20	10	10
3.....	4-9 to 5-1	40	0	60	0
4.....	6-8 to 7-5	0	40	30	30

quires use of the secondary allomorph in the accusative and the primary allomorph in the singular. The main finding of significance in table 28 is that the two older groups show significantly more correct performance on *zomor* than the two younger groups.

Discussion

These data suggest that 5-year-olds can search ongoing discourse, isolate allomorphs, and use these allomorphs together with allomorph selection productions to produce new inflected forms. These findings confirm claim 13 of the dialectical model. However, there is also evidence that this ability does not extend equally to all allomorphic pairs at this age. In the case of *zomor-zomr*, articulation of the /mr/ cluster is inhibited by a predisposition to break up such clusters. Thus a citation use of the allomorph *zomor* is favored by natural phonological factors. In the cases of *satár-satara* and *zű-züve*, on the other hand, both allomorphs are equally pronounceable. More work using a larger variety of stimuli and methods is needed to give a more accurate picture of abilities in this area.

IV. THE ACQUISITION OF FINNISH MORPHOPHONOLOGY

Several millennia ago the speakers of proto Ugro-Finnic split into two groups. One of these two groups gave rise to the Ugric languages, like Hungarian, Chuvash, and Cheremiss. The other group gave rise to the Finnic languages, like Finnish, Estonian, and Lappish. Despite the antiquity of the divergence of Finnish and Hungarian, the morphophonological systems of the two languages display striking similarities. Perhaps the most remarkable overlap is between the Finnish fronting harmony pattern (production 1) (Lehtinen 1963) and the Hungarian fronting harmony pattern (production 10 of Chap. III).

$$\text{Production 1: } \begin{bmatrix} +\text{front} \\ +\text{vocalic} \end{bmatrix} [+\text{ consonantal}]_n + \text{X} \left\langle \begin{bmatrix} +\text{vocalic} \\ +\text{front} \\ \text{X} \end{bmatrix} \right\rangle$$

$$\text{Example: kauppa} + \left\langle \begin{matrix} \text{ssa} \\ \text{ssä} \end{matrix} \right\rangle \rightarrow \text{kaupassa}$$

A historical relation can also be traced between the Hungarian rule of final vowel insertion (production 7 of Chap. III) and the Finnish rule of final vowel deletion (production 2).

$$\text{Production 2: } \begin{bmatrix} +\text{vocalic} \\ +\text{low} \\ \cdots \end{bmatrix} \rightarrow \phi \,/\, \_\_ + \text{i}$$

$$\text{Example: kuiva} + \text{in} \rightarrow \text{kuivin}$$

The most fully developed aspect of Finnish morphophonology is the system of "consonant gradation." This system has few parallels in Hungarian morphophonology apart from, perhaps, rules like v-assimilation (productions 12 and 13 of Chap. III). Productions 3 and 4 illustrate the consonant gradation patterns relevant to the present study.

$$\text{Production 3: } [+\text{long}] \rightarrow [-\text{long}] \,/\, \_\_\_ \begin{bmatrix} +\text{vocalic} \\ -\text{long} \end{bmatrix} [+\text{consonantal}]$$

Example: kauppa + ssa → kaupassa

$$\text{Production 4: } [\text{p}] \rightarrow [\text{v}] \,/\, \_\_\_ \begin{bmatrix} +\text{vocalic} \\ -\text{long} \end{bmatrix} [+\text{consonantal}]$$

Example: leipä + n → leivän

One final pattern is relevant here. This pattern changes [t] to [s] before suffixes beginning in [i].

$$\text{Production 5: } [\text{t}] \rightarrow [\text{s}] \,/\, \_\_\_ \begin{bmatrix} +\text{vocalic} \\ -\text{low} \end{bmatrix} [\text{i}]$$

Example: käte + illa → käsillä

Although there are no comprehensive published studies of the acquisition of Finnish morphophonology, Lyytinen (1972) and her colleagues at the University of Jyväskylä have gathered extensive quantities of data in nonce probe tasks. This group has not yet analyzed their data for the learning of specific morphophonological patterns. However, they have provided me with a fragment of their material from which the present analysis was made. The data included their pretests of 24 3-year-olds, 24 4-year-olds, and 24 5-year-olds. Each child was asked to produce 42 nonsense inflections. Because Lyytinen accepted the children's first answers whatever their nature, most of the responses were not really attempts to inflect nonsense forms. However, among the relevant responses, the ratio of correct responses to incorrect responses gives some indication of the learning of the rule. Table 29 summarizes the data.

TABLE 29

LYYTINEN'S PRETEST DATA

Production	Age	Correct	Responses (*N*) Incorrect	Responses (*N*) Irrelevant	Total	% Relevant Responses That Were Correct
1.....	3	15	0	225	240	100
	4	68	0	182	240	100
	5	138	0	102	240	100
2.....	3	0	2	70	72	0
	4	6	13	53	72	31
	5	7	9	56	72	44
3.....	3	22	7	235	264	76
	4	69	17	178	264	80
	5	101	25	138	264	80
4.....	3	2	2	20	24	50
	4	2	2	20	24	50
	5	4	6	14	24	40
5.....	3	6	1	41	48	85
	4	36	1	11	48	97
	5	40	5	3	48	88

The absence of any errors in production 1 for fronting harmony indicates that, like Hungarian children, Finnish children learn this production before age 3. Productions 3 and 5 are generally correct even from age 3, although a small proportion of errors continues to age 5. Production 3 is high in applicability. The number of inflected forms subject to this production is certainly very high. Thus the early acquisition of both production 1 and production 3 can be attributed to applicability and confirms claim 11. The early acquisition of production 5 is more puzzling.

The later acquisition of productions 2 and 4 can be attributed to their lesser applicability. Although a large number of roots are subject to production 2, each of these roots uses production 2 with only one suffix. Production 4, on the other hand, is limited in applicability because the number of roots it affects is small.

Thus, these highly preliminary data on the acquisition of Finnish morphophonology generally support the dialectic model. The child first learns the rules that are most highly applicable, in accord with claim 11. However, the early acquisition of production 5, if confirmed by further research, could constitute a piece of data tending to falsify claim 11.

V. THE ACQUISITION OF GERMAN MORPHOPHONOLOGY

There are four major areas of interest in German morphophonology: past participle formation, noun declension, article declension, and adjective declension. The first part of this chapter examines each of these four areas and summarizes the relevant research literature on their acquisition. Following this, two experiments on the learning of German morphophonology are presented.

PREVIOUS RESEARCH

Past Participle Formation

Most German verbs form the past participle by taking the root and then adding the prefix *ge-* and the suffix *-t*. Thus, the root *kleb* forms the past participle *geklebt*. Verbs following this pattern are members of the "weak" or regular conjugation. Irregular or "strong" verbs use *-en* in place of *-t* and show various alterations of the root.

There is some evidence that children encounter particular difficulty in learning to add the prefix *ge-* to the past participle. Cornioley (1935) found no use of *ge-* until age 3-0. Walter (1975) detected sporadic errors in the use of *ge-* into the early school years. Park (1971b) argues that the prefix is acquired late because it has no "specific semantic function." However, this is not strictly true, since the distinction between, say, the infinitive *sehen* and the participle *gesehen* is directly marked by *ge-*. Thus, it would be more accurate to say that the semantic content of the prefix is partially redundant with the semantic content of both the auxiliary and the suffix of the past participle. In effect, the auxiliary, the prefix, and the suffix form a discontinuous morpheme. Both the prefix and the suffix are subject to allomorphic variation dependent on cycle 5 patterns. The shape of the auxiliary, on the other hand, is not dependent on the shape of the root. Although the auxiliary enters only after age 3-0 (Park 1971b; Preyer 1882), it is the first form to express perfectivity. This finding supports claim 9 which states that the child will learn

first that part of a discontinuous morpheme which is subject to the most easily controlled allomorphic variation. The situation in English (Brown 1973, p. 319) is quite parallel. There the auxiliary is acquired before the suffix of the past participle. English, however, has no participial prefix.

Several observers have credited the child with use of the past participle before it is formally present. For example, Park (1971b) interprets *Vöglein funde* as *ich habe ein Vöglein gefunden.* "I have found a birdie." However, without the auxiliary *habe* and the prefix *ge-* there is little evidence that *funde* is a participle. This criticism applies to the observations of Bergmann (1903) at 4-0, Neugebauer (1915) around 2-3, Park (1971a) at 3-1, and Preyer (1882) at 2-6. What is needed here is evidence that the "strong" participle root *fund* tends to occur when the past perfect is semantically appropriate and that the present tense root *find* tends to occur when the present is semantically appropriate.

It is possible to examine participle formation in a way which does not rely on semantic data. First, one can examine the source of the root of the participle. For example, in the incorrect form *gegeht* (for *gegangen*) the root is *geh.* The form *geh* ("Go!") can be acquired as a cycle 1 intonational unit. Because it has no affixes, it is a citation form of the verb. Its use in overgeneralizations is therefore a confirmation of claim 7 (first root allomorph). Most of the diarists report that when the required form is some irregular secondary allomorph, nearly all overgeneralizations are of the citation allomorph, as in *gegeht* for *gegangen.* Such overgeneralizations are reported by Lindner (1898) from 2-3 to 2-9, Preyer (1882) from 2-5 to 2-6, Schädel (1905) at 3, Scupin and Scupin (1907, pp. 160–169; 1910, pp. 80, 110) from 2-9 to 4-4, Stern and Stern (1928/1965) from 2-6 to 3-0, and by Leopold (1949) in his English-German bilingual daughter from 4-0 to 5-0. Nearly identical overgeneralizations for English verbs are reported by Leopold (1949) and O'Shea (1907, p. 94). Lindner (1898) notes that, by the age of 2, his son Hans was correcting himself for errors of this type. Only Neugebauer (1915) reports, from 2-2 to 2-4, a significant number of overgeneralizations of irregular roots when regular roots are required. In all the forms reported by Neugebauer, the child erroneously used [o] as the vowel of the root. The forms reported by Neugebauer are not overgeneralizations of secondary allomorphs. Rather, they are overgeneralizations of a weak nonproductive pattern to roots not subject to that pattern. Such early overgeneralizations of a rare cycle 4 pattern are not in accord with the model offered in this paper. If Neugebauer's findings were found to be reliable and general, the model would have to be modified.

The only report of any significant overgeneralization of secondary (usually past tense) allomorphs is from Scupin and Scupin (1910, pp. 113, 126). They found that, between 4-4, and 4-7, their son Bubi began to use past tense allomorphs in the present. This seems to be a case of a phenomenon

that Slobin (1966; 1973, p. 205) has called "inflectional imperialism" and which is given as claim 15 of the model. At first the present-tense citation allomorphs are generally applied until correction decreases their strength. Then the child makes a short-lived attempt to apply the secondary allomorphs, and again correction intervenes. Finally the allomorph selection is controlled by a cycle 4 production. The initial use of the most general allomorphs supports claim 10 (first affix allomorph) while the later overgeneralization of secondary allomorphs supports claim 15. Such overgeneralization of secondary allomorphs occurs only when attempts to use cycles 3 and 4 productions have met with failure.

The second way of examining participle formation is to observe the choice of either the common allomorph *-t* or the less common allomorph *-en* as a suffix. Although *-en* is the suffix used with all irregular verbs, there is no reason to view *-t* as somehow more regular than *-en*. Rather *-t* occurs with one large class of less common verbs, and *-en* occurs with another, smaller class of very common verbs. The overall frequency of the two allomorphs is roughly equal. Moreover, the diary data indicate that both *-t* and *-en* are overgeneralized with roughly equal frequency. (Compare the discussion in Chapter VI of Zwicky's [1970] observations on English *-en*.) Thus, it appears that the strength of these allomorphs reflects their frequency in the input, as suggested by claim 10 (first affix allomorph).

Noun Declension

The second area of interest in German morphophonology is noun declension. Here attention has centered primarily on plural formation, which is the principal area of formal complexity (Antonsen 1973). Plurals (Grebe 1973, 188–694) are formed by suffixing *-e*, *-er*, *-(e)n*, *-s*, or ϕ to the singular. Additionally, some plurals require umlauting of the first vowel of the root. Umlauting results in *a* → *ä*, *o* → *ö*, *u* → *ü*, and *au* → *äu*. Other vowels are not affected. Eight productions may be offered to aid in choice of a plural form. Two of these are allomorph selection productions which can be stated in purely phonological terms.

Production 1—roots ending in /e/ or /ai/ add *-n:*

$$\begin{bmatrix} +\text{vocalic} \\ -\text{high} \\ -\text{low} \end{bmatrix} + \begin{Bmatrix} \text{n*} \\ \text{X} \end{Bmatrix}$$

Example: Tante → Tanten

Production 2—roots ending in vowels other than /e/ or /ai/ add *-s:*

$$\begin{bmatrix} +\text{vocalic} \\ +\text{high} \\ +\text{low} \end{bmatrix} + \begin{Bmatrix} \text{s*} \\ \text{X} \end{Bmatrix}$$

Example: Auto → Autos

Three other productions specify the use of a given plural allomorph after specific formative suffixes.

Production 3—roots ending in *-ling*, *-nis*, *-oss*, or *-ich* add *-e:*

$$\left\{\begin{matrix} \langle \text{ling} \rangle \\ \langle \text{nis} \rangle \\ \langle \text{oss} \rangle \\ \langle \text{ich} \rangle \end{matrix}\right\} + \left\langle \begin{matrix} \text{e}* \\ \text{X} \end{matrix} \right\rangle$$

Example: Teppich → Teppiche

Production 4—roots ending in *-heit*, *-keit*, *-schaft*, *-in*, and *-ung* add *en:*

$$\left\{\begin{matrix} \langle \text{heit} \rangle \\ \langle \text{keit} \rangle \\ \langle \text{schaft} \rangle \\ \langle \text{in} \rangle \\ \langle \text{ung} \rangle \end{matrix}\right\} + \left\langle \begin{matrix} \text{en}* \\ \text{X} \end{matrix} \right\rangle$$

Example: Regierung → Regierungen

Production 5—roots ending in *-chen*, *-lein*, *-le*, *-sal*, and *-erl* add ϕ:

$$\left\{\begin{matrix} \langle \text{chen} \rangle \\ \langle \text{lein} \rangle \\ \langle \text{le} \rangle \\ \langle \text{sal} \rangle \\ \langle \text{erl} \rangle \end{matrix}\right\} + \left\langle \begin{matrix} \phi* \\ \text{X} \end{matrix} \right\rangle$$

Example: Mädchen → Mädchen

Each of these first five productions has no more than a few exceptions.

Two other productions are based on formal word class (gender) membership as well as phonological properties.

Production 6—most masculine and all neuter roots ending in /el/, /en/, and /er/, add umlauting:

$$\left[\begin{matrix} \left\{\begin{matrix} +\text{class } 1 \\ +\text{class } 3 \end{matrix}\right\} \\ \text{X e} \left[\begin{matrix} +\text{consonantal} \\ -\text{obstruent} \end{matrix}\right] \end{matrix}\right] + \left\langle \begin{matrix} \text{umlaut}* \\ \text{X} \end{matrix} \right\rangle$$

Example: Brüder → Brüder

Production 7—a few masculine and all feminine roots ending in /e/, /en/, and /er/ take *-n:*

$$\left[\begin{matrix} \left\{\begin{matrix} +\text{class } 1 \\ +\text{class } 2 \end{matrix}\right\} \\ \text{X e} \left[\begin{matrix} +\text{consonantal} \\ -\text{obstruent} \end{matrix}\right] \end{matrix}\right] + \left\langle \begin{matrix} \text{n}* \\ \text{X} \end{matrix} \right\rangle$$

Example: Gabel → Gabeln

Finally, there is one cycle 3 allomorph modification production which deletes /e/ after vowels and liquids. This production applies not just to the plural but also to several other affixes.

Production 8: [e] → ϕ / [+vocalic] + ___

Example: Watte + en → Watten

Together these eight productions can assist the child in forming a large number of plurals. However, many of the most common plurals are not covered by these productions and must be learned by rote.

Several of the German diary studies report observations of the first uses of the plural. Lindner (1898) demonstrated the extreme lability of the few plural forms emerging around 2-0. At 1-10, under spontaneous conditions, his son Hans referred to his garters (*Strumpfbänder*) as *Bänder*. However, when specifically asked "What are these?" he replied in the singular *Band*. This error pattern suggests that the lexical encoding of *Bänder* as plural is either incomplete or inaccessible in the context of elicited use. These data support claim 4 (insulation) which holds that when children are forced to use forms outside of context there will be an increase in overregularization. This is because the child relies heavily on context as a cue to the location of weak rote forms.

Some months later, toward the middle of the third year, children begin to acquire a larger stock of plurals. Preyer (1882) found the first plurals at 2-6. Stern and Stern (1928/1965) report correct plurals in the third year. Scupin and Scupin (1910) report frequent overgeneralizations of -(*e*)*n* at 3-0 (p. 4) and of -*s* (p. 133) at 5-8. Researchers who have observed spontaneous monolingual speech (Schädel 1905, p. 102; Stern & Stern 1928/1965) report few errors in plural formation. However, using a Berko test, Park (1971a, 1971b) found a number of errors at 3-1 to 3-4, although none at 4-2. The five errors reported by Park include violations of productions 1 and 8. The other study reporting plural errors in the fourth year is Leopold's study of his bilingual daughter. Between 2-7 and 3-3 she apparently overgeneralized the English plural -*s* to many German words not taking -*s*.

The most detailed study of plural formation is a nonce test conducted by Walter (1975) in Heidelberg. Walter examined 135 subjects from eight age groups: 2-6 to 3-0, 3-1 to 3-6, 3-7 to 4-0, 4-1 to 4-6, 4-7 to 5-0, 5-1 to 5-6, 5-7 to 6-0, and 24-0 to 25-0. The stimuli included five nouns subject to production 2, five subject to production 3, five subject to production 6, five subject to production 4 or 7, and five subject to no production but taking -*er*. Each group of five contained two real nouns and three nonsense nouns. The use of articles with the nouns indicated to the subjects the gender of the nouns.

Although Walter's results are complex, the following generalizations can be offered for the seven groups of children:

1. For all groups, overgeneralizations of ϕ far exceed all other error

types combined. Unfortunately, there is no guarantee with such forms that the child is actually attempting to provide a plural.

2. Performance on the real nouns improves steadily between 2-6 and 6-0. Common plurals like *Autos* (cars) and *Bücher* (books) cause fewer errors than infrequent plurals like *Löwinnen* (lions). Such findings support the role of rote and claim 1.

3. The suffixes *-e* and *-(e)n* are used to form real and nonce plurals at all ages. Although these suffixes are productive throughout, there is no clear evidence that selection of one suffix over another is rule governed.

4. The suffix *-s* has a fairly irregular acquisition. It is absent at 2-6 to 3-0, heavily used at 3-1 to 3-6, nearly absent at 3-7 to 4-0, and present from 4-1 to 6-0. However, even by 6-0 its use is not fully productive by production 2.

5. Even by 6-0 there is little evidence of any use of production 3, although the prevalence of ϕ formations may confound this result.

6. Production 4 for *-in* is not used before 6-0.

7. Production 7 for *-er* is not used before 6-0. There is some apparent use of production 7 for *-el* (*Sabel* → *Sabeln*) from 4-1. However, Walter (1975) included a close real analog for *Sabel* (*Gabel*) but no such close analog for *Fauer*. Thus, performance on *Sabel* may be more influenced by analogy.

8. Production 8 is never violated.

In summary, Walter's results indicate that rote memorization plays a very large role in acquiring German plurals. This finding supports several claims of the dialectic model. First, the early acquisition of production 8 supports claim 11 (production applicability). This production applies to all roots ending in vowels or liquids followed by /e/. It applies in noun, adjective, and verb morphology. Because it is so highly applicable, it is acquired early. Second, the late acquisition of the other seven productions supports the part of claim 11 which holds that productions will be acquired early only if they apply correctly to a large number of combinations. These seven productions admit too many exceptions to permit early acquisition. Third, the fact that common plurals are correct more often than less common plurals supports claim 4 (insulation) which holds that the children are more likely to use rote for frequent forms than for less frequent forms.

Article Declension

The third area of interest in German morphophonology is article declension. The paradigm for the two articles is given in table 30. In order to select a definite article, a German speaker must know the case, number, and gender of the noun. Case and number are given by the semantics and syntax of the utterance. Although there are occasional clues and cryptoclues to semantic gender (Grebe 1973, pp. 150–158), gender is essentially a formal property of each noun.

TABLE 30

GERMAN ARTICLE DECLENSION

	Singular			Plural
	Masculine	Feminine	Neuter	Masculine~Feminine~Neuter
			Definite Article	
Nominative....	der	die	das	die
Genitive.....	des	der	des	der
Dative.....	dem	der	dem	den
Accusative.....	den	die	das	die
			Indefinite Article	
Nominative....	ein	eine	ein	...
Genitive.....	eines	einer	eines	...
Dative.....	einem	einer	einem	...
Accusative.....	einen	eine	ein	...

There seem to be at least two ways that the child could learn to control these patterns. The first way makes use of a system of positional associations much like Braine's (1963) contextual generalization. This system would be composed of classes of items that tend to co-occur with similar items. Thus, *der* (nominative), *des* (genitive), and *einem* (dative) all occur before nouns like *Mann*, *Spiegel*, and *Soldat*. At the same time, *Mann*, *Spiegel*, and *Soldat* all occur after *der*, *des*, and *einem*. These positional regularities allow the child to establish classes. Thus *Mann*, *Spiegel*, and *Soldat* would all be placed in one class. Similarly, *der*, *des*, and *einem* would all be placed in a class. Choice of *der* as an allomorph of the nominative article would then be based on the class of the following noun.

The dialectic model provides a somewhat different account of paradigm learning. The details of this processing were given in the discussion of cycle 5 in Chapter II and are indicated also in the flow charts of Appendix A. Both the dialectic model and contextual generalization assume that the child first learns *article* + *noun* associations. In the dialectic model these associations are called amalgams. Both accounts also assume that the child relates articles on the basis of their co-occurrence with the same noun. In the dialectic model these relations are called implications. In contextual generalization they are the beginnings of positional classes.

The fundamental difference between the two accounts is in the nature of the classes established. In contextual generalization only items occurring in the same syntactic position can be members of the same class. In the dialectic model items which imply each other, regardless of syntactic position, can be members of the same class. Thus, the pronoun *ihn* implies the article *der* (nominative) even though *ihn* does not occur before the noun. Claim 14 of the dialectic model focuses on this difference between the two approaches.

The German child language literature provides only scant information on the learning of article declension. Preyer (1882) reports the first definite articles at 2-6 and the first indefinite articles at 2-7. Scupin and Scupin (1907, pp. 122, 123, and 127) report the first definite article at 2-1. Between 2-1 and 2-4 article use was largely incorrect. From 2-4 errors in article use decreased. The Sterns (1928/1965) report that Hilde, their daughter, used the indefinite article before the definite but give no date for the emergence of either. However, they note that their son, Gunther, used his first indefinite at 2-4. Lindner (1898, p. 52) reports the first definite articles at 2-0. Leopold (1949) reports that his bilingual daughter only made frequent use of articles from 4-4. Park (1971a) found no articles at all between 2-6 and 2-9.

When articles do finally enter, their gender is often correct. The Sterns report few gender errors at 3-0, and Park (1971a) cites few gender errors. This suggests that at this time children may well be picking up nouns with articles as amalgams. The possibility that some amalgams have articles is supported by Lindner's (1898, p. 64) observations on article reduplication at 2-4, as in *mit ein das Messer* ("with a the knife"). Such errors have not, to my knowledge, been reported for English. They resemble the suffix reduplications made so often by Hungarian children and indicate that, for example, *das Messer* could be an amalgam. An exception to the general tendency in the fourth year to mark gender correctly is reported by Scupin and Scupin (1910, p. 50). Their son's first dative was *'m* (= dem) at 3-6. It was used at first for all genders, including the feminine which requires *der*. This overgeneralization of the most frequent allomorph supports claim 10 (first affix allomorph).

Although gender errors are rare, case errors are not. Overgeneralization of the nominative for the other cases is reported by Park (1971a) at 3-1 to 3-4, by Stern and Stern (1928/1965) at 3-0, and by Lindner (1898) at 2-6. The nominative and accusative are nonidentical only for masculine nouns, and it is for these that many such overgeneralizations are observed. Hildegard Leopold developed the reverse pattern between 4-9 and 5-5 according to which the accusative *den* was overgeneralized to the nominative *der*.

The general pattern of development suggested by these results is complex. At first children seem to pick up nouns in their citation form. Up until the second half of the third year most nouns have no articles at all. Thus, articles do not seem to be parts of the earliest amalgams. This is in accord with claim 6 (intonational packaging) which suggests that intonational unity is the chief initial determinant of the shape of the amalgam. Since the article is unstressed, it is filtered out, and only the noun remains. However, this course of action soon leads to a lack of correctness, and the child starts to focus on the definite article. In fact, Lindner (1898, p. 52) reports that, at 2-0, his son articulated the definite article with unusually heavy stress, as if it were a demonstrative adjective. This increased focus on

the article soon leads to its inclusion in the amalgams being acquired by the child, as Lindner's data suggest. While the child is working out his system of allomorphs, case errors abound. This is because many nouns are acquired as amalgams with the article in only one case.

Adjective Declension

The fourth area of interest in German morphophonology is adjective declension. When not preceded by an article, adjectives take "strong" endings (table 31). When preceded by the definite article they take "weak" endings, and when preceded by the indefinite article they take "mixed" endings.

Lindner reported that at 2-6 his son declined all adjectives, even those following articles, with "strong" endings. Moreover, he used strong endings on the indefinite article itself. Stern and Stern (1928/1965, p. 259) report that the first adjectives entered at 2-0 in "weak" or *-e* form when prenominal and in uninflected form when serving as predicate adjectives. Park (1974) reports the same distinction at 2-0 to 2-2. Schädel (1905, p. 102) reports overgeneralizations of weak forms (chiefly *-e*) even after 4-0. These observations indicate that (*a*) adjectives are first learned in their citation form, as suggested by claim 7 (first root allomorph); and (*b*) the form *-e*, which is the most common allomorph of the modificational suffix, is the first productive form of that suffix, in accordance with claim 10 (first affix allomorph).

However, Stern and Stern (1928/1965, p. 259) report that by 2-6 the

TABLE 31

GERMAN ADJECTIVE DECLENSION

	Singular			Plural
	Masculine	Feminine	Neuter	Masculine~Feminine~Neuter
			Strong	
Nominative....	-er	-e	-es	-e
Genitive.....	-en	-er	-en	-er
Dative.....	-em	-er	-em	-en
Accusative.....	-en	-e	-es	-e
			Weak	
Nominative....	-e	-e	-e	-en
Genitive.....	-en	-en	-en	-en
Dative.....	-en	-en	-en	-en
Accusative.....	-en	-e	-e	-en
			Mixed	
Nominative....	-er	-e	-es	-en
Genitive.....	-en	-en	-en	-en
Dative.....	-en	-en	-en	-en
Accusative.....	-en	-e	-es	-en

strong endings *-es* and *-er* had entered and that by 3-2 Hilde was using all five adjective endings (*-e*, *-es*, *-em*, *-er*, *-en*) appropriately. It is unlikely that children learn to decline each new adjective in all three genders by rote. Rather, they must be learning to attach suffixes to adjective roots. Moreover, suffix selection must involve the same type of learning as article selection. Thus the results of experiment 5 below on the learning of article declension also may be of relevance to the learning of adjective declension.

EXPERIMENT 4: FORMATION OF GERMAN PLURALS

Method

Subjects.—Twenty children were studied in each of three age groups: 3-0 to 4-0, 4-2 to 6-0, and 11-0 to 12-0. In each group, half of the children were girls and half were boys. The children were examined in nurseries and public schools in Göttingen, a university town where High German is spoken.

Stimuli.—The real and nonce words used in this experiment are listed in table 32. Children were asked to form plurals of the 36 nouns in that table. Stimulus pairs 1–6 are masculine, 7–11 are feminine, and 13–18 are neuter. Production 1 is relevant to stimulus pairs 9 and 10. Production 3 is relevant to pair 4. Production 5 is relevant to pairs 15 and 16. Production 6 is relevant to pair 3.

Ordering of stimuli.—Twenty orderings of the 18 real nouns were produced. In each ordering nine of the nonce roots were ordered directly after their real analogs. The remaining nine were placed elsewhere. Each subject

TABLE 32

STIMULI FOR EXPERIMENTS 4 AND 5

Real Noun	Meaning	Plural	Nonsense	Representation
1. der Mann.....	man	Männer	der Gann	samurai archer
2. der Soldat.....	soldier	Soldaten	der Molat	barbapapa doll
3. der Hammer.....	hammer	Hämmer	der Fammer	turtle-like creature
4. der Teppich.....	rug	Teppiche	der Leppich	green man
5. der Korb.....	basket	Körbe	der Norb	orange figure
6. der Baum.....	tree	Bäume	der Faum	dinosaur
7. die Frau.....	woman	Frauen	die Lau	fairy
8. die Kuh.....	cow	Kühe	die Puh	barbapapa doll
9. die Pfeife.....	pipe	Pfeifen	die Neife	june bug
10. die Schweinerei....	mesh	Schweinereien	die Teinerei	noise maker
11. die Hand.....	hand	Hände	die Gand	ichthysaurus
12. die Uhr.....	watch	Uhren	die Muhr	tyranosaurus rex
13. das Kind.....	child	Kinder	das Dind	octopus
14. das Pferd.....	horse	Pferde	das Nerd	stick figure
15. das Scheusal.....	monster	Scheusale	das Heusal	fire engine
16. des Stuhlchen.....	stool	Stühlchen	das Nulchen	robot
17. das Bett.....	bed	Betten	das Rett	kiwi
18. das Glas.....	glass	Gläser	das Schnas	mouselike creature

in a given age group received a different order. This ordering technique is identical to that used in experiment 1.

Procedure.—The procedure was identical to that used in experiment 1. The test question was, *Jetzt sind es zwei*——? ("Now there are two ——?"). No cue regarding the gender of the stimuli was given.

Results

As in experiment 1, the effects of analogy were examined by comparing the plurals of primed nonce roots with those of unprimed nonce roots. The measure used was the number of analogously constructed nonce plurals. A nonce plural was judged to be analogously constructed if it used the same suffix as the plural actually produced by the child for the real analog. Furthermore, it had to make the same use of umlauting. Analysis of variance showed a nearly significant, $F(1,57) = 3.60$, $p < .07$, effect of priming on the number of analogous nonce plurals. The main effect of age was significant, $F(2,57) = 3.38$, $p < .05$. The interaction of age and priming was nearly significant, $F(2,57) = 3.01$, $p < .07$. The nearly significant priming and interaction effects reflect a slight increase in analogous plurals, with the priming condition in the oldest group. The significant effect of age indicates that with age there is an increased tendency to form plurals by analogy whether or not the prime is overtly given.

Performance on the real plurals improves steadily with age. Of the total of 360 plural responses for each age group, the 3-year-olds made 146 errors, the 4–5-year-olds made 70 errors, and the 11-year-olds made 13 errors. This decrease in errors is highly significant, $F(2,57) = 85.10$, $p < .001$. The few errors produced by the 11-year-olds were confined to the plurals of *Hammer* and *Schweinerei*. Instead of the correct forms *Hämmer* and *Schweinereien*, these children formed *Hammer* (7), *Hammere* (1), *Hämmerer* (3), *Schweinerei* (1), and *Schweinereie* (2).

Table 33 summarizes the overgeneralizations of the various plural

TABLE 33

OVERGENERALIZATIONS OF PLURAL ALLOMORPHS IN EXPERIMENT 4
(% Total Responses)

Age	ϕ	*-e*	*-(e)n*	*-er*	*-s*	-	*-e*	*-er*	*-en*
					With Real Nouns				
3-0 to 4-0...	23	6	0	0	4	0	1	1	3
4-2 to 6-0...	6	5	0	0	5	0	0	1	1
11-0 to 12-0.	2	1	0	0	0	0	0	1	0
					With Nonsense Nouns				
3-0 to 4-0...	62	20	2	0	3	0	0	0	0
4-2 to 6-0...	27	16	8	0	9	0	2	2	0
11-0 to 12-0.	7	21	8	2	0	0	3	3	0

allomorphs for real and nonce roots. Analysis of variance for the use of the null allomorph indicates highly significant effects for age, $F(2,57) = 95.02$, $p < .001$, and noun group (real vs. nonce), $F(1,57) = 53.21$, $p < .001$. Use of the null allomorph declines with age but is higher for nonce roots at all ages. Use of *s* as a plural shows significant age differences, $F(2,57) = 13.65$, $p < .001$, and use of -(*e*)*n* occurs significantly, $F(1,57) = 9.72$, $p < .001$, more with nonce roots.

As in experiment 1, the data may be analyzed in terms of the evidence they provide for the learning of individual productions. The criteria are again: *moderately productive*, 50% correct on nonce forms; *fully productive*, 90% correct on nonce forms. This analysis focuses on the nonce plurals, since they provide the clearest evidence of productivity. Table 34 summarizes the percentages of plurals formed in accordance with certain productions at each age. The high percentage of plurals obeying production 4 is probably inflated by the fact that the use of the null allomorph cannot be distinguished from the use of no allomorph. Production 1 seems to be productive for *-e* long before it is productive for *-ei*. Production 3 is moderately productive by age 6.

Discussion

The results of experiment 4 agree quite closely with the findings of Walter (1975). Table 35 summarizes the data from both studies. Asterisks mark data points taken from Walter. The other data points are from experiment 4. Tables 35 and 36 are constructed like tables 7 and 27 for Hungarian. Unfortunately, the data are not straightforward on productions 5 and 6. Evaluation of the productivity of use of the null allomorph on these two productions must take into consideration the fact that use of the null allomorph in experiment 4 (table 34) and in Walter (1975) was much higher for nonce roots than real roots. Thus, if productions 5 and 6 were productive, the use of the null allomorph on items within their domain would have to be clearly above this baseline use of the null allomorph. The ages for acquisition of productions 5 and 6 in table 35 reflect this more conservative estimate. Also, productivity of production 3 must be estimated in a similar conservative

TABLE 34

% PLURALS OBEYING CERTAIN PRODUCTIONS

Production	Item	3-0 to 4-0	4-2 to 6-0	11-0 to 12-0
1.....	Neife	60	90	95
1.....	Teinerei	0	15	55
3.....	Leppich	20	70	80
4.....	Nulchen	90	100	100
4.....	Heusal	20	50	80
6.....	Fammer	0	0	20

TABLE 35

AGES OF GERMAN PLURAL PRODUCTION ACQUISITION

Production	Fully Productive	Moderately Productive	Fully Learned	Moderately Learned
1*a* (-e)	4-2	3-0	3-0	3-0
1*b* (-ei)	24-0[a]	11-0	11-0	4-2
2	NDOP[a]	24-0[a]	~8-0[a]	4-1[a]
3*a* (-ich)	NDOP	11-0	11-0	4-2
3*b* (-ling)	24-0[a]	24-0[a]	24-0[a]	5-7[a]
4 (-in)	24-0[a]	24-0[a]	24-0[a]	24-0[a]
5*a* (-chen)	11-0	4-2	4-2	4-2
5*b* (-sal)	NDOP	11-0	11-0	11-0
6	24-0[a]	24-0[a]	11-0	4-2
7	NDOP	24-0[a]	24-0[a]	6-0[a]
8	3-0	3-0	3-0	3-0

NOTE.—NDOP = not acquired at this level during the observational period.
[a] Data from Walter (1975); other data are from experiment 4.

TABLE 36

GERMAN PLURAL PRODUCTIONS ORDER OF APPLICABILITY AND ORDER OF ACQUISITION

Production	Applicability	Order of Applicability	Order of Acquisition
1*a*	Nearly all roots in -e (15.8)[a]	2	2
1*b*	All roots in -ei (.8)	7	4
2	Roots in other vowels (1.4)	6	10
3*a*	Roots in -ich (.14)	9	5
3*b*	Roots in -ling (.14)	10	8
4	Roots in -in (.57)	8	7
5*a*	Roots in -chen (1.4)	5	3
5*b*	Roots in -sal (.02)	11	6
6	Masculine and neuter roots in -el, -en, -er (~7.2)	3	9
7	Feminine and some masculine roots in -el, -en, -er (~1.4)	4	11
8	Roots that end in consonants before various suffixes including the plural -(e)n	1	1

[a] *N*'s in parentheses indicate % of the total vocabulary in the inverse dictionary by Mater (1965) ending in these sounds. The figures for noun roots alone are somewhat lower.

manner, since children at all ages show a high overgeneralization rate for *-e* (table 33).

Only three productions in table 36 are of even moderate applicability. These are productions 1*a*, 6, and 8. Moreover, none of these productions, except for 8, apply outside of the plural. Thus, the situation in German is quite different from the situation in Hungarian. In Hungarian many of the productions apply to large portions of the vocabulary. There are a few productions that apply to small numbers of roots. However, these apply to a large number of suffixes occurring with these roots. In view of these facts on applicability, it is not surprising that only two productions are fully productive before 11-0. These are the only two correct and applicable produc-

tions of German plural formation—productions 1*a* and 8. This is a strong confirmation of claim 11 (production applicability).

Calculations of the number of roots with endings relevant to productions 1–7 were made on the basis of the data in Mater's (1965) inverse dictionary for German (see table 36). According to these estimates, productions 2, 5*a*, 6, and 7 are at the next level of applicability. Of these, only production 5*a* is acquired before adulthood, because it is fully correct. Two others, productions 6 and 7, admit many exceptions even in adults. These findings provide further support for claim 11. On the other hand the late acquisition of production 2 cannot be solely attributed to its lack of correctness. Rather, it seems that production 2 is actually a cover term for separate productions for the endings *-a*, *-ai*, *-au*, *-ee*, *-i*, *-eu*, *-o*, and *-u*. Direct confirmation of this conjecture will require further detailed work with a variety of vowel-final nonce roots.

None of the remaining productions are fully productive in childhood. The data on their productivity in adulthood generally match their order of applicability, although production 5*b* for *-sal* is moderately productive earlier than its extremely low applicability would indicate. Nonetheless, it does enter significantly later than production 5*a* for *-chen*, indicating that even here claim 11 is relevant.

EXPERIMENT 5: MARKING OF GENDER BY THE DEFINITE ARTICLE

Method

Subjects.—The subjects of experiment 4 also participated in this experiment: 20 children in each of three age groups: 3-0 to 4-0, 4-2 to 6-0, and 11-0 to 12-0.

Stimuli.—The roots listed in table 32 were the stimuli in this experiment. Nominative definite articles were elicited in three different conditions. In the first condition, the experimenter showed the child the toy and said, *Dieses Spielzeug heisst X* ("This toy is called *X*"). The symbol *X* stands in the place of the real or nonce root. Taking the nonce root *Gann* as an example, the statement was, *Dieses Spielzeug heisst Gann.* This is called the no-clue condition, since it gives the child no overt clue regarding the gender of the noun. The second condition is the article-clue condition, since an article gives the child a clue to the root gender. The statement was, *Ich nehme ein* [*eine*, *einen*] *X in die Hand* ("I'm picking up an *X*"). If the article is *ein*, the child can deduce that the noun must be neuter. If it is *eine*, it must be feminine. If it is *einen*, it must be masculine. The third condition was the pronoun-clue condition. Here the statement was, *X. Ich nehme es* (*sie*, *ihn*) *in die Hand* ("*X*. I'm picking it up"). Here the pronoun (he, she, it) gives unambiguous information regarding gender.

In all three conditions, the probe technique was the same. The toy was

hidden under the table, and the experimenter said, *Wie fragst du? Wo ist . . . ?* ("How do you ask? Where is . . . ?"). The child should respond with, for example, *Wo ist der Gann?* Thus his answer must use the nominative definite article and must therefore reveal the gender to which he assigns the root. All children gave responses to all roots in all conditions.

Inspection of table 32 reveals that, of the real nouns, six were masculine, six were feminine, and six were neuter. Within the three gender groups, two nouns had real or inherent semantic gender (*Mann*, *Soldat*, *Frau*, *Kuh*, *Kind*, *Pferd*). Two roots had phonological endings which served as clear cues for their gender (*Hammer*, *Teppich*, *Pfeife*, *Schweinerei*, *Scheusal*, *Stühlchen*). The gender of the other six real roots was quite arbitrary. As in experiments 1, 2, and 4, roots were presented either in pairs (primed) or separately (unprimed).

The design of the experiment thus involves six crossed factors. Factor 1 is age with three levels. Factor 2 is semanticity with two levels; real or nonce. Factor 3 is overt cueing with three levels: no clue, article clue, and pronoun clue. Factor 4 is root gender with three levels: masculine, feminine, and neuter. Factor 5 is covert cueing with three levels: semantic cue, phonological cue, and no clue. Factor 6 is priming with two levels: primed, and unprimed. One of the two nouns within each factor 3 $\times$ factor 4 $\times$ factor 5 combination was primed, and the other was unprimed. Subjects were nested within age.

Results

There were significant main effects for age, $F(2,57) = 78.79, p < .001$, semanticity $F(1,57) = 710.06, p < .001$, and overt cueing $F(2,114) = 93.40$, $p < .001$. Older children performed better than younger children; real roots were easier than nonce roots; and the use of either type of overt cueing was better than no cueing at all. The patterns of responses on the two different cueing conditions—pronoun and article—were nearly identical. The main effects of noun gender, covert cueing, and priming were not significant.

Several of the two-way interactions were significant. The age $\times$ semanticity interaction was particularly strong, $F(2,57) = 142.59, p < .001$. Nonce roots were handled relatively better by older children. The age $\times$ overt cueing interaction was significant, $F(4,114) = 3.66$, $p < .01$. Overt cueing was more effective for older children than younger children. The age $\times$ noun gender interaction was significant, $F(4,114) = 14.52$, $p < .001$. This was due to the increased use of the neuter article *das* with age. The semanticity $\times$ overt cueing interaction was fairly strong, $F(2,114) = 89.43$, $p < .001$. Cueing was more effective for nonce roots than for real roots. Similarly, the semanticity $\times$ covert cueing interaction was significant, $F(2,114) = 31.14, p < .001$. This was primarily due to the increased use of phonological cues for the gender of nonce roots. The noun gender $\times$ covert cueing inter-

action was significant, $F(4,228) = 13.14$, $p < .001$. Covert semantic and phonological cues were relatively less effective for masculine roots. Finally, the semanticity × covert cueing interaction was significant, $F(2,114) = 31.14$, $p < .001$. The phonological cues were of relatively greater importance for determining nonce gender.

There were eight significant three-way interactions. These are all readily interpreted. The significant, $F(4,114) = 15.13$, $p < .001$, age × semanticity × overt cueing interaction can be interpreted by noting that overt cueing was particularly helpful to older children asked to produce nonce genders. The significant, $F(4,114) = 10.16$, $p < .001$, age × semanticity × covert cueing interaction can be interpreted by noting that phonological rules were particularly helpful to older children faced with the task of producing genders for nonce nouns. Similarly, the significant age × semanticity × priming interaction, $F(2,57) = 10.97$, $p < .001$, indicates that priming was particularly helpful to older children working with nonce gender. The significant, $F(4,228) = 15.88$, $p < .001$, semanticity × overt cueing × covert cueing interaction can be interpreted by noting that phonological cues were particularly effective when there was no overt cue to nonce gender. The significant, $F(4,28) = 13.70$, $p < .001$, semanticity × noun gender × covert cueing interaction can be interpreted by noting that phonological cues for nonce gender were most effective for feminine nouns. The significant, $F(4,114) = 5.58$, $p < .01$, age semanticity × noun gender interaction can be interpreted by noting that older children tended to overgeneralize the neuter *das* particularly often with nonce roots. Related to this is the significant, $F(8,228) = 6.93$, $p < .001$, age × overt cueing noun gender interaction which is attributable to the tendency of older children to make more use of *das*, particularly when no overt cue was given. Also related is the significant, $F(4,228) = 14.52$, $p < .001$, semanticity × overt cueing × gender interaction which can be interpreted by noting that, for nonce nouns, the absence of an overt cue led to relatively fewer errors in the neuter.

There were two significant four-way interactions. Both involved the tendency of older children to make use of all available cues when no overt cues are given for nonce gender. The significant, $F(8,228) = 5.78$, $p < .01$, age × semanticity × overt cueing × covert cueing interaction is related to increased use of phonological cues in this case, and the significant, $F(4,114) = 12.76$, $p < .001$, age × semanticity × overt cueing × priming interaction is related to increased use of priming cues in this case. None of the five-way interactions were significant.

Discussion

The results of this study support three claims of the dialectic model. First, there is clear support for claim 1 (goal stack). Children at all ages rely on the use of rote forms whenever possible. When rote fails, even the youngest

group shows some ability to utilize overt cues to gender in terms of a cycle 5 system of implications. Analogy is utilized by the older children only when rote and combination have been unsuccessful. These results also agree with the results of experiment 1 in which analogy was seen to play a decidedly minor role in morphophonological productions. However, in experiment 1, analogy was used by 2-year-olds and 6-year-olds, whereas 3-year-olds and 4-year-olds seemed to use almost no analogy at all. In experiment 5, on the other hand, use of analogy increased with age. It would seem that analogy is available as a strategy at all ages but that its use at a given age depends largely on the structure of the language. Use of analogy leads to fewer errors in Hungarian than in German. Thus young Hungarian children may rely more on analogy than young German children (claim 11). Older children may make use of analogy once they have exhausted the rule-governed regularities of their language (claim 1).

Second, use of phonological cues to gender enters rather late. Such cues are often incorrect and their late acquisition tends to support claim 11. If the child is to make use of phonological cues to gender, he must already have developed a system which selects article allomorphs on the basis of noun gender. In order to classify nouns by gender, he must already have at least the beginnings of a system of implications. Thus use of phonological cues to gender cannot emerge before the use of overt cues to gender. Moreover, because phonological cues are often incorrect, they will tend to be acquired later. Covert semantic cues to gender are of such limited applicability and admit so many exceptions that the child makes no use of them at all. Similar observations have been made by Popova (1958/1973) for Russian gender.

Third, this investigation supports claim 14, which holds that children who can use affix information regarding the class membership of a root will also be able to use information not directly affixed to the root. In this experiment, the effects of overt cueing with an article were not significantly different from the effects of overt cueing with a pronoun. Articles occurred directly before roots as does *einen* in (11), whereas pronouns occurred in separate clauses, as does *es* in (12).

Ich nehme einen X in die Hand. (11)

X. Ich nehme es in die Hand. (12)

The possible contexts which can intervene between the pronoun *es* in (12) and its referent *X* are potentially infinite. Because of this, the gender of the nonce root in (12) cannot be inferred from contextual generalization. The fact that 3-year-olds can use both pronouns and articles as cues to gender indicates that their behavior cannot be explained only by reference to contextual generalization. Rather, they appear to have developed a system of implications much like those proposed in cycle 5 of the dialectic model.

VI. THE ACQUISITION OF MORPHOPHONOLOGY IN SEVEN OTHER LANGUAGES

ENGLISH

The English plural, possessive, and third-person singular present-tense suffixes are homonymous. Each of them has the three allomorphs, /s/, /z/, and /ɨz/. Selection of one of these three allomorphs depends on the nature of the final segment of the root. Table 37 summarizes the co-occurrence possibilities for these three suffixes. It can be seen in table 37 that the pattern of allomorph selection is formally identical for these suffixes. The patterns of allomorph selection for the past-tense suffix and the past-participle suffix (/t/, /d/, /ɨd/) are analogous.

Of these five suffixes, the plural is the one which has been studied most intensely. Brown (1973), Leopold (1949, p. 80), O'Shea (1907, p. 89), and others have noted the very first uses of inflections are often semantically incorrect. Such observations are not confined to the English plural but have been reported quite generally (Lindner 1898; MacWhinney 1976). There is evidence, however, that inflections emerge semantically before they emerge

TABLE 37

ENGLISH INFLECTIONAL MORPHOLOGY

	Allomorph				
Type	Plural	Possessive	3PS	Final Segments	Features
1.....	s	s	s	p t k f θ	[−continuant, −voice]
2.....	z	z	z	b d g δ v m n ŋ	[−strident, +voiced, −vocalic]
3.....	z	z	z	w r l y and vowels	[+vocalic]
4.....	ɨz	ɨz	ɨz	s z ʃ ʒ t ʃ d ʒ	[+strident, +continuant]

NOTE.—3PS = third-person singular.

morphologically. Brown (1973) and MacWhinney (1974) note that the semantic accuracy in the use of inflections reaches asymptote just before overgeneralization errors attest inflectional productivity. Thus, in both English and Hungarian, it appears that the use of inflections in amalgams is stabilized semantically (cycle 1) before these amalgams are analyzed morphologically (cycle 2). These findings support claim 8 (embedding).

The two productions governing English plural formation can be given as follows:

$$\text{Production 1: } [-\text{voice}] \rightarrow [+\text{voice}] \,/\, \begin{bmatrix} -\text{obstruent} \\ +\text{voice} \end{bmatrix} + \_\_$$

$$\text{Example: door} + \text{s} \rightarrow \text{door} + \text{z}$$

$$\text{Production 2: } \phi \rightarrow \text{ɨ} \,/\, \begin{bmatrix} +\text{coronal} \\ +\text{obstruent} \\ \alpha\text{strident} \\ \beta\text{del. rel} \end{bmatrix} + \_\_ \begin{bmatrix} +\text{coronal} \\ +\text{obstruent} \\ \alpha\text{strident} \\ \beta\text{del. rel} \end{bmatrix}$$

$$\text{Example: church} + /\text{z}/ \rightarrow \text{church} + /\text{ɨz}/$$

Production 1 serves to change /s/ to /z/ after roots ending in voiced segments. This production works within the context of two natural predispositions:

$$\text{Predisposition 1: } +\text{ voice} \rightarrow -\text{ voice} \,/\, \begin{bmatrix} +\text{obstruent} \\ -\text{voice} \end{bmatrix} \_\_$$

$$\text{Predisposition 2: } -\text{ voice} \rightarrow +\text{ voice} \,/\, \begin{bmatrix} +\text{obstruent} \\ +\text{voice} \end{bmatrix} \_\_$$

Predisposition 1 alters /kaetz/ to /kaets/, while predisposition 2 alters /dɔgs/ to /dɔgz/. Only in the case of roots with final nonobstruents is application of production 1 necessary. Moreover, it is only necessary for such roots if /s/ has been chosen as an allomorph. Note that this analysis obviates any need for ordering production 2 before production 1 (Anderson 1974, pp. 66–67).

Data from Anisfeld and Tucker (1967), Berko (1958), and Bryant and Anisfeld (1969) indicate that real plurals like *cars* (type 3, table 37) enter later than real plurals like *cats* (type 2, table 37). Similarly, nonce plurals like *nars* come in later than nonce plurals like *nats*. This differential emergence can be attributed to the impact of predispositions 1 and 2. Incorrect forms like */kaetz/ and */dɔgs/ go against these predispositions, since they combine voiced consonants with unvoiced consonants, that is, /t/ (unvoiced) and /z/ (voiced) or /g/ (voiced) and /s/ (unvoiced). Such forms are not likely to be produced, since the child would naturally reduce them to cat/s/ and dog/z/. Alternatively, as Graves and Koziol (1971) observed, children may form the plural of nonce words ending in voiceless consonants by de-

voicing the final consonant, as in /trok/ + plural → /trok/ + /z/ → /trogz/. This suggests that predispositions probably apply after allomorph selection has already occurred. The allomorph /s/ is selected as the strongest or unmarked form, and then the weak nonce root is assimilated to the form of the suffix.

Predispositions are not relevant to roots with final [-obstruent] sounds. The fact that English has both *parse* /pars/ and *pars* /parz/ indicates that use of /z/ for type 3 roots is not determined by natural phonology but must be overtly learned. The emergence of plurals governed by predispositions before plurals based on learned productions seems to provide support for claim 16 (predispositions).

Type 4 plurals using the /ɨz/ allomorph like *glasses* are the last to emerge (Anisfeld & Tucker 1967; Bellamy & Bellamy 1969; Berko 1958; Bryant & Anisfeld 1969; Derwing & Baker 1977; Ervin 1964, p. 175; Graves & Koziol 1971; Leopold 1949; Natalicio & Natalicio 1971). Even at age 6 their formation is still imperfect. Derwing and Baker (1977) and Solomon (1972, p. 48) have suggested that the [ɨz] allomorph is often missing because it attaches to roots that already "sound" like plurals. This supports claim 2 (affix checking) which holds that the child lets through forms which seem to end in the required suffix. A study by Anisfeld and Gordon (1968) on the psychophonological reality of the plural indicates that the features [+strident] and [+continuant] are crucial in defining the plural. It is precisely these features that are common to the final segments of type 4. For a thorough review of the many competing linguistic analyses of the underlying form of the English plural, the reader is invited to consult Zwicky (1975).

Slobin (1971, p. 221) examined overgeneralizations of the regular past tense in Miller and Ervin-Tripp's unpublished data from 24 children between the ages of about 1½ and 4. He found that overgeneralizations of the regular past tense almost never occurred when the irregular past ended in /t/ or /d/. Slobin explained these results by noting that these partially irregular past tenses like *lost* or *left* already end in a sound (/t/ or /d/) that could be a past tense. He viewed this as a type of "anchor to the regular rule." Claim 2 (affix checking) holds that children filter outgoing morphological formations for the presence of the required marker. Only past tenses ending in dentals would pass such a filter. Unfortunately, Slobin does not indicate what proportion of the overgeneralizations to the fully irregular past tenses use the root of the present (i.e., *felled*) and what proportion use the root of the past (i.e., *falled*).

Because the plural, the possessive, and the third-person singular present have the same three allomorphs, it is possible to study the correlations of use of an allomorph in one suffix morpheme with its homonymous allomorph in another. If productions are presumed to be "general," once they are learned for one archimorph they should "transfer" to other archimorphs.

Dale (1972, p. 186) made an informal report of such a comparison in which a moderate correlation was found between vowel insertion in the plural and vowel insertion in the past tense. Baird (1973) examined the nine possible correlations of the three allomorphs of the plural, the possessive, and the third-person singular present and found only two significant correlations. On the other hand, Derwing and Baker (1977), working with a much larger sample, reported allomorph-allomorph correlations of $r = .80$ and above.

The problem with these studies of morpheme-morpheme transfer in the English plural is that transfer is confounded with natural predispositions and affix checking. Selection of /s/ versus /z/ is based on natural predispositions in most formations. Study of the transfer of productions across morphemes should focus on unaffected roots. In the case of the insertion of [ɨ] by production 2, it would appear that plurals like *glasses* which have the root ending in an exact replica of a plural allomorph would be harder to learn than plurals like *churches* which have the root ending in only an approximation of a plural allomorph. In general, studies of production transfer might be more rewarding if they focused on productions like production 1 in Hungarian which are not so deeply intertwined with predispositions and affix checking.

The formation of the English progressive presents an interesting contrast with the formation of the German perfective. Both formations use discontinuous morphemes. In both, the first part of the discontinuous morphemes is a verbal auxiliary (English = *am*, *is*, etc; German = *habe*, *hat*, etc.). In German, the second part of the formation involves choice between several past participle allomorphs. As noted in Chapter V, choice between these allomorphs is largely a matter of cycle 5 learning. In English, all present participles take *-ing*. Thus, the suffix has only one allomorph. As we have seen, German children first mark the progressive with the auxiliary, whereas Brown (1973) found that English children first use the suffix. In each language, children prefer the item with the most easily controlled allomorphic variations. Note that there is no need to invoke any hypothesized universal preference for inflectional marking over analytical marking to account for this example. These findings support claim 9 (discontinuous morphemes) of the dialectic model.

In most forms the English participle is identical with the past tense (i.e., *jumped* and *jumped*). However, many verbs that form irregular pasts form participles by addition of *-en* rather than the *-ed* of the past (i.e., *drove* and *driven*). Zwicky (1970) reports that at age 4-6 his daughter produced these overgeneralizations of *-en: aten*, *gaven*, *roden*, *sawn*, *shooken*, *tooken*, and *wroten*. However, the suffix *-en* was never used with verbs that formed regular past tenses (i.e., there was never *jumpen* or *jumpeden*). Nor, at 4-6, was it used with the present-tense root of irregulars (i.e., there was no *shaken* or *taken*). These errors at 4-6 indicate marking of *-en* as applicable to the past-tense

allomorph of a class of roots showing allomorphic variation between tenses. This is a case of cycle 4 learning with low applicability. Its late acquisition supports claims 11 and 12.

FRENCH

Studies of French morphophonology have dealt with three major areas: gender, verb conjugation, and errors in analysis.

Gender

The first area of interest is gender. Cohen (1927, 1933) reports in detail on the acquisition of gender in personal pronouns. The speech heard by his children, however, obliterated both gender and number distinctions in the third-person nominative. The confounding effects of dialect variation make these data difficult to examine. Gregoire (1947, p. 109) found that, in the third year, his son Charles tended to reduce both masculine and feminine third-person pronouns to a common phonological form.

Gregoire (1947, pp. 19–20, 40–41) reports a large variety of gender errors early in the third year. Before this time articles were usually omitted, and gender was not marked overtly. At 2-4.7 Gregoire (p. 20) observed forms like *sur le l'eau* ("on the the-water"), which suggest that children are acquiring articles together with nouns as amalgams (claim 8). The portmanteau forms *du* (de le) and *au* (a le) enter later than the more frequent allomorphs *de* and *à* (claim 10).

Verb Conjugation

The second area of interest is verb conjugation. French has three major conjugations and a collection of irregular verbs. Guillaume (1927/1973) notes that the few irregular verbs account for the majority of verb tokens used by the child. On the other hand, the three regular conjugations apply to more actual types of verbs. Grammont (1902), Gregoire (1947), and Guillaume (1927/1973) all note that children tend to conjugate irregular verbs by using regular suffixes. In particular, Gregoire (p. 356) notes that the [e] of the infinitive of the first conjugation is overgeneralized quite widely. This use of the most frequent allomorphs in early overgeneralizations provides support for claim 10 (first affix allomorph).

The largest number of errors in verb formation involve use of the root allomorph used in the present or the imperative where another allomorph (usually the infinitive) should be used. Gregoire (1947, pp. 125, 356–357) reports a wide variety of such errors, such as **dormra* for *dormirai* or **buver* for *boire*. The tendency to overgeneralize allomorphs of common forms like the imperative and the present provides support for claim 7 (first root allomorph).

Grammont's (1902) observations indicate that children have a fairly deep command of the implicational structure of the conjugation. If an ir-

regular verb has a form in its paradigm similar to the form specified by a regular paradigm, the child treats the irregular verb as regular and overgeneralizes the regular paradigm to other parts of the paradigm of the irregular verb. For example, *courir* ("to run") ends in *-ir* which could qualify it for the second conjugation. In that conjugation, the participle ends in *-i*. Thus the child forms **couri* where the correct form is *couru*. In effect, the child has used the implication: *-ir* ↔ *-i*. The overgeneralizations *tiendre*, *s'assir*, and *prendu* are produced in the same paradigmatic (cycle 5) fashion. These errors indicate that French verb conjugation functions much like German article declension (claim 14). A second type of overgeneralization is less paradigmatic. Here *buver* ("to drink") (=*boire*) is produced by taking the root of, say, *buvons* ("we drink"). This is an extension of a secondary allomorph, a common error in Hungarian.

Self-Corrections

The third major area of interest has been the examination of self-corrections. Guillaume (1927/1973) points to three types of child self-corrections. In the first type the original form is not a member of the desired category. Thus, one child at 3-0.3 used *tient* ("he holds") for *tenir* ("to hold"). Minutes later, he corrected himself to *tiendre* ("to hold") for *tenir*. The first production *tient* would have failed any internal checking (claim 2) for an infinitive, since it had no final /r/. The second production *tiendre* was an overgeneralization of the third conjugation. Guillaume cites two examples of another correction type where the child first produces a correct irregular form and then follows it moments later with an incorrect regular form. Thus at 2-0.10 a child says the correct irregular *pris* ("taken") and then the incorrect regular *prendu* ("taken"). Another child at 3-0.9 says the correct irregular *ouverte* ("open") and then the incorrect regular *ouvrie*. In both of these cases the first form is produced by rote but fails to pass affix checking (claim 2). The second form is based on combination. The third type of correction replaces an incorrect regular form with a correct irregular form. Thus, at 3-0.9, a child says the incorrect regular *tiendre* ("to hold") and replaces it immediately with the correct irregular *tenir* ("to hold"). Here combination functions just before the child locates the correct form by rote.

LATVIAN

The inflectional systems of Latvian and Lithuanian are among the most developed and complex of the Indo-European languages. However, the only available report on the acquisition of these Baltic languages is Rūķe-Draviņa's (1959) case study of the acquisition of Latvian. Moreover, Rūķe-Draviņa's report focuses on inflectional semantics rather than the productive use of morphophonology. Nonetheless, the report includes a few observations relevant to the present review.

Latvian nouns are separated out into declensions partially on the basis of their endings. Most roots ending in *-ā* are feminine and are declined as ā-stems. A few roots ending in *-ā* are masculine and are declined as o-stems. Rūķe-Draviņa found overgeneralization of the o-stem dative suffix (*-am*) for the ā-stem dative suffix (*-ai*) at 1-11. This was quickly reversed and, up to age 8, the feminine ā-stem pattern was overgeneralized to masculine words ending in *-a*. If it were the case that *-am* was more applicable than *-ai*, then the early choice of the masculine pattern would support claim 10, which holds that the first allomorph of an affix is the one applicable to the most formations. Later overgeneralization of *-ai* to masculine roots ending in *-a* indicates emergence of a cycle 3 production sufficiently high in applicability to tolerate occasional incorrectness (claim 12).

Another set of errors demonstrates productivity of the accusative at 1-10. The words *baznīca* ("church") and *laīva* ("boat") are used by the child in the forms *baźe* and *aīve*. Since these child forms end in *-e*, they should be declined as *e-stems*. In fact, the accusatives used by the child are the incorrect forms **baźi* and **aīvi*, exactly those required for *e-stems*. The *a-stem* accusatives of the adult roots are totally ignored. This shows how the child uses his own lexical representations as inputs to his own morphophonological productions.

A third observation indicates how an inflection can be semantically acquired before it is morphologically productive (cycle 1). At 1-10, the child used the nominative plural *-s* correctly on the demonstrative *tās* ("these") even when the noun itself was singular, as in *tās kupe* ("these shoe"). This finding supports claim 8 (embedding).

A fourth example reveals an attempt to maximize the application of the definite suffix. Although Latvian uses the definite suffix only in the singular, Rūķe-Draviņa reports a number of uses of the form *root* + *definite* + *plural case* around 2-0.

Rūķe-Draviņa presents an interesting argument for a functional account of the order of acquisition of inflections in a given language. She notes that the copulars "is" and "is not" enter in Latvian far before they enter in German (Stern & Stern 1928/1965). However, in Latvian, these verbs also function as "yes" and "no" in response to questions. In German, on the other hand, their function is largely formal. This example supports claim 5 (functional importance).

RUSSIAN

Studies by Popova and Zakharova have examined the acquisition by Russian children of the marking of noun gender on nouns and verbs. Russian has gender agreement between the subject and the verb in the past tense. If the subject is masculine the verb takes no ending, but if it is feminine it

takes *-a*. Working with real nouns and verbs, Popova (1958/1973) found that 22 children between 1-10 and 3-2 overgeneralized the feminine *-a* most often, whereas nine children between 2-6 and 3-3 overgeneralized the masculine ϕ most often. From this, Popova concluded that overgeneralization of one competing form is somewhat arbitrarily followed by overgeneralization of another. However, the small size of the second group and the fact that it overlaps the first, as well as further complexities in the structure of the acquisition, cast doubt on Popova's account. In fact, an attempt by Dingwall and Tuniks (1973) to replicate Popova (1958/1973) found that masculine agreement predominated even at 1-6 to 2-6.

It appears that, in Popova's study, children were often unsure of the gender of the noun. Without clear knowledge of noun gender, agreement will often be incorrect. Both Popova (1958/1973) and Zakharova (1958/1973) found that the chief cues to gender in Russian were phonological. Moreover, they indicate that the sequence of acquisition of the various phonological rules for gender is related to applicability, just as was the case in German. Although Dingwall and Tuniks (1973) found many errors in nonce noun gender, as marked on the adjective and verb, the overall performance was clearly above chance. This indicated that children make at least some use of word endings as phonological cues to gender. Zakharova also notes that, in cases where gender is not known, the child selects a case suffix by a fallback strategy. This strategy establishes one suffix for each case as the one to use when all else fails. Thus, Zakharova's brief report suggests a strategy goal stack (claim 1) much like that observed in German.

Apart from these two cross-sectional studies, there are a number of further diary-based observations of the acquisition of case and gender marking. In the accusative, masculine and neuter nouns take no suffix, whereas feminine nouns take the suffix *-u*. A number of Russian observers (Gvozdev 1949; Pavlova 1924; Zakharova 1958/1973) indicate that, at some stage, *-u* is overgeneralized to all genders. Exactly the same situation attains in Serbo-Croatian (Mikeš & Vlahović 1966; Pavlovitch 1920) with the accusative *-u*. Unfortunately, comparisons of actual inflections with a null allomorph inflection (e.g., Walter 1975) are difficult. It is impossible to fully distinguish omission of inflection from use of the null allomorph.

These same observers have also noted that the first instrumental allomorph overgeneralized by children is the masculine and neuter allomorph *-om* rather than the feminine allomorph *-oy*. Popova (1958/1973) has calculated that the young child's noun vocabulary is composed of 70% feminine nouns. Thus, on the basis of frequency, the first allomorph to be overgeneralized should be *-oy*, rather than *-om*. Thus, the early overgeneralization of *-om* tends to falsify claim 10 (first affix allomorph). However, it should be noted that overgeneralizations of *-oy* may well have escaped observation, since *-oy* is used as the case suffix for feminine nouns in four cases. When

children used *-oy* on masculine nouns, observers may have failed to note the child's intention to express instrumentality. Thus it may well be the case that, in the earliest stages, *-oy* was overgeneralized for *-om* but that such overgeneralizations went largely undetected. In fact, overgeneralization of *-om* is quite transitory, which is exactly as predicted by claim 15 (inflectional imperialism).

SPANISH

Little is known about the acquisition of Spanish morphophonology. However, in nonce testing of Mexican children, Kernan and Blount (1966) found that the plural allomorph *-s* entered before the plural allomorph *-es* and was overgeneralized for *-es*. The allomorph *-s* occurs after vowels, and *-es* occurs after consonants. Thus there were overgeneralizations like *papels* and *camions* for *papeles* and *camiones*. The *-s* allomorph is probably more frequent in the child's amalgams and is, therefore, chosen as the first productive allomorph. This supports claim 10 (first affix allomorph).

ARABIC

The languages we have examined in this *Monograph* all belong to either the Ugro-Finnic or the Indo-European language families. I am aware of only two studies of morphophonological development in languages outside of these two families. One is a study of Egyptian Arabic by Omar (1970). The morphophonologies of Arabic and the other Semitic languages are interesting for their use of infixes, since productive use of infixes is relatively rare cross-linguistically. Omar studied a variety of inflections in Arabic, and there is evidence (e.g., p. 406) for some productivity of infixes, although this was never directly examined. However, Omar did observe early stages in the acquisition of the Arabic suffixes for the noun plural, the dual, the adjective plural, and the adjective feminine. Of these, the first to enter is the adjective feminine suffix *-a* which is used productively before 3-0. It is highly applicable and nearly always correct because most adjectives take *-a*. The early acquisition of this allomorph supports claim 10.

Between ages 3 and 6 children acquire the noun-plural suffix in the form *-at* and the adjective plural in the form *-in*. Both of these plural allomorphs compete against a variety of irregular-plural patterns. In the end, the child must simply memorize these irregular plurals. In fact, Omar (p. 374) found that rote memorization of irregular plurals was very strong. These findings support claim 4 (insulation). They also provide an interesting comparison with the results of experiment 2 on the Hungarian adjective and noun plurals. In Hungarian the two plurals sound enough alike to be coded as a single morpheme. However, Arabic *-at* and *-in* must be learned as different morphemes.

The Arabic dual *-en* entered quite late. It appears that the concept of

duality as opposed to plurality is elusive for young children. Thus Omar attributes the late acquisition of the dual to semantic factors.

Omar also reports that the negative particle *miš* enters long before the negative form *ma-š*. The *ma-š* form is composed of the prefix *ma-* and the suffix *-š*. The early entry of *miš* is in accord with claim 9, which holds that children avoid acquisition of discontinuous morphemes.

CHINESE

The other study of morphophonological acquisition in a language outside of Ugro-Finnic and Indo-European is a study of the acquisition of tone sandhi in Mandarin Chinese by Li and Thompson (1977). The two-tone sandhi patterns both affect tone of morphemes when combined with other morphemes into sentences. Thus, unlike the other patterns we have studied, these tonal patterns operate on the level of the sentence and not the level of the word. Thus they can only apply once words have been linearized. Despite these differences from true morphophonological patterns, these sandhi patterns resemble morphophonological productions in that they lead to modifications of the phonological shapes of morphemes. The two productions are as follows:

Production 1: dipping tone → rising tone / ___ # dipping tone

Production 2: dipping tone → low-level tone / ___ # $\left\{\begin{array}{l}\text{high tone}\\ \text{rising tone}\\ \text{falling tone}\end{array}\right\}$

Dipping tones only remain unchanged when they are in sentence-final position or when they stand alone.

Li and Thompson find that these patterns are first present in unanalyzed amalgams like [šyáonyǎo] ("small bird"). Of course, in such forms, the intonation is not yet controlled by productions. As soon as children begin combining words errors in production 1 emerge. In one type of error cited by Chao (1951), the child simply fails to alter the dipping tone. This type of error indicates that words are often acquired from sentences in which they stand alone. This is in accord with claim 6 (intonational packaging). In a second type of error, the dipping tone is replaced by a low-level tone rather than by a rising tone. This error could be due to overgeneralization of production 2 or to the use of a low-level tone allomorph as the basic form of the morpheme. There is nothing in Li and Thompson's report to distinguish these alternatives.

Both Chao (1951) and Li and Thompson (1977) found no errors in the use of production 2 at any time. The early acquisition of this highly applicable cycle 3 production provides support for claim 11 (production applicability). For an investigation of the productivity of tone sandhi in older Taiwanese subjects, the reader may consult Hsieh (1970).

VII. CONCLUSION

Our investigation of the acquisition of morphophonology is now complete. We began with the observation that data on the ways children learn widely differing languages can help us to make inferences about the universal set of language-learning abilities common to all children. Next we examined a model of these abilities which arose out of precisely this type of cross-linguistic developmental comparison. The essential aspects of the model were summarized in a set of 16 empirical claims. In Chapters III, IV, V, and VI we examined data on the acquisition of morphophonology in Arabic, Chinese, English, Finnish, French, German, Hungarian, Latvian, Russian, and Spanish. Now we are ready to ask whether the data support or contradict the 16 claims of the dialectic model.

EVIDENCE SUPPORTING THE 16 CLAIMS

The overwhelming majority of the evidence presently available serves to support the 16 claims of the dialectic model.

Claim 1: Goal Stack

Two lines of evidence indicate that combination is only used when rote is not available. First, children make fewer errors on common words than on rare words (experiments 1–5; Graves & Koziol 1971; Omar 1970; Walter 1975; and many others). This is because common words are more likely to have been learned by rote than are less common words. Second, regular real roots are more often correct than nonce roots (experiments 1–5; Graves & Koziol 1971; Walter 1975). This is because real words can be learned by rote, whereas nonce words cannot.

Experiments 1 and 5 also indicated that analogy can be used when rote and combination are not available. For nonce forms rote is never available. Combination is generally used for these forms, but analogy may be used when the child has reason to doubt his control of combination. In particular

the data in experiments 1 and 5 and Zakharova (1958/1973) indicate that analogy will receive some use where cycle 4 or cycle 5 patterns occur.

Claim 2: Affix Checking

In the English plural (Derwing & Baker 1977; Solomon 1972) and past tense (Slobin 1971), forms which appear to contain a desired suffix resist addition of that suffix. In French, Guillaume (1927/1973) found that children who produced correct irregular forms would "correct" themselves with regular forms when the irregular forms did not end with the regular suffix.

Claim 3: Overt Correction

Brown and Hanlon (1970) have shown that continuous and persistent corrections of child errors by adults may fail to lead to any obvious change in behavior.

Claim 4: Insulation

Lindner (1898) and MacWhinney (1974) note that, when children are forced to use words out of context, overregularizations increase. This indicates a decline in rote and a rise in combination. As noted above, experiments 1–5, Graves and Koziol (1971), Gregoire, (1947), Omar (1970), Walter (1975), and others have found that overregularizations are less frequent for common real words than for less common real words. This is because common words are more likely to be learned by rote.

Claim 5: Functional Determination

This claim holds that children will only acquire forms for intentions they want to express. Experiment 2 demonstrated how children avoid acquisition of a form synonymous with a form they already possess. In Arabic (Omar 1970) acquisition of the dual is very late. Evidently this is because the plural serves to express most of the functional value of the dual. The copular is acquired earlier in Latvian (Rūķe-Draviņa 1959) than in German. Apparently this is because the Latvian copular also serves to express affirmation or negation—functions of importance to the child.

Claim 6: Intonational Packaging

As Slobin (1973) has noted, the Bulgarian article, which is a suffix, enters earlier than the German article, which is like a preposition. Slobin presents a variety of data indicating that suffixes enter earlier than prepositions. In general, it may be the case that both prefixes and suffixes enter before prepositions and postpositions. This would be because affixes are picked up as integral parts of intonational units. In Mandarin, the early overgeneralization of dipping tone indicates that many dipping-tone words are initially acquired from utterances in which they occur alone. Such presentation minimizes segmentation problems.

Claim 7: First Root Allomorph

In the Hungarian diary data (MacWhinney 1974), overgeneralizations of the citation allomorphs of roots are four times more frequent than overgeneralizations of other allomorphs. In German, the overwhelming majority of diary reports of verb and adjective overgeneralizations are of citation allomorphs. In French verbs, the citation form is generally the same as the root of the present. It is this form which is involved in most overgeneralizations.

Claim 8: Embedding

Kahane, Kahane, and Saporta's (1958) review of the diary literature provides abundant evidence of the nonproductivity of the earliest embedded inflections. MacWhinney's (1976) review of the Hungarian literature indicates three lines of evidence suggesting that early affixes are embedded in unanalyzed amalgams. First, affixes are used correctly before they are used productively, as Brown (1973) has noted. Both Brown (1973) and MacWhinney (1974) note that the semantic accuracy of inflections reaches asymptote just before overgeneralization errors attest inflectional productivity. Second, underanalysis of amalgams is reflected in semantic extensions, affix redundancies, and affix contradiction. Rūķe-Draviņa (1959) provides an example of this that was discussed above. Third, the absence of errors in the ordering of affixes suggests that often the component morphemes are not being produced by combination but by rote. The relative paucity of errors in article gender in German also suggests that articles are learned together with nouns as units.

Claim 9: Discontinuous Morphemes

Whereas the German child first uses the auxiliary to express the progressive, the English child first uses the suffix *-ing*. In each case the child has acquired that piece of a discontinuous morpheme which is subject to the most easily controlled allomorphic variation. In Arabic the continuous negative is learned before the discontinuous negative.

Claim 10: First Affix Allomorph

The first overgeneralizations of affixes seem to be based on use of the most frequent form. Examples of this include: the Arabic adjective feminine suffix *-a*, the English plural [z], the French prepositions *de* and *à*, the endings of the first conjugation in French, the German adjective ending *-e*, the Latvian dative *-am*, the Slavic accusative *-u*, and the Spanish plural *-s*.

Claim 11: Production Applicability

Data from the Hungarian diary literature, Lyytinen's study (1972) of Finnish morphophonology, Walter's study (1975) of German pluralization, and experiments 1, 4, and 5 all indicate that applicability is a major determi-

nant of the order of acquisition of morphophonological productions. However, when a highly applicable production such as Hungarian production 15 is also low in correctness, its acquisition will be significantly delayed.

Claim 12: Cycle 4 Strength

In experiment 1, productions 3, 4, 5, and 11 attained moderate productivity in the oldest group (6-8 to 7-5). This suggests that this group was involved in acquiring these cycle 4 productions as cycle 3 ones. The learning of the English past participle (Zwicky 1970) and the Latvian dative (Rūķe-Draviņa 1959) follows a similar course.

Claim 13: Cycle 4 Productivity

Experiment 3 indicated that children could isolate new allomorphs and control their use through allomorph selection productions. However, this ability seems to vary with the shapes of the allomorphs being selected. Further work will be needed to give a more accurate account of abilities in this area.

Claim 14: Implication Position

Experiment 5 showed that judgment of the class membership of a root is not more successful with information that is contiguous to the root than with information with no fixed position vis-à-vis the root. Anecdotal evidence from Hungarian and French suggest that paradigms are manipulated as sets of implications.

Claim 15: Inflectional Imperialism

The transitory use of the German past tense in the present and the Russian *-om* for *-oy* both demonstrate attempts by the child to delimit the range of application of weak allomorphs.

Claim 16: Predispositions

Blockage of rounding harmony in Hungarian and voicing assimilation in the English plural are fairly clear cases of the impact of predispositions on morphophonological formations. It is entirely likely that other, weaker predispositions had some effect on the data reported in this *Monograph*. As predispositions become weaker, however, their effect becomes correspondingly more difficult to detect.

EVIDENCE CONTRADICTING THE 16 CLAIMS

Only two pieces of evidence run counter to the claims of the dialectic model. The first piece of contradictory evidence is the relatively early acquisition of production 5 in Finnish, even though this production is not high in applicability. This contradicts claim 11. The second piece of contradictory

evidence is the report by Neugebauer (1915) of early overgeneralization of a weak, usually nonproductive pattern. This contradicts claims 7 and 11.

EVALUATION OF THE MODEL

The dialectic model seems to perform adequately in accounting for the data presently available on the acquisition of morphophonology. Future research, however, will subject the model to more severe tests. Appendix A presents the logic underlying a computational simulation of the model which is already fairly far underway. The simulation is designed to accept as input the words of any real language together with their meanings. In evaluating the model, the program will be taught words in some language, say Navaho, about whose acquisition we know little. The output of the program should include a set of inflected real and nonce forms. These forms will illustrate the nature of the successes and overgeneralizations made by the program as it moves step-by-step to a formulation of the morphophonological productions of the language. These simulated data will then be compared to data gathered from real subjects, that is, Navaho children. Finally, the real and simulated data will be compared in an attempt to evaluate the predictive power of the model.

APPENDIX A

COMPUTATIONAL SIMULATION

This Appendix outlines the logic underlying a computational simulation of the dialectic model that is now being implemented in Pl-1 on the Burroughs 6700. The logic will be displayed as a series of flow charts. The structure of this Appendix is essentially identical with the structure of Chapter III above because each flow chart expresses one process in the model and because the orders in which the processes are discussed are identical.

What does a computational simulation of an acquisitional model tell us that a verbal statement of the model does not? There seem to be at least three uses that can be made of computational models in language acquisition. Of these three uses, two seem to be proper uses and one seems to be improper.

Some workers in artificial intelligence have attempted to treat computational models as exact replicas of mental functioning. It would seem that this is not a proper use of a computer simulation. There are a variety of problems (Chandrasekaran & Reeker 1974; Dresher & Hornstein 1976) inherent in this approach to simulation. No one should misconstrue the phenomenological (Wittgenstein 1958) status of computer simulations, nor should anyone attempt to view the computer as a brain. In terms of both anatomy and physiology, computers and brains are quite dissimilar. Consequently, simulations on present-day machines cannot duplicate mental processes; they can only mimic them.

There seem to be two other uses of simulations which are entirely legitimate and proper. First, the precision required by the computer tends to demand a certain explicitness in theory construction (Weizenbaum 1976). Although the computational model is not the only formalism that demands explicitness, it seems to be the one most suited to the expression of very complex systems. Examples of such complex systems can be found in epidemiology, where computational models provide several practical advan-

tages not offered by pencil-and-paper models (Elvebach, Ackerman, Gatewood, & Fox 1971). The main use of the present Appendix is as an explicit statement of the model. As such, it allows the reader not only to study the detailed functioning of the model but also to relate this functioning to data in a maximally concrete fashion.

The second proper use of an acquisitional simulation is as a verification automaton. In this use, one treats the simulation as an accurate representation of some acquisitional model. By providing the simulation with new data, one can assess the ability of the model to account for new, relevant facts. Moreover, one can contrast the performances of alternative models in accounting for the same data. Unfortunately, most of the existing computational models of language acquisition (Anderson 1975; Kelley 1967; Klein & Kuppin 1970; Reeker 1976; Siklossy 1972) have not paid sufficient attention to the nature of psycholinguistic data. In particular, these programs have confined themselves to simulation of English acquisition, although Anderson (1975) and Siklossy (1972) did look at segments of French and Russian. The authors of these programs do not give explicit statements regarding the type of data their models are designed to predict. Nor do they indicate how their models could be tested against other models.

THE PLACE OF MORPHOPHONOLOGY WITHIN THE LINGUISTIC SYSTEM

Before examining the detailed structure of the proposed simulation, it is important to locate the place of morphophonology within the larger linguistic system. In the present model, morphophonology is viewed as an integral part of the process of lexicalization. When lexicalization proceeds by rote, there is no true morphophonological processing. When lexicalization proceeds by combination, however, the system of morphophonological productions may also apply, even if only vacuously.

Figure 2 gives the reader a general impression of the place of receptive lexicalization within the process of reception and of expressive lexicalization within the process of expression. This figure is not intended as an accurate representation of all the possible sequences in processing. Rather, it indicates one common, perhaps basic, processing sequence.

In reception, the phonetic system takes the speech signal and reduces it to a phonological representation. This representation is then taken by receptive lexicalization as a guide to the lexical files. The lexical items retrieved by this process are then sent to receptive syntax where word-order information is used to decode any additional semantic content.

In expression, lexicalization maps semantic content onto phonological form. Affixes are ordered about their roots by a set of presyntactic concatenation patterns. Then morphophonological processes are applied. The

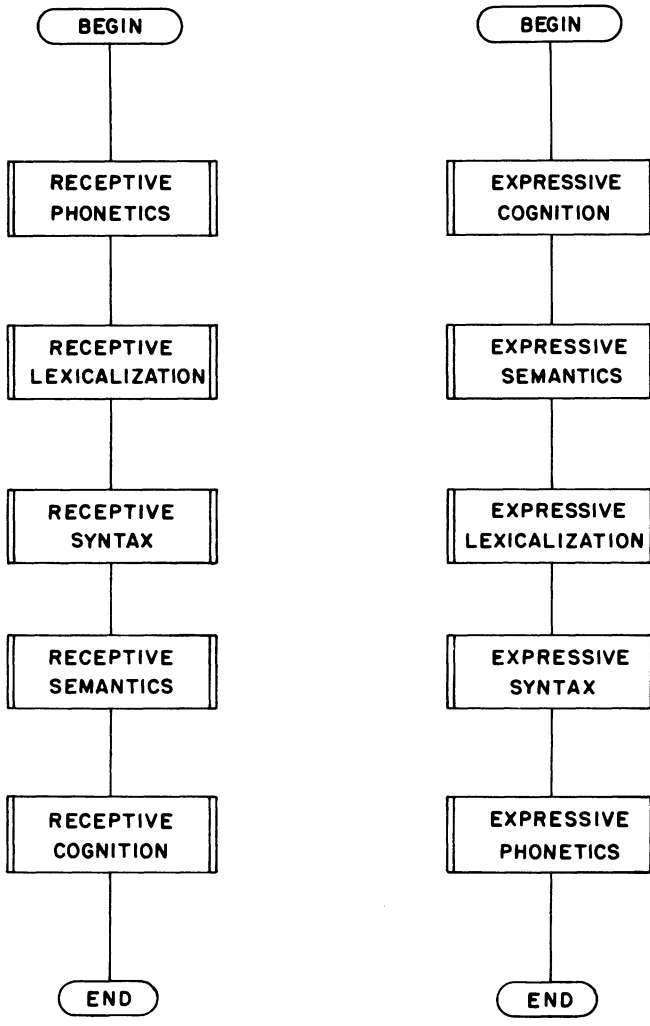

FIGURE 2.—Reception (left) and expression (right)

resultant words are then ordered by expressive syntax and finally translated into articulation by expressive phonetics. All of the processing mentioned above lies outside the domain of the present simulation.

MAIN CONTROL

Because this program only seeks to simulate the acquisition of a part of the phonological component, the above two charts are not yet actually implemented. To do so would be to construct a complete device for the acquisition of language. The present simulation avoids these larger tasks by making

two simplifying assumptions. First, by limiting input and output to single words, it becomes possible to exclude consideration of word ordering (syntax) from the simulation. Second, treatment of semantic and cognitive processing is avoided by providing semantic representations when inputing forms for either reception or expression. At present, the exclusion of syntax and semantics from the simulation seems to be necessary. However, the inclusion of realistic syntactic processing seems to be clearly feasible (Anderson 1975; Reeker 1976).

Although consideration of the roles of syntax, semantics, and cognition is sidestepped in the current implementation, the ordering of receptive versus expressive systems is accurately reflected in the main control flow chart (fig. 3). The main control allows the user to select the language he wishes to

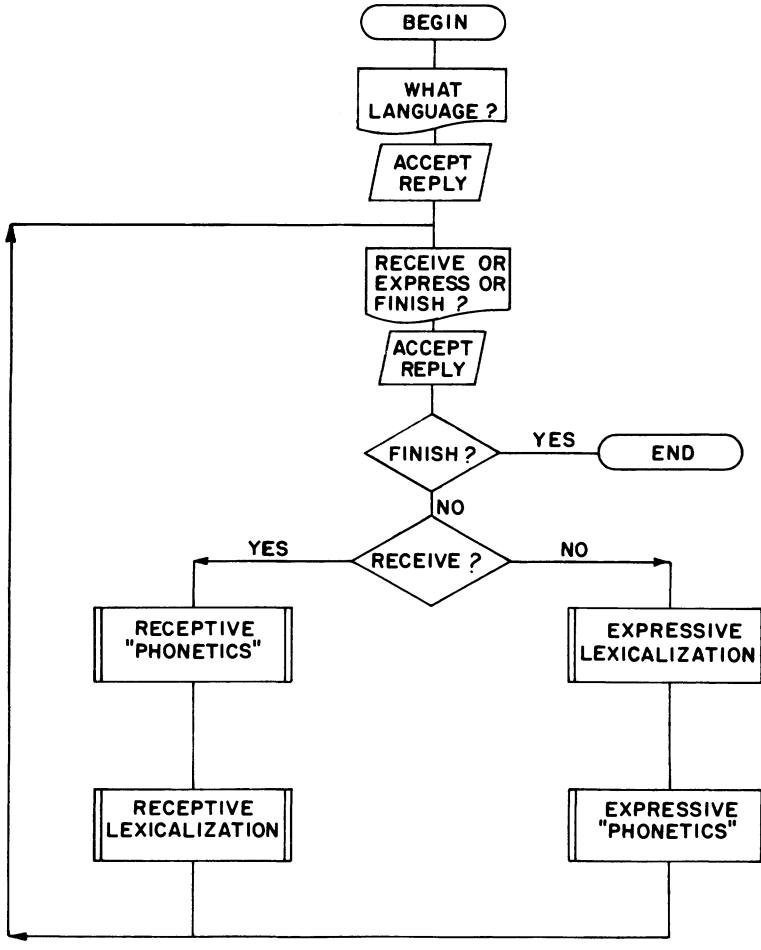

FIGURE 3.—Main control

examine. He then decides whether he wants the program to receive as input the words that he wants to give to it or to give as output some forms that will express some intention. In the latter case, the user must provide the program with intentions, since the program has no intentions of its own.

The "phonetic" systems are constructed as interpreters which convert keyboard symbols in a given natural language into distinctive feature representations. In a more complete simulation, the interpreter would be replaced by a phonetic component which would accept sine waves as input and generate distinctive feature representations as output. Natural phonological predispositions are incorporated within the phonetic systems. Articulatory predispositions are placed into expressive phonetics, and auditory predispositions are placed into receptive phonetics. Another series of housekeeping procedures sends error messages and information regarding the processing involved in the generation of expressions and receptions. A record of all input is stored on paper tape to permit later testing of variations on the model.

EXPRESSIVE AND RECEPTIVE LEXICALIZATION

Within the main control procedure are four processes within boxes that have double lines. These lines indicate complex procedures that must be broken down in further flow charts. Because the phonetic translators entail few substantive claims, they will not be charted. The two remaining complex procedures are expressive lexicalization and receptive lexicalization. They are charted in figures 4 and 5.

The separate systems of expressive and receptive lexicalization share a common control structure based on the dialectic cycle. In both procedures, the child first enters application. If application succeeds, correction and acquisition ensue. The child continues to process records until he either has no more to say or there is nothing more to listen to. When the operator is working in the expression mode, he must input to the program a series of "intentions." These are records composed of semantic features. They represent the things that the program might wish to say, if it had any thoughts of its own it wanted to communicate. Expressive application seeks to convert this "intention" into a phonological expression.

When working in the receptive mode, the operator must input both a sound representation and a semantic representation. The sound representation is converted into an "audition" by the system of receptive phonetics. Receptive application seeks to convert this audition into a semantic "reception." The "situational semantics" input by the operator are not used to produce the reception. Rather, they are used to guide receptive correction.

APPLICATION

The overall design of both expressive application and receptive application is that of a goal stack or habit-family hierarchy with rote on the top,

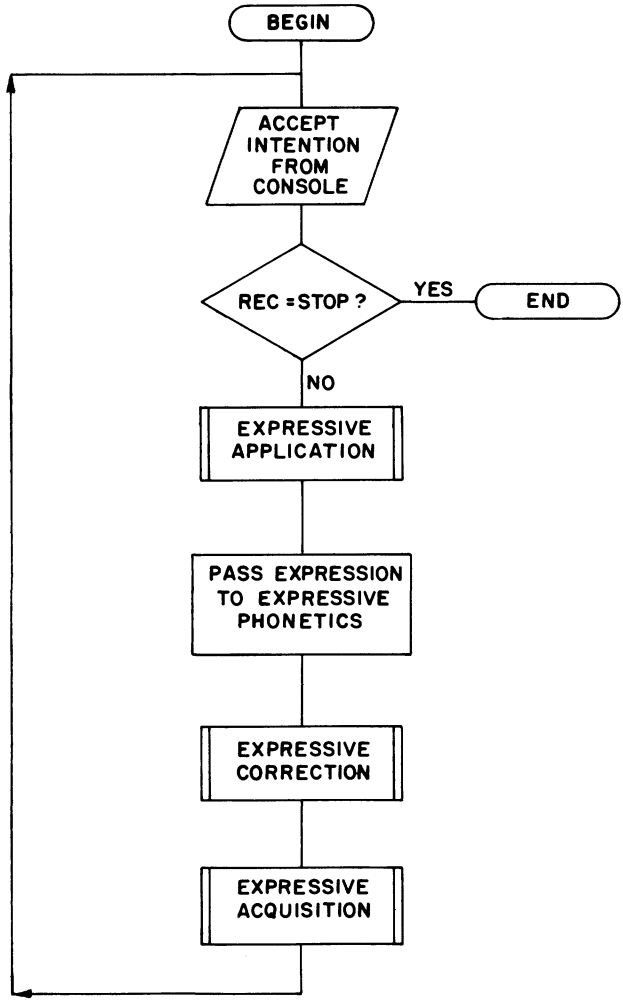

FIGURE 4.—Expressive lexicalization

combination in the middle, and analogy on the bottom. Although the two procedures have parallel structure, they must be charted separately because the internal contents of the subcomponents differ markedly. In expressive application (fig. 6), the expression starts out with no substance (ƀ) and remains without substance unless one of the applicational procedures succeeds. Similarly, in receptive application (fig. 7), the reception remains blank unless a procedure succeeds.

Rote Application

The preceding flow charts started with a main control which was then broken down into receptive and expressive lexicalization. These sys-

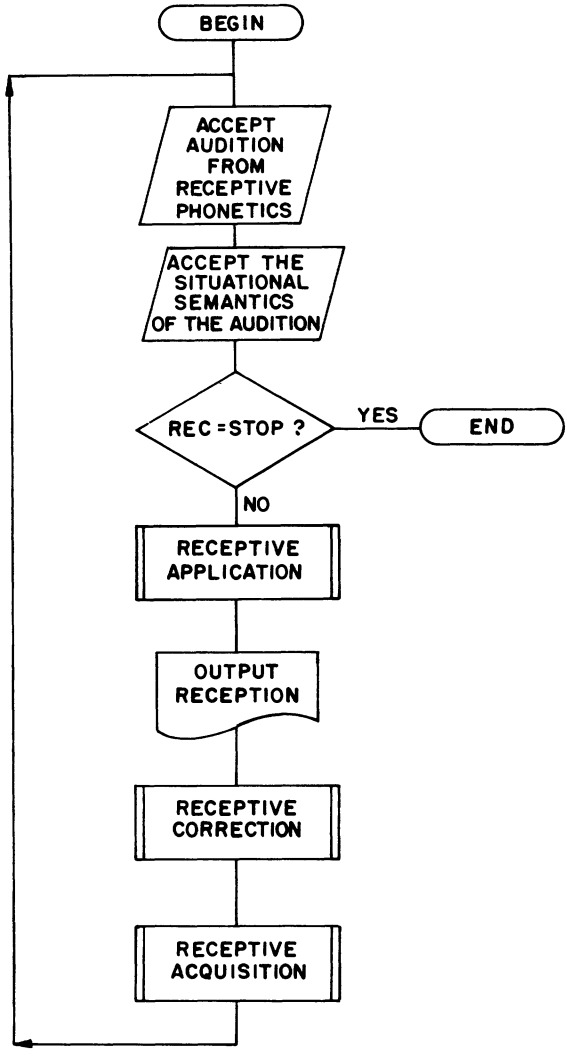

FIGURE 5.—Receptive lexicalization

tems are then decomposed into application, correction, and acquisition. Application was further decomposed in rote, combination, and analogy. Now, on the fourth level of decomposition, expressive and receptive rote application will be broken down into a set of programmable operations. These procedures operate on a data file called file 1 which is essentially a word lexicon. It includes phonological and semantic representations for all items learned as amalgams, that is, free forms that are not yet analyzed morphologically. Analyzed or bound items are in file 2 for affixes and file 3 for roots.

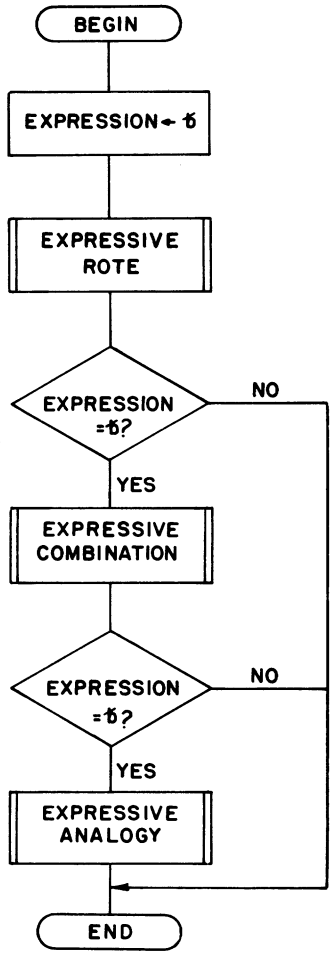

FIGURE 6.—Expressive application

Expressive rote (fig. 8) first uses a keyed index to retrieve all file 1 records with bases like that in the intention. Then rote looks for a perfect match across all semantic features of the intention and the record. If this perfect match is weak in lexical strength, it will be stored as a weak form. If the perfect match is strong, it will be output as the expression.

Receptive rote (fig. 9) looks for a perfect match across all phonological features. If the sound of a file 1 record exactly matches an audition, its meaning becomes the reception. Note that the "answer" output in expression is a phonological representation whereas the "answer" output in reception is a semantic representation.

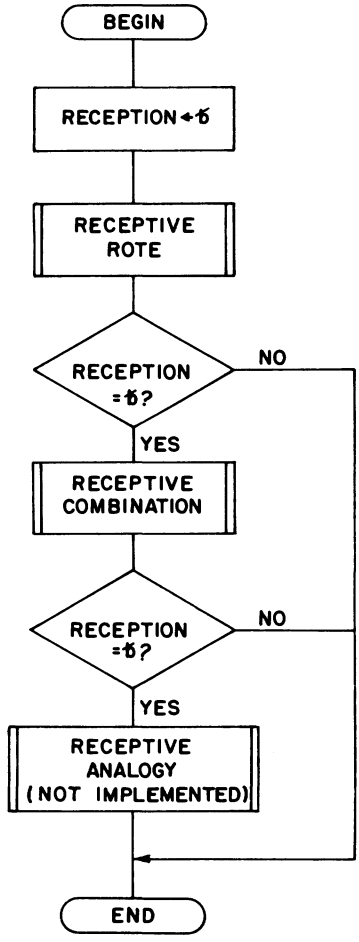

FIGURE 7.—Receptive application

Combination

Expressive combination.—This process (fig. 10) first tries to produce an expression or reception by rote use of the lexicon. If this rote lookup fails, the child next tries to build up a productive form out of its component pieces. This process of expressive combination begins with a search for a file 1 item that can express a proper subset of the intention. If no file 1 form is available, the child goes to file 3 and gets the strongest form with the desired root. At this point, the child realizes that he has expressed at least some of his intentions. He places flags on the parts he thinks he has expressed. Next, he turns to file 2 to express those intentions that remain unflagged. If he finds a form like *feet* that expresses plurality, he will only look for a plural suffix if he is not sure he has expressed plurality by using the form *feet*. Once he finds a

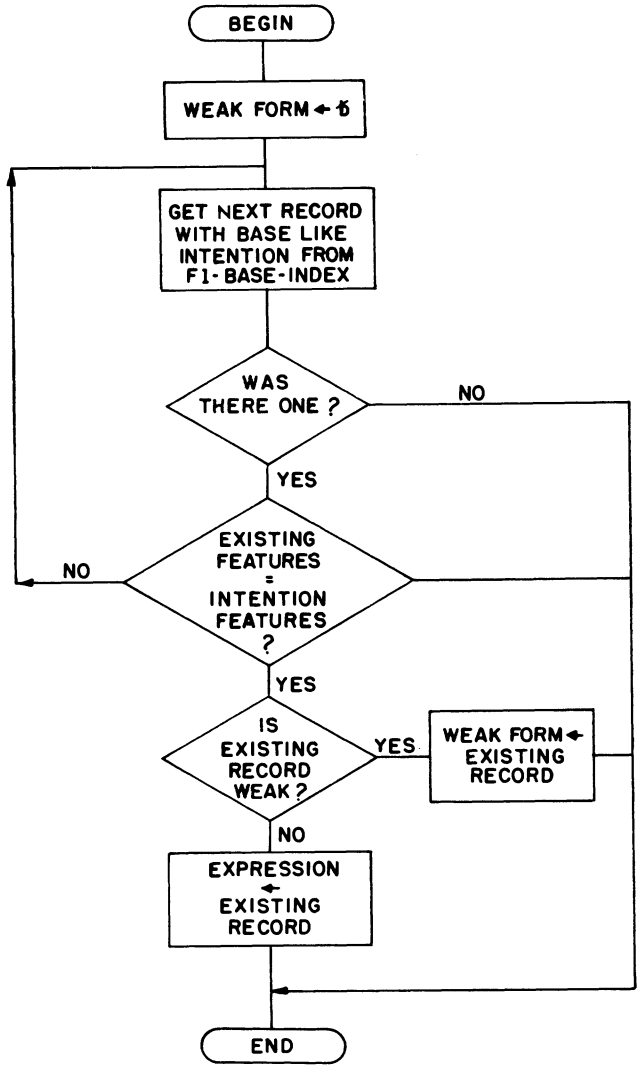

FIGURE 8.—Expressive rote

file 2 affix that might express some unflagged part of his intentions, he returns to the candidate expression to see if it already contains the affix.

When the child has decided upon the morphemes he wishes to lexicalize, he proceeds to apply file 5 implications to select between possible allomorphs on the basis of co-occurrence data. Then he linearizes the morphemes by a sorting procedure based on rank-order information stored on all file 2 items (see figs. 11 and 21). Following linearization, the child applies his file 4 morphophonological productions to the concatenated morphemes. First,

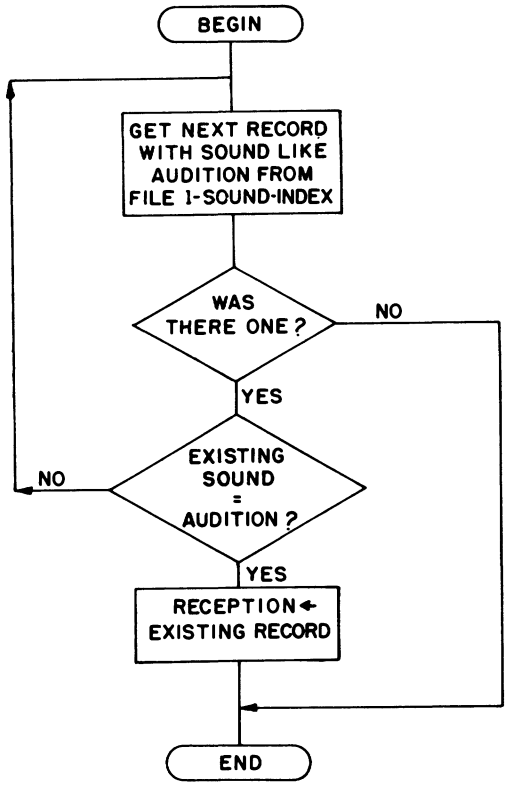

FIGURE 9.—Expressive rote

all selectional productions apply simultaneously, and then all modificational productions apply simultaneously.

Receptive combination.—This process (fig. 12) might alternatively be called decomposition or analysis. The child takes the form that he could not find in file 1 and tries to find at least part of it in either file 3 or file 1. He then takes the remaining phonological segments and tries to find them in file 2. Finally, he combines the meaning from files 1 or 3 with the meaning from file 2 to derive the final reception. The details of this procedure involve the treatment of material that cannot be located in any file. In particular, the process decides whether the "untype" (i.e., the morphological class of the unknown part of the word) is "root," "suffix," or "prefix." This information will be used later in acquisitional processing.

Analogy

When both rote and combination fail, the child attempts to apply analogy (fig. 13). Expressive analogy begins by examining the rhyming structure of the input root (i.e., the root that is to be inflected). In the context

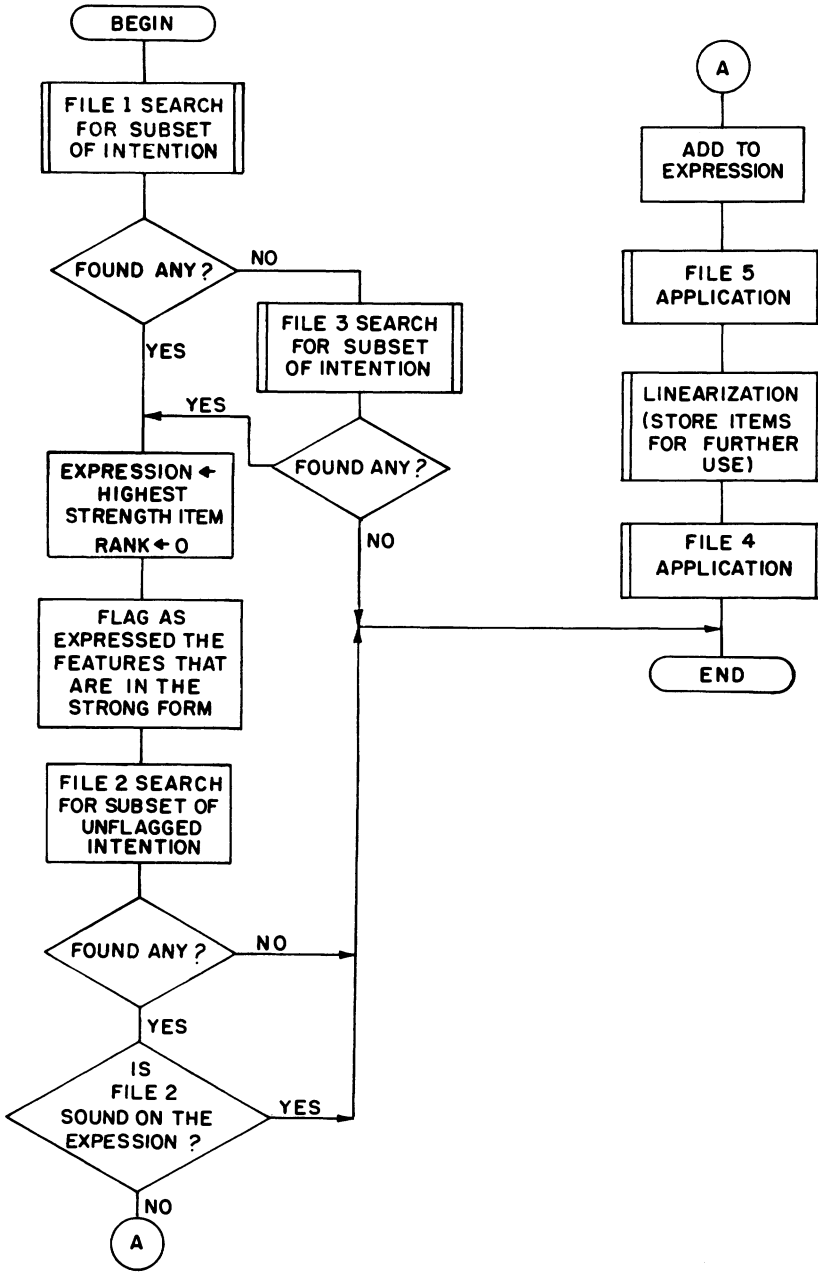

FIGURE 10.—Expressive combination

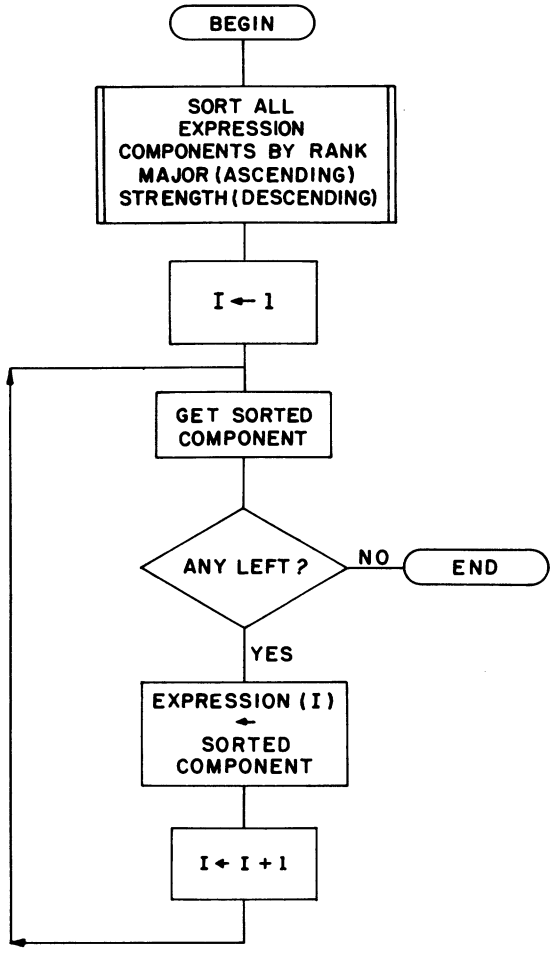

FIGURE 11.—Linearization

of a nonce probe test, the input root would be a newly learned file 1 item. The child first pulls off the last vowel of the input root and any following consonants as the rhyming string (Rhymestr) and saves the rest of the item (Beg) for further use. He then searches through a table of sound segments for potential initial clusters. Next, he takes the initial cluster he has chosen and attaches it to the rhyming string. Thus *wug* → (*w*)(*ug*) and then (*b*)(*ug*) → *bug*. The child then looks up the candidate root (i.e., *bug*) in file 1 to see if there is an item with a set of affixes with the same meaning, in terms of semantic features, as needed for the inflection of the input root. If so, the front of this word is pulled off and the front of the input record (Beg) is put into its place. The result is an analogy.

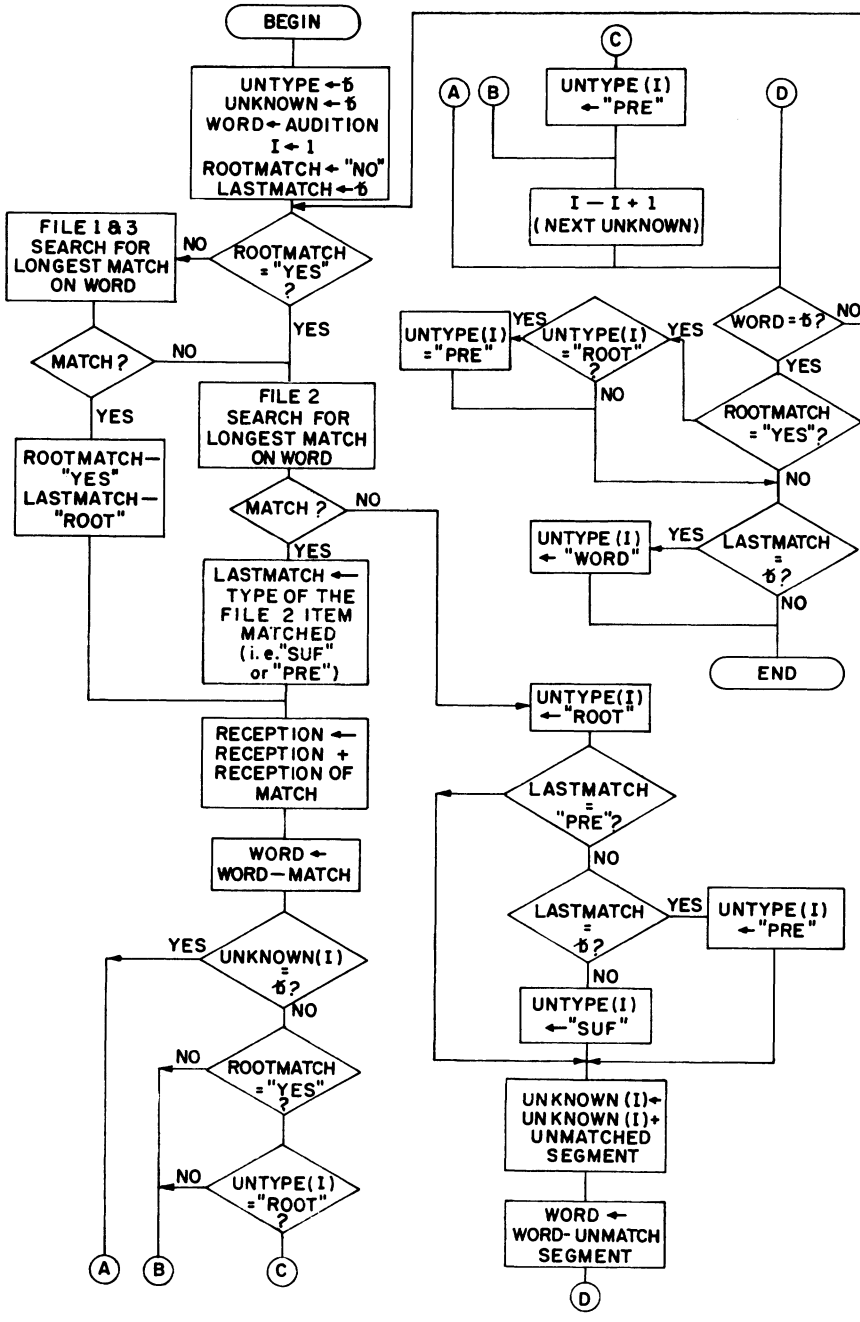

FIGURE 12.—Receptive combination

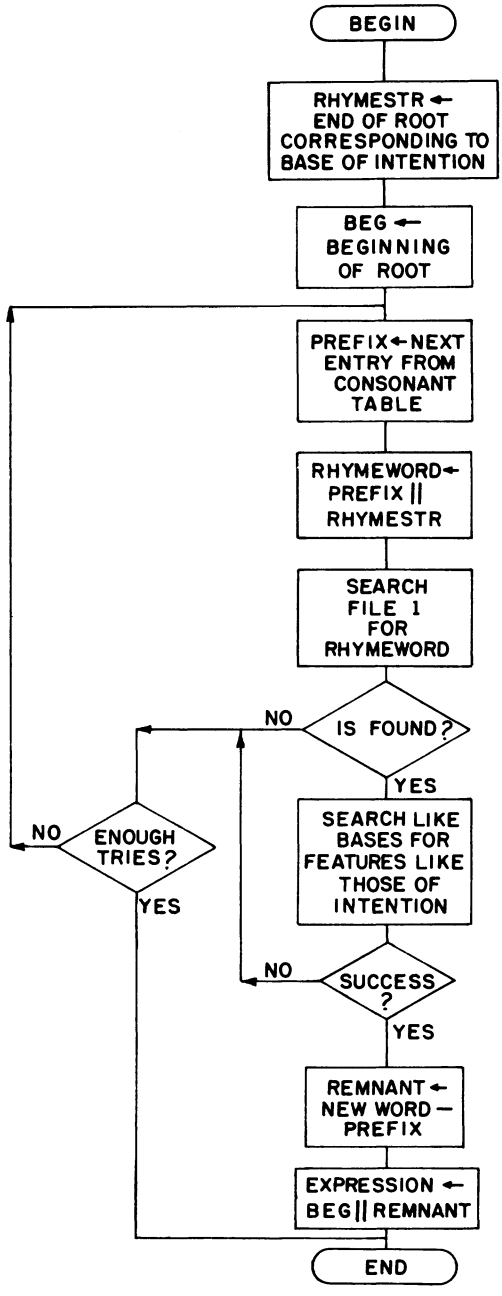

FIGURE 13.—Expressive analogy

Receptive analogy is not yet implemented. Although it is possible to imagine how analogy could operate in reception, the kinds of outputs it could produce would seem to be a proper subset of the kinds of outputs that could be produced by receptive combination.

CORRECTION

Correction compares the products of application with other information available to the child. The four types of disequilibrated pairs have already been presented in some detail. Figures 14 and 15 display in somewhat greater detail the logic underlying their formation.

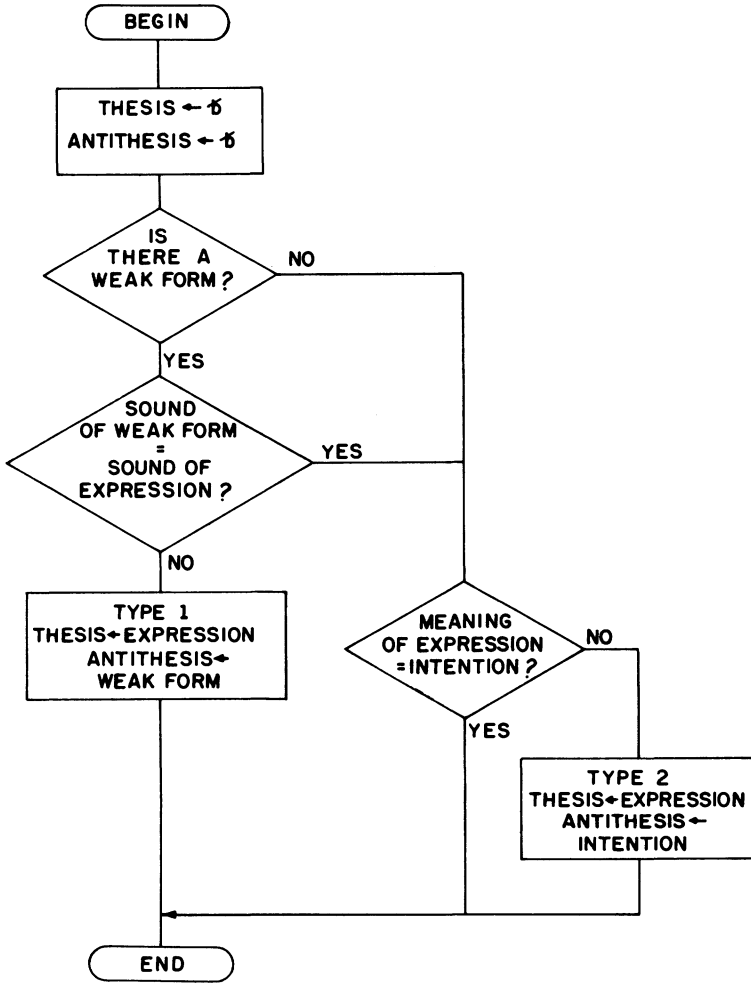

FIGURE 14.—Expressive correction

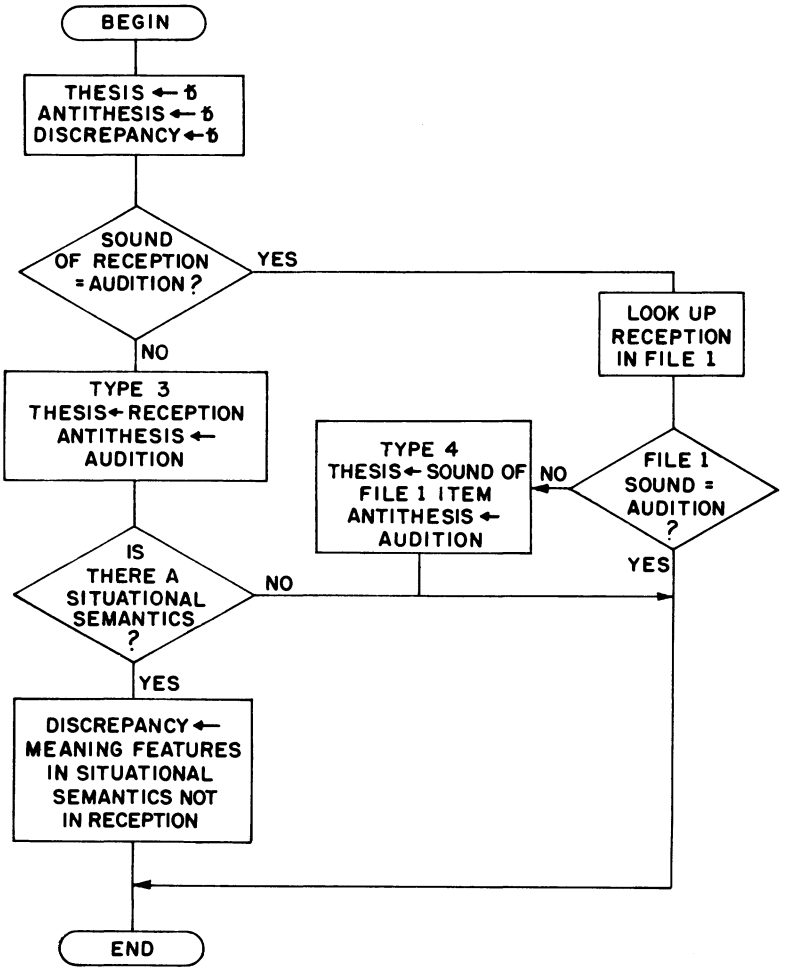

FIGURE 15.—Receptive correction

Two types of disequilibrated pairs can be formed in expression. Type 1 pairs are formed when there is a weak form whose sound does not match the sound of an expression. When there is no weak form or when its sound matches the sound of the expression, the child tests to see if he has expressed everything he intended to say. If not, a type 2 pair is formed. Note that a single expression can only participate in one disequilibrated pair.

In reception, a type 3 pair is formed when the sound of the reception does not match the (sound of the) audition. If the situation is rich in information, it may also be possible to detect some aspects of the situation that are not included in the reception. If a type 3 pair is not formed, the child checks

to see if the sound of the reception matches the form of whatever he might have in file 1. This type of correction allows the child to weed out erroneous forms he may have acquired from his own combinations.

ACQUISITION

When there is no antithesis, there is no formation of a disequilibrated pair. In this case, the system is in equilibrium and acquisition serves merely to strengthen the forms that were used in generating the expression or reception. In expressive acquisition (fig. 16) the child not only strengthens his forms, but, if they are not yet in file 1 as a unit, he adds them to that file.

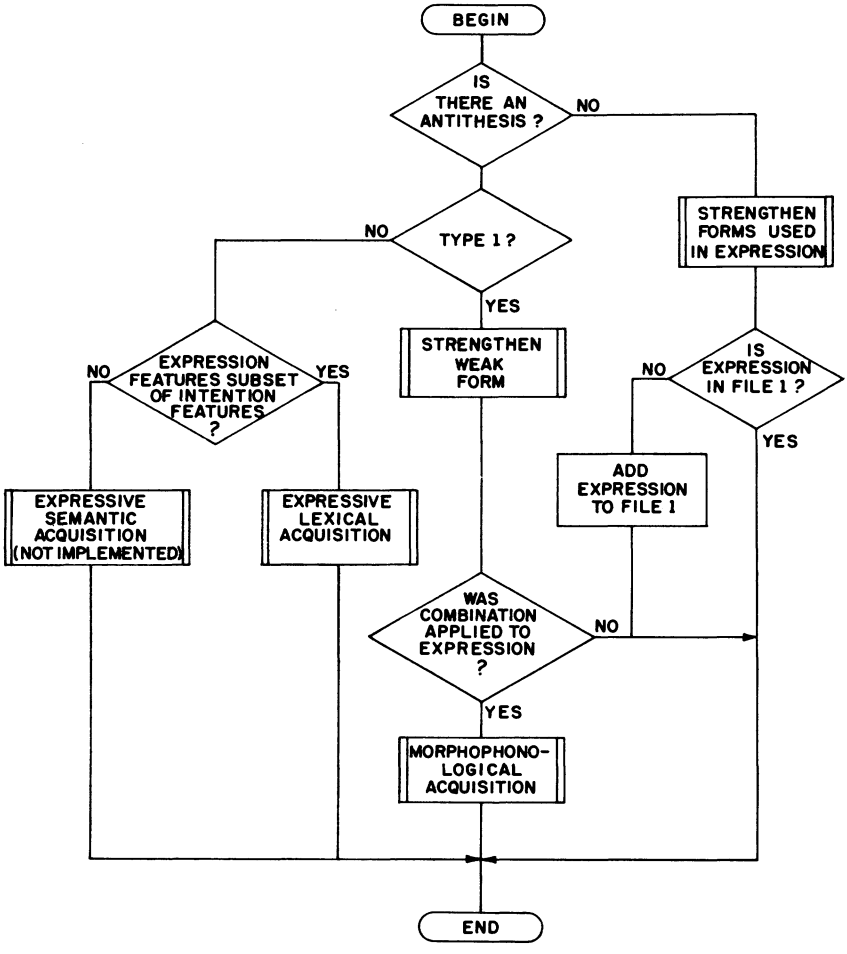

FIGURE 16.—Expressive acquisition

Expressive Acquisition

When there is a disequilibrated pair in expression, it may be of type 1 or of type 2. If the pair is a type 1 pair, its thesis must have been an expression generated by combination or analogy, and its antithesis must have been generated by rote as a weak form. Acquisition first strengthens the weak form in order to minimize future errors. Then, if the thesis was generated by combination, morphophonological acquisition is used to improve the performance of expressive combination. The operation of morphophonological acquisition will be detailed below.

If the disequilibrated pair is of type 2, there must be a mismatch between what the child intended to express and what he was actually able to express. If this mismatch is due to a semantic overgeneralization, the feature sets of the intention and the expression will be partially disjoint. In this case, expressive semantic acquisition will occur. This kind of nonmorphological processing is not implemented in the current simulation. If, on the other hand, the features of the expression are a proper subset of the features of the intention, expressive lexical acquisition can occur. This process (fig. 17) simply takes the features that were not expressed and places them in a file of unexpressed intentions called file 6. If the unexpressed intentions are already in that file, their expression indices are strengthened.

Receptive Acquisition

As in expressive acquisition, there are three major alternatives in receptive acquisition (fig. 18). First, if there is no antithesis, all the forms used in generating the reception are strengthened. Second, if the disequilibrated pair is of type 4, then there must be something wrong with a file 1 item. If this same file 1 item has caused problems in the past, its strength will have been decremented repeatedly and may now have reached a certain minimum value. When strength reaches this minimum level, the item is deleted from the file. This is the end of processing for type 4 pairs.

The third type of receptive acquisition works on type 3 pairs. Such pairs have a mismatch between what is heard and what is understood. The uncomprehended part of the audition (see fig. 12) is called the unknown. If the child is able to isolate a set of features in the situation that are not included in the reception, he can attempt receptive lexical acquisition (fig. 19).

Receptive lexical acquisition works to associate an unknown sound sequence (see fig. 12) with some unexpressed intention (see fig. 17). If the unknown is discontinuous, acquisition is terminated. If there is no discrepancy between the meaning of the reception and the situational semantics, the child adds the unknown material to the surrounding morphemes as new allomorphs. For example, if the reception of *ablakot* is *ablak* ("window") + *t* ("accusative"), then the unknown is *o*. The new allomorphs will then be *ablako* and *ot*.

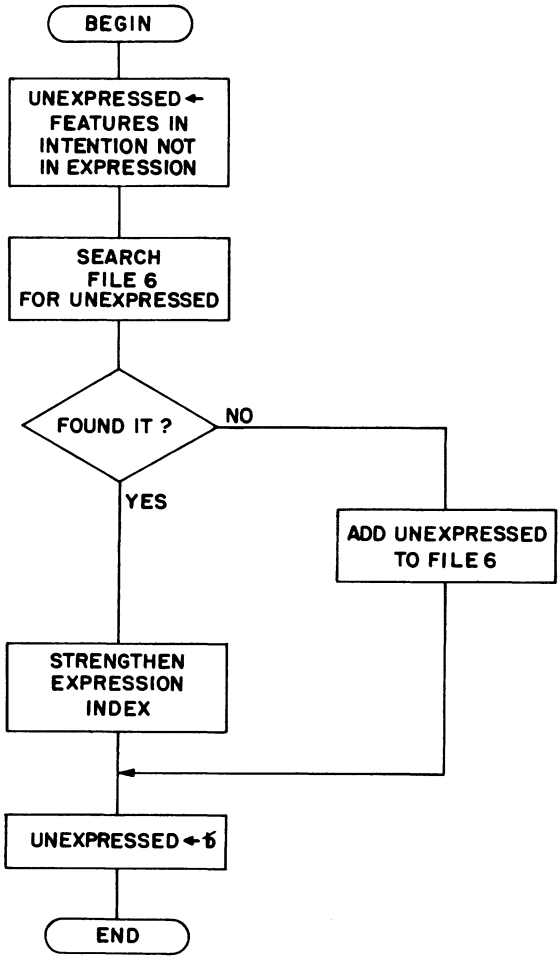

FIGURE 17.—Expressive lexical acquisition

If there is a discrepancy between the reception and the semantics of the situation, the child looks in file 6 to see if the discrepancy corresponds to some meaning he has been intending to express. If he finds it, he takes the morphological class of the unknown from receptive combination and adds the unknown and the unexpressed to the appropriate lexical file. If there is no file 6 intention corresponding to the discrepancy, the child looks in files 2 and 3 for material corresponding to the meaning discrepancy. If he finds an item with a meaning matching the meaning discrepancy, he adds the unknown as a new allomorph of that item.

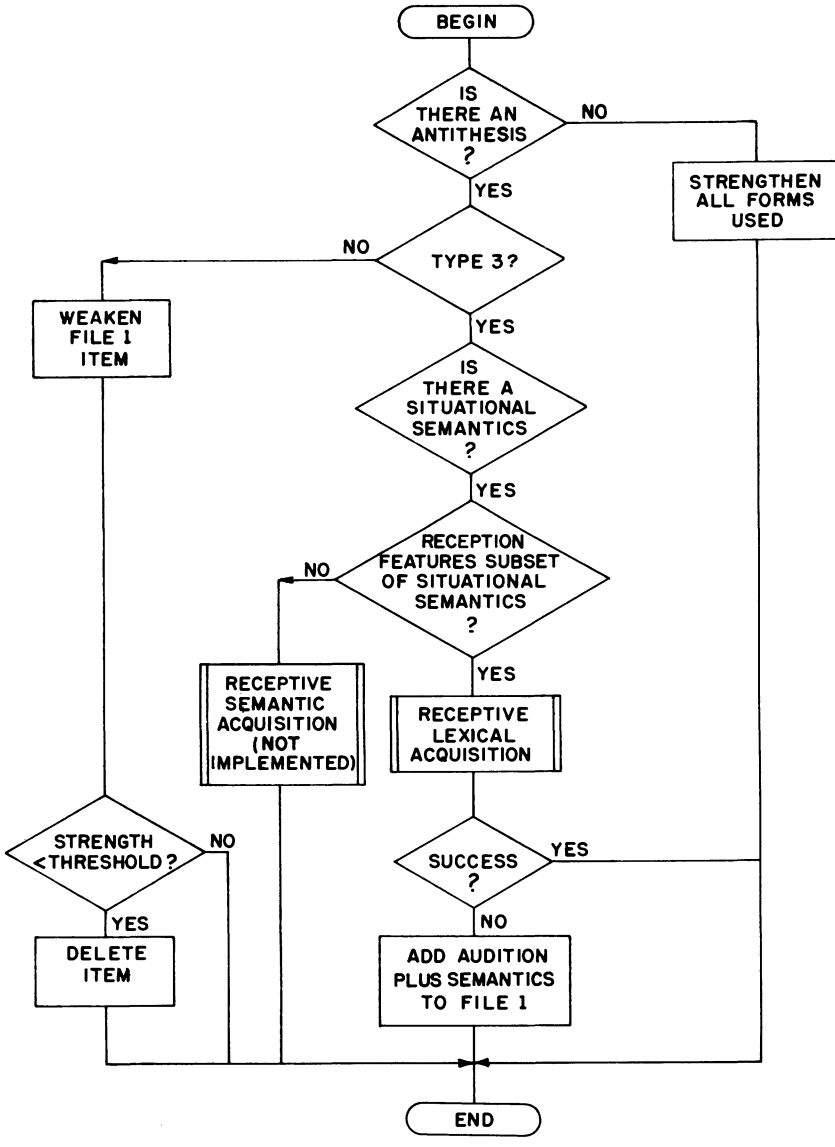

FIGURE 18.—Receptive acquisition

Morphophonological Acquisition

Type 1 disequilibrated pairs are rich in formal information that can be used to extract morphophonological productions. Figure 20 lists the three types of acquisition that may result from type 1 pairs.

Positional ranking.—When morphemes are incorrectly ordered, the positional ranking procedure works to adjust the rank of the item as coded on

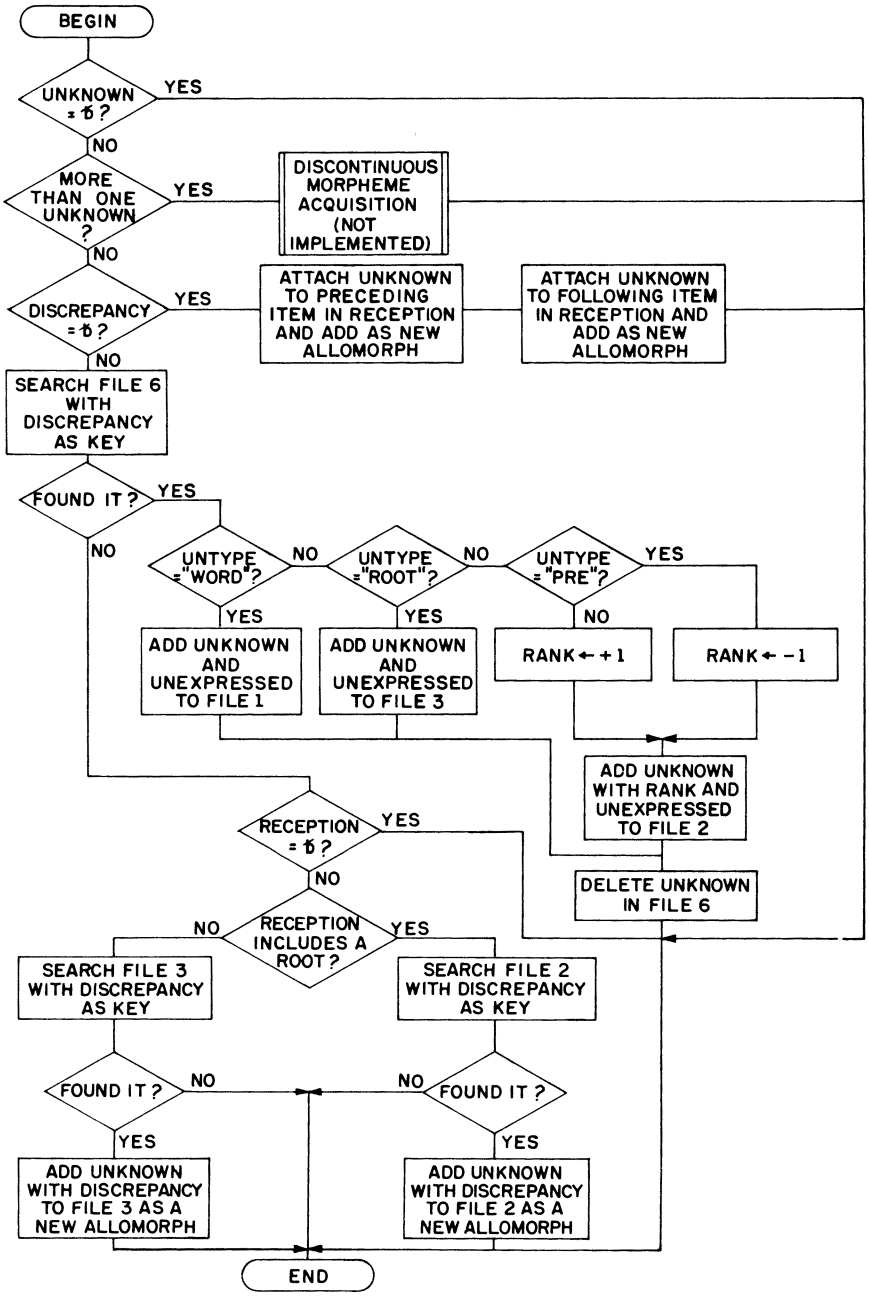

FIGURE 19.—Receptive lexical acquisition

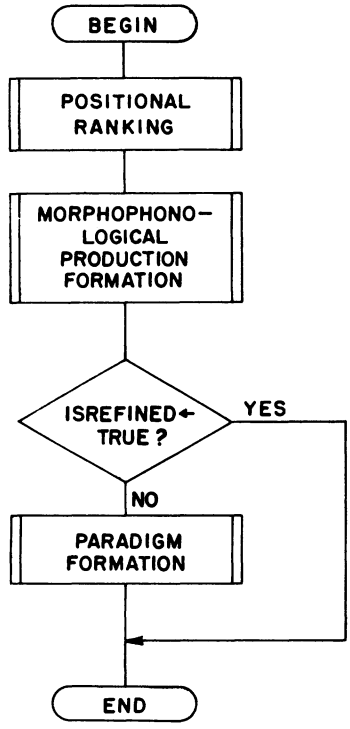

FIGURE 20.—Morphophonological acquisition

its lexical record (fig. 21). All prefixes start out with a rank of -1 and all suffixes start out with a rank of +1. If the prefix A is ordered after the prefix B in the expression, but before the prefix B in the weak form, the rank of prefix A is decremented by −1. Similarly, if suffix A is ordered before suffix B in the expression, but after suffix B in the weak form, the rank of suffix A is incremented by +1.

Morphophonological production formation.—The process of production acquisition (fig. 22) was discussed in some detail in Chapter III. The process first compares the expression with the weak form to extract a modification affecting a single segment. If no production had been applied to that segment, the child searches for an existing file 4 cycle 3 production with such a modification. If he finds one, he uses the new pair to prune the production down. If he finds no relevant production, he begins a new production. If a production had already been applied to that segment, he weakens the overgeneralized production and attempts cycle 4 selection production acquisition (fig. 23). The selection production acquisition procedure places mismatched allomorphs into brackets and isolates the context determining the selection between allomorphs.

Paradigm formation.—The process of paradigm formation (fig. 24) has

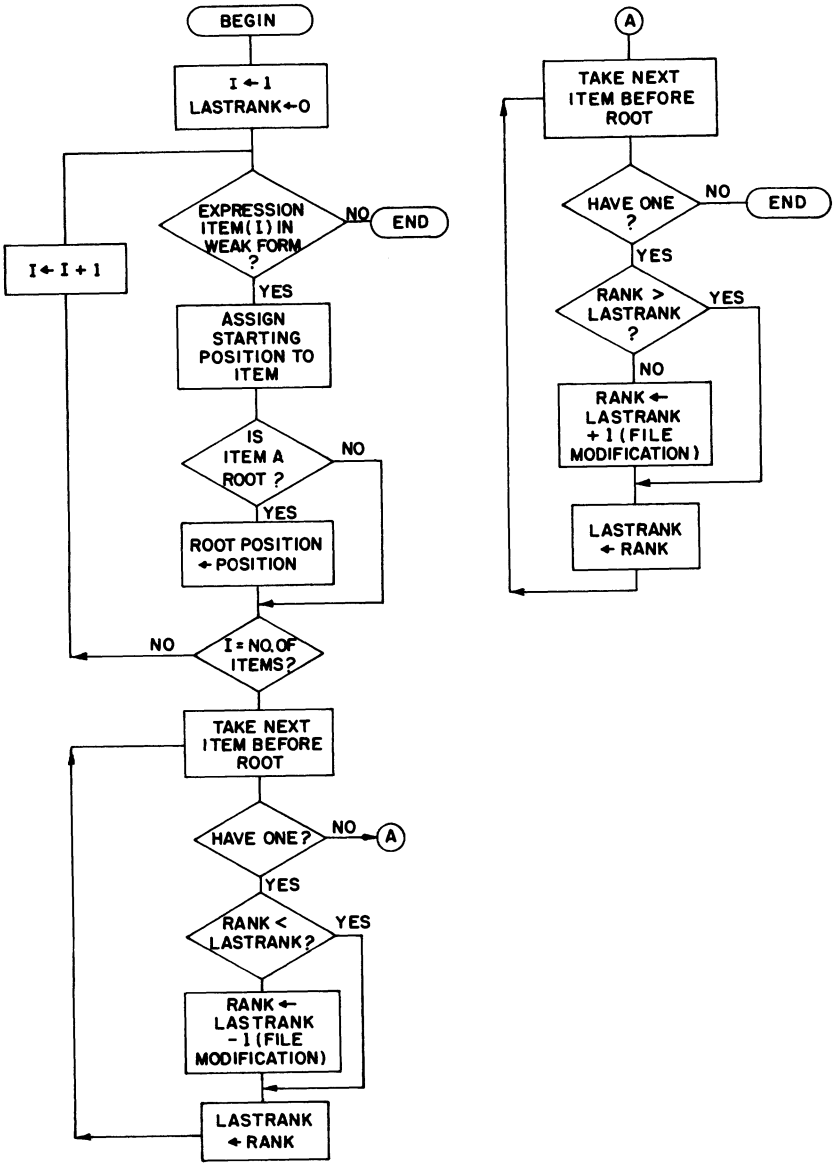

FIGURE 21.—Positional ranking

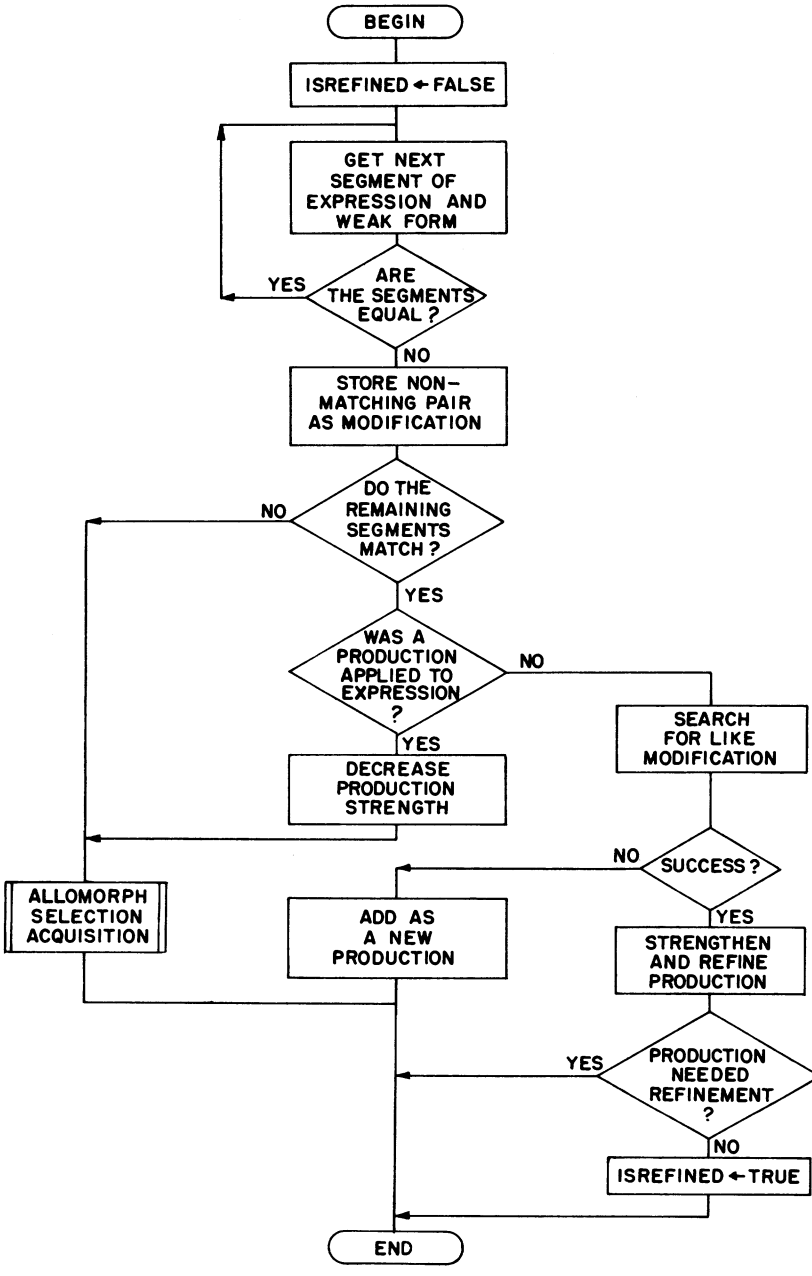

FIGURE 22.—Morphophonological production formation

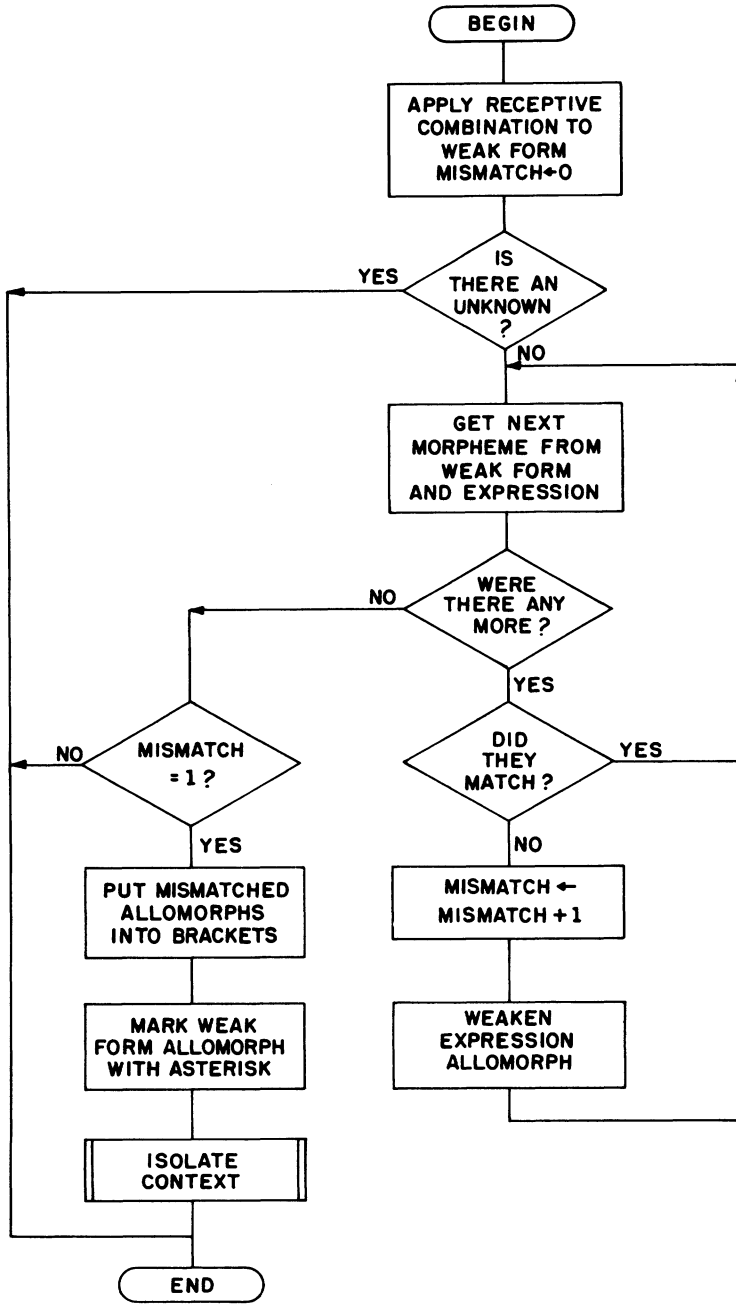

FIGURE 23.—Allomorph selection production acquisition

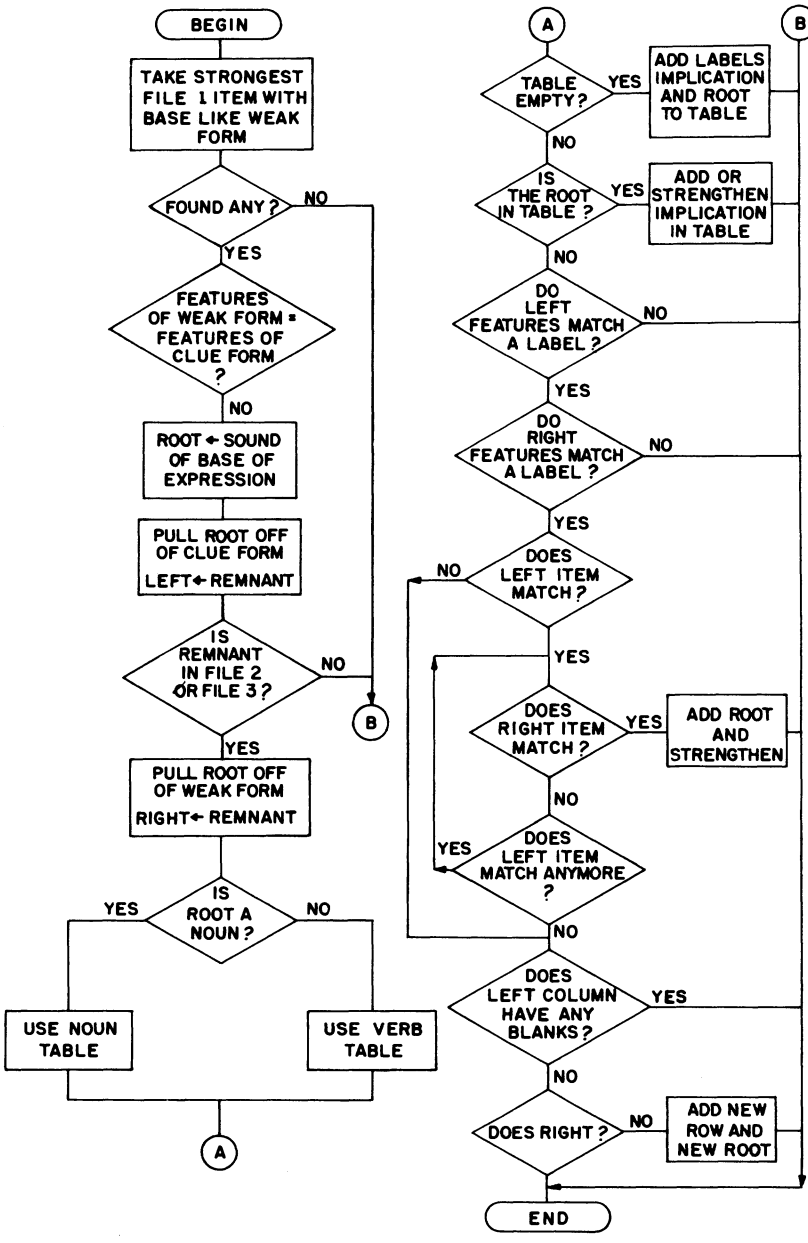

FIGURE 24.—Paradigm formation

also been discussed in some detail in Chapter III. The process first searches file 1 for another amalgam with a base (i.e., a root) like that of the weak form. This item becomes the clue form. By pulling the root off of the clue form, the child extracts a remnant. Thus, in the clue form *das Wasser* (nominative), the root is *Wasser* and the remnant is *das*. Similarly, the remnant of the weak form *dem Wasser* (dative) is *dem*. The child then goes to the nominal or verbal implicational table and tries to locate the *dem* ↔ *das* implication. He can add the implication if (*a*) the table is empty; or (*b*) the root *Wasser* is found at the head of a row, that is, is marked for class membership; or (*c*) the implication is already there; or (*d*) there are no empty spaces in either column.

APPENDIX B

GLOSSARY

Acquisition	The creation of new productions and the modification or destruction of old ones
Affix	A morpheme which must be attached to a root and cannot appear alone
Allomorph	One of possibly several different sound shapes assumed by a morpheme; the allomorphs of the English plural are: [z], [s], and [ɨz]
Amalgam	A word that has not been analyzed into its component morphemes
Analog	A form that rhymes with the given form
Analogy	A procedure which generates a target form from a given form by locating two other known forms related to each other functionally as the given is related to the target and applying their differences to the target, i.e., *wug* : X : : *bug* : *bugs*, where X → *wugs* (*ana* ["back, again"] + *logos* ["word"])
Analysis	The breaking up of a larger unit into its component pieces
Antithesis	A piece of data contradicting a thesis
Applicability	The number of combinations to which a production should apply divided by the total number of combinations produced by the speaker
Application	The use of forms in reception and expression
Audition	A verbal message as detected by the sensory apparatus
Citation form	The form in which a root appears without affixes
Combination	A procedure which generates an expression or a reception by union of its component pieces
Competence model	An account of the relations inherent in a set of structures
Context-sensitive production	A production which operates only when certain contextual requirements are satisfied; the context itself is not rewritten by the production; in syntax, context-sensitive productions take the shape: XAY → XBY
Contextual generalization	A procedure which uses co-occurrence data to extract positional classes
Correction	The comparison of expressions and receptions with possibly contradicting data
Correctness	The number of combinations to which a production applies divided by the total number of combinations to which it should apply
Cycle 1	Amalgam acquisition
Cycle 2	Allomorph acquisition

APPENDIX B (*Continued*)

Cycle 3	Modification production acquisition
Cycle 4	Selection production acquisition
Cycle 5	Implicational table acquisition
Dialectic	The genesis of new structures through the continuing resolution of contradiction; some theorists tend to see the dialectic as synonymous with development (Riegel 1976), others as synonymous with the scientific method (Kemeny & Snell 1972), while others, such as Moore, reject it altogether
Discrepancy	A difference between what a listener understands from a reception and what he understands from the situation in which the reception occurred
Disequilibrated pair	An antithesis together with its thesis
Distinctive feature	A parameter of articulation and/or audition
Embedded	Contained within a larger not-yet-analyzed unit
Expression	The speaker's conversion of his intentions into verbal messages
Expression (an)	A set of forms (i.e., words) uttered by a speaker in an attempt to express his intentions
File 1	The set of amalgams
File 2	The set of affix allomorphs
File 3	The set of root allomorphs
File 4	The set of morphophonological productions
File 5	One or more tables of implications
File 6	The set of unexpressed intentions
Human-information processor	The learner and thinker as seen through the lenses of theories of artificial intelligence and information processing
Implication	A record of any type of co-occurrence of two items with some third item, i.e., *dem Wasser* (dative) and *das Wasser* (nominative) suggest *dem* ↔ *das*
Infix	An affix inserted into the middle of a root
Inflection	An affix
Insulation	Incrementation of the lexical strength of irregular forms
Intention	Something a speaker wants to communicate
Lexicon	The dictionary of a language, relating sounds to meanings
Linearization	Placement of an unordered set of elements into a linear order
Modification production	A production that deletes, adds, or permutes data on the basis of aspects of the context
Morpheme	The smallest meaningful sound unit (i.e., *dog*, *-ness*, *re-*)
Morphology	The system of morphemes together with the system of morphophonological productions
Morphophonological production	A production which either selects or modifies allomorphs on the basis of data in the morphological context
Morphophonology	The system of productions governing the alterations morphemes undergo when combined with other morphemes in words (*morpho* ["shape"] + *phono* ["sound"] + *logos* ["study"])
Nonce	Having a novel meaning; here the meaning is one devised to suit the experimental context
Nonce probe	A nonce root used as a probe
Null allomorph	An allomorph which has no content, i.e., one which is empty
Overanalysis	Segmentation of a morpheme into its purported component pieces
Performance model	An account of the functioning of the human-information processor
Phonology	The sound system of a language, including (1) lexical representations, (2) morphophonological productions, (3) sandhi productions, (4) phonotactic productions, and (5) phonological predispositions

APPENDIX B (*Continued*)

Phonotactics	The system of limitations on the phonological structure of allomorphs
Portmanteau lexicalization	Use of a single morpheme to express content otherwise expressed by several morphemes
Positional class	A group of items occurring in a fixed position with respect to some other group of items
Predisposition	A tendency to reduce certain "unnatural" articulations to other more "natural" ones
Prefix	An affix attached to the beginning of a root
Priming	Presentation of a word rhyming with a target immediately before an attempt to elicit an inflected form of the target
Probe	A stimulus root used to elicit a morphophonological formation
Production	A rewriting operation in a performance model
Productivity	A state which a production obtains when it begins to apply to items that were not involved in its acquisition
Pruning	The deletion of noncriterial features in a production through successive comparisons
Pushdown stack	A series of alternatives ordered so that an alternative only applies when alternatives that are higher in the stack no longer apply
Reception	The listener's conversion of verbal messages into received understandings
Reception (a)	A set of understandings derived by a listener from an audition
Root	A morpheme which can appear alone
Rote	A procedure which looks up a whole intention or a whole audition in the lexicon without using any morphological analysis
Rote memorization	Acquisition of a new lexical item without any morphological analysis
Rule	A rewriting operation in a competence model
Sandhi	Selections among or modifications of allomorphs on the basis of information outside the word in which the allomorph occurs
Segment	A bundle of coarticulated distinctive features
Selection production	A production that chooses between a set of predefined alternatives on the basis of aspects of the context
Semantics	Meaning
Structural description	The input or "left side" of a production
Suffix	An affix attached to the end of a root
Thesis	An expression or reception generated by the language user
Umlauting	Movement of a back vowel to the front
Underanalysis	Treatment of a morphophonological combination as if it were a unit
Unexpressed	Refers to a part of an intention that cannot be mapped onto an expression
Unknown	Refers to a part of an audition that cannot be mapped onto a reception
Weak form	A file 1 rote amalgam with a long latency to lexicalization
Word	A combination of one or more morphemes into an intonational unit

APPENDIX C

SYMBOLS

Symbol	Meaning
/ /	Phonological representation
[ ]	Phonetic representation
⟨ ⟩	Allomorphic variants
→	Rewriting
/	Context specification
−	Negative value of a distinctive feature
+	When followed by a space, marks a morpheme boundary, i.e., *good* + *ness;* when not followed by a space, marks a positive value of a distinctive feature, i.e., [+voiced]
#	Word boundary
X	Any string of units
*	When used in slant brackets, marks an allomorph to be selected; when used outside slant brackets, marks an incorrect form
↔	Bidirectional implication
=	Sound-meaning association
- - -	Association between semantic components
~	Alternates with
——	Position in context of unit being modified
( )	Optional material
[ ]	Selection of all items
{ }	Selection of one item
Quotes	A word or morpheme as a meaning unit
Italics	A word or morpheme as a sound unit
ϕ	The null element, a null allomorph
ƀ	In flow charts, a blank field

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