

## 9 On the Bases of Phonology\*

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### I

Our central concern in this section is the framework to be used for characterizing speech in a linguistic description. It is required of such a framework that it not only make it possible to represent the observed data with a sufficient degree of accuracy, but also that this representation lead to reasonable, fruitful, insightful, and simple descriptions of the relevant facts. As an illustration consider the following example.

It is an easily observed fact that speakers of English can produce plural forms of nouns regardless of whether or not they have ever heard the noun before. This bit of linguistic behavior is usually described by saying that in forming the regular plural [z] is added if the noun ends in [s z š ž č ž] (e.g., *busses, causes, bushes, garages, beaches, badges*); [s] is added if the noun ends in [p t k θ f] (e.g., *caps, cats, cakes, fourths, cuffs*); and [z] is added in all other cases.

Underlying this rule is the assumption that the speech signal is a linear sequence of discrete entities variously termed phonemes, sounds, segments, allophones, and so on. It is this assumption which makes it possible to give the concise account quoted above. Without making use of the phoneme these facts can be expressed only with the greatest laboriousness as one can easily convince oneself by trying to give the rule in terms of syllables, words, or such clear acoustical properties as periodicity, formant behavior, noise spectrum, and the like.

The layman may regard as somewhat paradoxical our terming as an assumption the proposition that speech is a linear sequence of sounds. It does not seem to be widely known that when one examines an actual utterance in its purely physical manifestation as an acoustical event, one does not find in it obvious markers which would allow one to segment the signal into entities standing in a one-to-one

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<sup>1</sup>For discussion of some of  
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relationship with the phonemes that, the linguist would say, compose the utterance.<sup>1</sup>

The inability of instrumental phoneticians to propose a workable segmentation procedure has, however, not resulted in a wholesale abandonment of the phoneme concept. Only a few easily frightened souls have been ready to do without the phoneme. The majority has apparently felt that absence of a simple segmentation procedure does not warrant abandoning the discrete picture of speech. The most important justification that could perhaps be offered for this stand is that almost every insight gained by modern linguistics from Grimm's Law to Jakobson's distinctive features depend crucially on the assumption that speech is a sequence of discrete entities. In view of this fact many linguists have been willing to postulate the existence of discrete entities in speech even while accepting as true the assertion of instrumental phoneticians that there are no procedures for isolating these entities. There are numerous precedents in science for such a position. For instance, Helmholtz postulated that electric current is a flow of discrete particles without having isolated or even having much hope of isolating one of these particles. The status of the phoneme in linguistics is, therefore, analogous to that of electrons in physics, and since we do not regard the latter as fictional, there is little reason for applying this term to phonemes. They are every bit as real as any other theoretical entity in science. It now appears, moreover, that the insurmountable difficulties encountered in the attempt to state a procedure for segmenting the speech signal are no bar to constructing a device which will transform (continuous) speech into sequences of discrete entities.<sup>2</sup>

In addition to viewing utterances as composed of phonemes, the phonemes themselves shall be regarded here as simultaneous actualizations of a set of attributes. This view can be traced back almost to the very beginnings of abstract concern with language since rudimentary schemes for classifying speech sounds are implicit already in the earliest alphabets. This is hardly surprising, for it is all but self-evident that speech sounds form various intersecting classes. Thus, for instance, the final sounds in the words *ram*, *ran*, *rang* share the property of nasality; i.e., the property of being produced with a lowered velum, which allows air to flow through the nose. In a similar fashion, the sound [m] shares with the sounds [p] and [b] the property of being produced with a closure at the lips, or, as phoneticians would say, of having a *labial point of articulation*.

The proposed frameworks differ, of course, from one another, and up to the present, phoneticians have not agreed on any single framework that is to be used in all linguistic descriptions. In the present study I shall utilize the *distinctive feature framework* that is due primarily to R. Jakobson. Since the distinctive features have

<sup>1</sup>For discussion of some of the evidence, see P. Ladefoged's contribution to the Teddington Symposium, *The Mechanization of Thought Processes*, National Physical Laboratories, Symposium #10 (London 1959). Analogous observations have been made also with regard to other physiological, motor aspects of speech; cf. the report by Menzerath on his x-ray moving pictures of speech at the Fourth International Congress of Linguists (Copenhagen, 1938).

<sup>2</sup>For a discussion of these procedures see D. MacKay "Mindlike Behaviours of Artefacts," *Proc. J. for the Phil. of Sci.*, 2, (1959) 105-21, and M. Halle and K. N. Stevens, "Speech Recognition: A Model and a Program for Research," pp. 604-612 in this volume.

been described in detail elsewhere, I shall present here only the articulatory correlates of the most important features and comment briefly on some of them.<sup>3</sup>

### ARTICULATORY CORRELATES OF THE DISTINCTIVE FEATURES (PARTIAL LIST)

In the description below four degrees of narrowing in the vocal tract will be distinguished.

The most extreme degree of narrowing, termed *contact*, is present when two opposite parts of the vocal tract touch. Stop consonants such as [p] [d] or [k] are articulated with *contact* at different points in the vocal tract.

A less extreme degree of narrowing, termed *occlusion*, is one capable of producing turbulence. *Occlusions* are characteristically involved in the production of fricatives such as [v] [s] or [ʃ].

The next degree of narrowing, termed *obstruction*, is exemplified in the articulation of glides such as [w] or [j].

The fourth degree of narrowing, termed *constriction*, is that manifest in the articulation of diffuse ("high") vowels such as [i] or [u].

**VOCALIC—NONVOCALIC:** vocalic sounds are produced with a periodic excitation and with an open oral cavity, i.e., one in which the most extreme degree of narrowing is a *constriction*. Nonvocalic sounds are produced with an oral cavity narrowed at least to the degree of an *obstruction* or with an excitation that is not periodic.

**CONSONANTAL—NONCONSONANTAL:** consonantal sounds are produced with *occlusion* or *contact* in the central path through the oral cavity; nonconsonantal sounds are produced with lesser degrees of narrowing in the central path of the oral cavity.

**GRAVE—NONGRAVE:** grave sounds are articulated with a primary narrowing located at the periphery of the oral cavity (i.e., at the lips or in the velar or pharyngeal region); nongrave sounds are articulated with a primary narrowing located in the central (i.e., dental-alveolar-palatal) region of the oral cavity.

**FLAT—NONFLAT:** flat sounds are produced with a secondary narrowing at the periphery of the oral cavity; nonflat sounds are produced without such a narrowing.<sup>4</sup>

<sup>3</sup>The fact that in the following list, reference is made only to the articulatory properties of speech and nothing is said about the acoustical properties, is not to be taken as an indication that the latter are somehow less important. The only reason for concentrating here exclusively on the former is that these are more readily observed without instruments. If reference were to be made to the acoustical properties of speech it would be necessary to report on experimental findings of fair complexity which would expand this paper beyond its allowed limits. For a fuller discussion, see R. Jakobson, C. G. M. Fant, M. Halle, *Preliminaries to Speech Analysis* Cambridge, Mass.: M.I.T. Press, 1963.

<sup>4</sup>Sounds produced with a single narrowing which is located at the periphery of the oral cavity may be classed either as flat or nonflat; they are, of course, grave. Sounds articulated with two narrowings, of which one is central and the other peripheral, are acute and flat; whereas sounds articulated with two narrowings both of which are peripheral are grave and flat.

**DIFFUSE—NONDIFFUSE:** degree equals or e: the vocal tract; n: either of a lesser d: dividing line betw: other sounds: for 1: for other sounds, alveolar and palat

**COMPACT—NONCOMPACT:** produced with a f: or narrowings of: oral cavity that is

**STRIDENT—NONSTRIDENT:** sounds are produc: edged obstacle or: siderable noisiness: Nonstrident sound: of the factors ment

**VOICED—VOICELESS:** voi: voiceless sounds ar

**NASAL—NONNASAL:** nas: allowing air to pass: produced with a rai: nose from the rest

**CONTINUANT—INTERRUPTANT:** which the passage f: of an *occlusion*; int: the passage from th

The first two features of speech into liquids, [r], [l], which are vocalic and consonantal; consonantal. This division vowels (consonants).

A further difference between the two systems lies in the treatment of consonants. In most star features which are totally articulation," whereas vowels in the distinctive features have the same features, *diffuse*

<sup>5</sup>Over 2000 years ago, Hindu their solution differs from the in terms of their points of arti

**DIFFUSE—NONDIFFUSE:** diffuse sounds are produced with a narrowing which in degree equals or exceeds that of a *constriction* and is located in the front part of the vocal tract; nondiffuse vowels are articulated with narrowings which are either of a lesser degree or are located in the back part of the vocal tract. The dividing line between *front* and *back* is further retracted for vowels than for other sounds: for the vowels, *front* includes almost the entire oral cavity, while for other sounds, the dividing line between *front* and *back* runs between the alveolar and palatal regions.

**COMPACT—NONCOMPACT:** this feature is restricted to vowels. Compact vowels are produced with a forward flanged oral cavity which contains no *constrictions* or narrowings of higher degree; noncompact vowels are produced with an oral cavity that is not forward flanged.

**STRIDENT—NONSTRIDENT:** this feature is restricted to consonantal sounds. Strident sounds are produced by directing the air stream at right angles across a sharp edged obstacle or parallel over a rough surface, thereby producing considerable noisiness which is the major acoustical correlate of stridency. Nonstrident sounds are produced with configurations in which one or several of the factors mentioned are missing.

**VOICED—VOICELESS:** voiced sounds are produced by vibrating the vocal cords; voiceless sounds are produced without vocal vibration.

**NASAL—NONNASAL:** nasal sounds are produced by lowering the velum, thereby allowing air to pass through the nasal pharynx and nose; nonnasal sounds are produced with a raised velum which effectively shuts off the nasal pharynx and nose from the rest of the vocal tract.

**CONTINUANT—INTERRUPTED:** continuant sounds are produced with a vocal tract in which the passage from the glottis to the lips contains no narrowing in excess of an *occlusion*; interrupted sounds are produced with a vocal tract in which the passage from the glottis to the lips is effectively closed by *contact*.

The first two features on the above list produce a quadripartite division of the sounds of speech into (1) vowels, which are vocalic and nonconsonantal; (2) liquids, [r], [l], which are vocalic and consonantal; (3) consonants, which are nonvocalic and consonantal; and (4) glides, [h], [w], [j], which are nonvocalic and nonconsonantal. This division differs from the traditional one—into vowels and nonvowels (consonants).

A further difference between most standard systems and the distinctive feature system lies in the treatment of two major classes of segments, the vowels and the consonants. In most standard systems these two classes are described in terms of features which are totally different: consonants are described in terms of "points of articulation," whereas vowels are described in terms of the so-called "vowel triangle." In the distinctive feature system, on the other hand, these two classes are handled by the same features, *diffuse-nondiffuse*, and *grave-acute*.<sup>5</sup>

<sup>5</sup>Over 2000 years ago, Hindu phoneticians had the idea of treating vowels and consonants together. Their solution differs from the one proposed here in that it classified vowels as well as consonants in terms of their points of articulation.



characterized in terms of dis- there. [s] is characterized as  
 onnasal, continuant, voice-  
 , grave, diffuse, nonstrident,  
 s [s] and [m], by which we  
 nothing but abbreviations  
 as feature complexes, rather  
 regarded hereinafter.

CONSONANTS OF ENGLISH

ð	n	s	z	ç	ʒ	ʃ	ʒ
-	-	-	-	-	-	-	-
+	+	+	+	+	+	+	+
-	-	-	-	-	-	-	-
+	+	+	+	-	-	-	-
-	-	+	+	+	+	+	+
-	-	+	-	-	-	-	-
+	+	-	+	-	-	+	+
-	+	+	-	+	-	+	-

veniently to classes of speech  
 Table 1 belong to the class of  
*vocalic* and *consonantal*. We  
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 share the features *grave* and  
 ures which would distinguish  
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 speech sounds forms a *natural*  
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 viduals cited above form *natural*  
 a *natural* class.  
 varied linguistic facts we con-  
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 of sounds which require long  
 characterization. As a case in point  
 is [s]. As was noted above, [ʒ]  
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 h the suffix [s] is added and is  
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express purpose of affording a convenient description of the rules for forming the English plural.

The total number of different distinctive features is quite small; there seem to be about fifteen. These 15 attributes are sufficient to characterize all segments in all languages. Since we cannot have knowledge of all languages—e.g., of languages which will be spoken in the future—the preceding assertion must be understood as a statement about the nature of human language in general. It asserts in effect that human languages are phonetically much alike, that they do *not* “differ from one another without limit and in unpredictable ways.” Like all generalizations this statement can be falsified by valid counter-examples. It can, however, not be proven true with the same conclusiveness. The best that can be done is to show that the available evidence makes it very likely that the statement is true. Most important in this connection is the fact that all investigations in which large numbers of languages have been examined—from E. Siever’s *Grundzüge der Phonetik* (1876) to Trubetzkoy’s *Grundzüge der Phonologie* (1939)—have operated with an extremely restricted set of attributes. If this can be done with about a hundred languages from all parts of the globe, there appears good reason to believe that a not greatly enlarged catalogue of attributes will be capable of handling the remaining languages as well. It is true that a small set of attributes suffices to describe the phonetic properties of all languages of the world, then it would appear quite likely that these attributes are connected with something fairly basic in man’s constitution, something which is quite independent of his cultural background. Psychologists might, therefore, find it rewarding to investigate the phonetic attributes, for it is not inconceivable that these attributes will prove to be productive parameters for describing man’s responses to auditory stimuli in general. It must, however, be noted that for purposes of linguistics, the lack of psychological work in this area is not fatal. For the linguist it suffices if the attributes selected yield reasonable, elegant, and insightful descriptions of all relevant linguistic data. And this in fact they accomplish.

II

It has been noted that in linguistic descriptions utterances are represented as sequences of discrete segments, which themselves are characterized by means of distinctive features. Although in many instances there is a one-to-one relationship between the segments and specific stretches of the acoustical signal, there are many instances where this relationship is anything but simple. The part of linguistics that is concerned with the relationship between segment (phoneme) and sound is called *phonology*.

A complete description of a language must include a list of all existing morphemes of the language, for without such a list the grammar would fail to distinguish a normal English sentence such as “it was summer,” from the jabberwocky “’twas summig.” Our purpose in preparing a scientific description of a language is, however, not achieved if we give only an inventory of all existing morphemes; we must also describe the structural principles that underlie all existing forms. Just as syntax must be more than an inventory of all observed sentences of a language, so phonology must be more than a list of its morphemes.

In order to generate a specific sentence it is obviously necessary to supply the grammar with instructions for selecting from the list of morphemes the particular morphemes appearing in the sentence. Instead of using an arbitrary numerical code which tells us nothing about the phonetic structure of the morphemes, it is possible—and also more consonant with the aims of a linguistic description—to utilize for this purpose the distinctive feature representation of the morphemes directly. In other words, instead of instructing the grammar to select item (#7354), we instruct the grammar to select the morpheme which in its first segment has the features *nonvocalic, consonantal, diffuse, grave, voiced*, and so on; in its second segment, the features *vocalic, nonconsonantal, diffuse, acute*, and the like; in its third segment, the features *vocalic, consonantal*, and so forth. Instructions of this type need not contain information about all features but only about features or feature combinations which serve to distinguish one morpheme from another. This is a very important fact since in every language only certain features or feature combinations can serve to distinguish morphemes from one another. We call these features and feature combinations *phonemic*, and we say that in the input instructions only phonemic features or feature combinations must occur.<sup>6</sup>

Languages differ also in the way they handle nonphonemic features or feature combinations. For some of the nonphonemic features there are definite rules; for others the decision is left up to the speaker who can do as he likes. For example, the feature of aspiration is nonphonemic in English; its occurrence is subject to the following conditions:

- All segments other than the voiceless stops [k], [p], [t] are unaspirated.
- The voiceless stops are never aspirated after [s].
- Except after [s], voiceless stops are always aspirated before an accented vowel.
- In all other positions, aspiration of voiceless stops is optional.

A complete grammar must obviously contain a statement of such facts, for they are of crucial importance to one who would speak the language correctly.

In addition to features which, like *aspiration* in English, are never phonemic, there are features in every language that *are* phonemic, but only in those segments where they occur in conjunction with certain other features; for example, the feature of voicing in English is phonemic only in the nonnasal consonants—all other segments except [h] are normally voiced, while [h] is voiceless.

So far we have dealt only with features which are nonphonemic regardless of neighboring segments. There are also cases where features are nonphonemic because they occur in the vicinity of certain other segments. As an example we might take the segment sequences at the beginning of English words. It will be recalled here that the features *vocalic-nonvocalic* and *consonantal-nonconsonantal* distinguish four classes of segments: vowels, symbolized here by *V*, that are vocalic and nonconsonantal; consonants, symbolized by *C*, that are nonvocalic and consonantal; liquids [r], [l], symbolized by *L*, that are vocalic and consonantal; the glide [h],

<sup>6</sup>The requirement to represent morphemes in the dictionary by phonemic features only is a direct consequence of the simplicity criterion discussed on pp. 335ff in this volume.

symbolized by *H*, that is with restrictions on these disregarded here.

English morphemes ca odd, do, rue, who, stew, ch —e.g. *LCV, LLV*. These are part of the grammar

- RULE 1: If a morpheme b latter is also cons
- RULE 2: If a morpheme b the sequence is v
- RULE 3: If between the be venes, the segme

These rules enable us t sequences:

vocalic	—
consonantal	+

vocalic	—
consonantal	+

The above rules must l will have to be given in a the effects of ordering of vowel system, which shall can be characterized by 1

	[a]
flat	—
compact	+
diffuse	—
grave	—

This matrix is clearly

<sup>7</sup>We consider the semivowel vowels [i], [u], respectively; cf.

symbolized by *H*, that is nonvocalic and consonantal.<sup>7</sup> We shall be concerned solely with restrictions on these four classes; all further restrictions within the classes are disregarded here.

English morphemes can begin only with *V, CV, LV, HV, CCV, CLV,* and *CCLV*: *old, do, rue, who, stew, clew, screw*. A number of sequences are not admitted initially, —e.g. *LCV, LLV*. These constraints are reflected in the following three rules which are part of the grammar of English:

- RULE 1: If a morpheme begins with a consonant followed by a nonvocalic segment, the latter is also consonantal
- RULE 2: If a morpheme begins with a sequence of two consonants, the third segment in the sequence is vocalic
- RULE 3: If between the beginning of a morpheme and a liquid or a glide no vowel intervenes, the segment following the liquid or the glide is a vowel

These rules enable us to specify uniquely a number of features in certain segment sequences:

vocalic	-	-		
consonantal	+		+	

is converted by rules 1, 2, and 3

into

vocalic	-	-	+	+
consonantal	+	+	+	-

which stands for a sequence *CCLV*, e.g., *straw*.

The above rules must be applied in the given order. If no order is imposed, they will have to be given in a much more complex form. An interesting illustration of the effects of ordering on the complexity of the rules is provided by the Finnish vowel system, which shall now be examined. Finnish has eight vowel sounds which can be characterized by means of the following distinctive feature matrix.

	[æ]	[a]	[e]	[ø]	[o]	[i]	[ü]	[u]
flat	-	-	-	+	+	-	+	+
compact	+	+	-	-	-	-	-	-
diffuse	-	-	-	-	-	+	+	+
grave	-	+	-	-	+	-	-	+

This matrix is clearly redundant, since it utilizes four binary features to

<sup>7</sup>We consider the semivowels [j] as in *you* and [w] as in *woo*, to be positional variants of the lax vowels [i], [u], respectively; cf. N. Chomsky and M. Halle, *The Sound Pattern of English* (to appear).

necessary to supply the morphemes the particular arbitrary numerical of the morphemes, it is linguistic description—to of the morphemes par to select item (#7354), n its first segment has the d so on; in its second seg and the like; in its third Instructions of this type about features or feature from another. This is a 1 features or feature come another. We call these that in the input instruct must occur.<sup>6</sup> phonemic features or feature here are definite rules; for as he likes. For example occurrence is subject to the re unaspirated. ore an accented vowel. ional. nent of such facts, for they anguage correctly. glish, are never phonemic, but only in those segments es; for example, the feature consonants—all other seg- less. nonphonemic regardless of es are nonphonemic because s an example we might take rds. It will be recalled here -nonconsonantal' distinguish /, that are vocalic and non- onvocalic and consonantal, consonantal; the glide [ɥ] by phonemic features only 35ff in this volume.

characterize eight entities. The redundant features have been omitted in the table below.

	[æ]	[a]	[e]	[ø]	[o]	[i]	[ü]	[u]
flat	-	-	-	+	+	-	+	+
compact	+	+	-			-		
diffuse			-	-	-	+	+	+
grave	-	+		-	+		-	+

The omitted nonphonemic features are supplied by the following rules:

RULE 4: Flat vowels are noncompact.

RULE 5: Compact vowels are nondiffuse.

RULE 6: Noncompact nonflat vowels are nongrave.

The treatment just proposed has an interesting further consequence. In Finnish there is a restriction on what vowels can occur in a given word (vowel harmony). The Finnish word can contain a selection either from the set [i e ü ö æ] or from the set [i e u o a]. If [e i] are temporarily set aside, one could propose that Finnish is subject to

RULE 7: In a word all vowels are either grave or nongrave, depending on the nature of the root morpheme.

If [e i] are included, Rule 7 leads to incorrect results, since in words with *grave* root morphemes, [e] and [i] would be turned by Rule 7 into grave vowels, whereas in fact they remain nongrave. This incorrect result is immediately avoided if we let Rule 6 apply after, rather than before Rule 7, for Rule 6 makes all nonflat noncompact vowels nongrave and Rule 7 does not affect either flatness or compactness of any vowel.

### III

In the preceding, the distinctive features have been utilized for two separate purposes. On the one hand, they have been used to characterize different aspects of vocal tract behavior, such as the location of the different narrowings in the vocal tract, the presence or absence of vocal cord vibration, lowering or raising of velum, and so forth. On the other hand, the features have functioned as abstract markers for the designation of individual morphemes. It is necessary at this point to give an account of how this dual function of the features is built into the theory.

As already noted the rules that constitute the phonological component of a grammar relate a matrix consisting of abstract markers—the phonemic representation—to a matrix where each marker represents a particular aspect of vocal tract behavior. The latter matrix is our counterpart of the conventional phonetic transcription. In the phonemic representation the different features are allowed to assume only two values, plus or minus. In this representation, however, no phonetic content is associated directly with the features which function here as abstract differential markers.

The rules of the phonemic matrices of the phonemic features, the phonetic interpretation assigned to the row in the matrix will be with the feature CONSON practice of designating differential markers, b designate a given row in feature, we imply that phonetic feature in ques

The statement that t matrices is uniform for a of man is the same every same few aspects of the therefore, the capacities sense, the universal ph features are binary, the j of the pluses and minus degrees of intensity whic for instance, the fact th English [u] as in *poop* w for the feature gravity by

In the light of the abo distinctive features are bi tion of abstract phonemi associated by the rules of phonemic markers and p for the fact that there ar gravity does not invalidat of morphemes there are c

been omitted in the table

[ ]	[ü]	[u]
-	+	+
-		
+	+	+
	-	+

the following rules:

or consequence. In Finnish  
 an word (vowel harmony),  
 a set [i e ü ö æ] or from the  
 old propose that Finnish is

e, depending on the nature

, since in words with *grave*  
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onological component of a  
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 a particular aspect of vocal  
 f the conventional phonetic  
 rent features are allowed to  
 ation, however, no phonetic  
 1 function here as abstract

The rules of the phonological component modify—at times quite radically—the matrices of the phonological representation: the rules supply values to non-phonemic features, they change the values of certain features, and they assign a phonetic interpretation to the individual rows of the matrix. The phonetic interpretation assigned to the rows of the matrix is uniform for all languages; i.e., some row in the matrix will be associated with the feature VOCALIC-NONVOCALIC, another with the feature CONSONANTAL-NONCONSONANTAL, and so on. This fact explains our practice of designating the rows in the phonemic matrices which represent abstract differential markers, by names of the different phonetic features. When we designate a given row in the phonemic matrix by the name of a particular phonetic feature, we imply that the grammar will ultimately associate this row with the phonetic feature in question.

The statement that the assignment of phonetic interpretations to phonemic matrices is uniform for all languages reflects the fact that the articulatory apparatus of man is the same everywhere, that men everywhere are capable of controlling the same few aspects of their vocal tract behavior. The phonetic features represent, therefore, the capacities of man to produce speech sounds and constitute, in this sense, the universal phonetic framework of language. Since not all phonetic features are binary, the phonological component will include rules replacing some of the pluses and minuses in the matrices by integers representing the different degrees of intensity which the feature in question manifests in the utterance. Thus, for instance, the fact that the English [ʌ] as in *pup* is less grave ("back") than English [u] as in *poop* will be embodied in a phonological rule replacing the plus for the feature gravity by a higher integer in the vowel in *poop* than in the vowel in *pup*.

In the light of the above, the extensive discussion concerning the claim that the distinctive features are binary appears to have been due primarily to an identification of abstract phonemic markers with the phonetic features with which they are associated by the rules of the grammar. Once a distinction is made between abstract phonemic markers and phonetic features, there is little ground for disagreement, for the fact that there are many more than two phonetically distinct degrees of gravity does not invalidate the claim that in the abstract phonemic representation of morphemes there are only binary features.





The theory of generative grammar postulates, moreover, a mechanical procedure by means of which preferred descriptions are chosen from among several alternatives. The basis of this choice, which in accordance with common usage is termed *simplicity*, must be some formal feature of the set of statements. In many obvious cases, simplicity can be equated with brevity. Thus, a short formula, like that embodied in Verner's Law, for example, is normally regarded as simpler and hence preferred over a list of all forms implied by the formula. It would seem, therefore, natural to attempt to extend this notion of simplicity to all cases. In order to accomplish this, it is necessary to define a formal measure of length of descriptions which would appropriately mirror all considerations that enter into simplicity judgments. For example, in all cases where independent grounds exist for preferring one of several alternative descriptions, the preferred description must also be judged shorter than the rest by the proposed measure of length.

The measure of length that apparently possesses the desired properties is the number of alphabetic symbols (capital letters in (1-3) or the symbols by which these are replaced in later examples) appearing in the description. Given two alternative descriptions of a particular body of data, the description containing fewer such symbols will be regarded as simpler and will, therefore, be preferred over the other.

In the rest of this paper, I shall outline in detail some consequences of these abstract conditions on the form of phonological descriptions and exhibit the manner in which, by mechanical application of the proposed simplicity measure, certain formulations are chosen from among several alternatives. The plausibility and intrinsic appeal of the descriptions so selected will provide the primary justification not only for the proposed simplicity criterion, but also for the theory of generative grammar, of which the criterion is an integral part.

## I

It has been noted above that the symbols appearing in the statement of a generative grammar belong to a restricted alphabet. In phonology, the majority of statements deal exclusively with segments or segment sequences. In order to simplify the discussion, I shall consider here only statements of this type and exclude from consideration statements involving junctures, morpheme class-markers, and so on. In the present discussion, the capital letters will, therefore, represent phonological segments, classes of segments, or sequences of these.

There are basically two ways in which phonological segments have been treated in linguistic descriptions. In some descriptions they are represented as further indivisible entities, in others, as complexes of properties. In order to choose between these two manners of representation, I propose to compare them in situations where the preferred solution is self-evident. The statement:

$$/a/ \text{ is replaced by } /æ/ \text{ if followed by } /i/ \quad (4)$$

is manifestly simpler than the statement:

$$/a/ \text{ is replaced by } /æ/ \text{ if followed by } /i/ \text{ and preceded by } /i/ \quad (5)$$

Chomsky, *Syntactic Structures* (The Hague, 1959); R. B. Lees, *Phonology of English Nominalizations* (Bloomington, Indiana, 1960); N. Chomsky and M. Halle, *The Sound Pattern of English* (in preparation).



g phonological segments as

/ (6a)

-/i/ (6b)

complexes of properties,<sup>2</sup> we

-	[	+vocalic	]	(7a)
tal		-consonantal		
		+diffuse		
		-compact		
		-grave		

-	[	+vocalic	]	(7b)
tal		-consonantal		
		+diffuse		
		-compact		
		-grave		

proposed simplicity criterion

the equivalents of (4) utilize

/, 19) symbols utilized in the

s for a language possessing

y /i/ (8a)

y front vowel (8b)

, to be preferred over (8a)

n and viewing phonemes as

/ (9a)

i/ (9b)

e/ (9b)

æ/ (9b)

in:

[	+vocalic	]	(10a)
	-consonantal		
	+diffuse		
	-compact		
	-grave		

properties in terms of which segments  
network, however, would not affect  
on to operate with the distinction  
as "labial stops" are to be under-  
state the exposition, but lacking  
ures, see chapter 9 of this volume.

[+grave] → [-grave] in the env.

[	+vocalic	]	(10b)
	-consonantal		
	-diffuse		
	+compact		
	-grave		

The alternative reformulations of (8) are not consistent with each other: (9a) utilizes fewer symbols than (9b), whereas (10a) utilizes more symbols than (10b). Since we know on independent grounds that (10b) is more general than (10a) and must, therefore, be preferred over the latter, the results obtained in the reformulations (9) are also inconsistent with the results obtained in (6), where the preferred statement required fewer symbols. It follows, therefore, that if we wish to operate with the simplicity criterion that has been proposed here, we must regard phonological segments as complexes of properties.

Finally, compare (10b) with the following:

/a/ is replaced by /æ/ if followed by /i/, /p/, or /z/ (11)

Translated into standard form with phonemes regarded as indivisible entities, (11) would read:

/a/ → /æ/ in the env.  $\left\{ \begin{array}{l} /i/ \\ /p/ \\ /z/ \end{array} \right\}$  (12)

Since (12) utilizes exactly the same number of symbols as (9b), it will be judged by the proposed simplicity criterion as of the same complexity as (9b). There can, however, be little doubt that linguists would regard (9b) as simpler than (11), on the grounds that the environment in the former is constituted by a *natural class* of phonemes (cf. pp. 328 of this volume), while in the latter the environment is made up of an odd, unsystematic collection of phonemes. The proposed simplicity criterion thus yields a counter-intuitive result if it is applied to statements in which phonemes are regarded as indivisible entities.

It can readily be seen that if (11) is translated into the standard form utilizing distinctive features instead of phonemes, it will require considerably more symbols than (10b), for we shall have to specify /i/, /p/, /z/ by their whole complement of features, whereas in (10b) we are able to take advantage of the fact that the set /i/, /p/, /z/ constitutes a natural class and can, therefore, be unambiguously specified by fewer features than any of its members. We observe that the intuitively correct result is yielded by the proposed simplicity criterion in conjunction with a representation of phonemes as bundles of distinctive features, whereas the above counter-intuitive result is obtained if phonemes are regarded as indivisible entities. The failure of the simplicity criterion in the latter case is due to the fact that the notion of *natural class* has no obvious meaning if phonemes are regarded as indivisible entities.

It is, of course, conceivable that a simplicity criterion may be formulated that yields the proper results even when segments are represented as indivisible entities. The burden of proof, however, is clearly on those who reject the view that segments are complexes of distinctive features. Rather than explore here alternative simplicity criteria, I shall attempt to justify the proposed view of phonological segments by

examining some of its consequences. These consequences will incidentally provide ample justification for the decision to operate with the Jakobsonian distinctive feature framework rather than with one of the other phonetic frameworks (IPA or Jespersen's antalphabetic notation, and so on).

## II

Significant simplifications can be achieved by imposing an order on the application of the rules. Consider in this connection the rules which constitute the essence of the Sanskrit vowel sandhi. In Whitney's *Grammar*, where order of application is not a factor, the vowel sandhi is described by means of the following four rules.

- (1) Two similar simple vowels, short or long, coalesce and form the corresponding long vowel . . . (Section 126)
- (2) An *a*-vowel combines with a following *i*-vowel to *e*; with a *u*-vowel, to *o* . . . (Section 127)
- (3) The *i*-vowels, the *u*-vowels and the *r* before a dissimilar vowel or a diphthong, are each converted into its own corresponding semi-vowel, *y* or *v* or *r* . . . (Section 128)
- (4) Of a diphthong, the final *i*- or *u*-element is changed into its corresponding semi-vowel, *y* or *v*, before any vowel or diphthong: thus *e* (really *ai* . . .) becomes *ay*, and *o* (that is *au* . . .) becomes *ay* . . . (Section 131).

If the first three rules are applied in the order (1), (3), (2), two important economies can be effected. First, in rule (3), the qualification "before a dissimilar vowel or a diphthong" can be simplified to "before a vowel," for at the point where rule (3) applies, only sequences of dissimilar vowels remain, since rule (1) replaces all sequences of identical vowel by single long vowels. Moreover, rule (4) can be dispensed with altogether. Since rule (3) converts /i/ and /u/ in position before vowel into /y/ and /v/, respectively, no sequences of /ai/ and /au/ in position before vowel will ever be turned into /e/ or /o/, respectively, by the subsequent application of rule (2). Inasmuch as rule (2) is the only source of /e/ and /o/ in the language, there is now no need for rule (4), whose sole function is to convert /e/ and /o/ into /ay/ and /av/ in those cases where by the proposed ordering of the rules, /e/ and /o/ could not have arisen. Thus, the forms quoted by Whitney as requiring rule (4) are handled properly without it: /naia/ and /b<sup>h</sup>aua/ are turned by rule (3) into /naya/ and /b<sup>h</sup>ava/ to which rule (2) does not apply. The same stems without the suffix /a/, on the other hand, are not subject to rule (3) and are, therefore, affected by (the later) rule (2), which converts /nai/ into /ne/ and /b<sup>h</sup>au/ into /b<sup>h</sup>o/.

In sum, rule (4) is superfluous as long as the proposed ordering of the rules is maintained. Should we choose to allow random access to the rules or impose a different order on the rules, we should have to pay for it by admitting rule (4). Our simplicity criterion leaves us no alternative but to choose the former solution.

## III

A complete description of a language must evidently include a list of all actually occurring morphemes, i.e. the dictionary of the language. Being part of the description, the dictionary is also subject to the notational conventions and simplicity

criterion that have been given in the form of place of an entry /dɔg/.

- vocalic
- + consonant
- strident
- compact
- grave
- continuant
- nasal
- tense
- + diffuse
- flat
- + voiced

This representation contains (14). English vowels—i nasal, nonstrident, voice

- |            |
|------------|
|            |
| vocalic    |
| consonant  |
| nasal      |
| continuant |
| strident   |
| flat       |
| compact    |
| diffuse    |
| grave      |
| voiced     |

The distinctive features of modern English specified since nontense vowels

criterion that have been outlined above. The items in the dictionary will, therefore, be given in the form of sequences of distinctive feature complexes. For instance, in place of an entry /dɒg/, our dictionary might contain the entry

$$\left[ \begin{array}{l} - \text{vocalic} \\ + \text{consonantal} \\ - \text{strident} \\ - \text{compact} \\ - \text{grave} \\ - \text{continuant} \\ - \text{nasal} \\ - \text{tense} \\ + \text{diffuse} \\ - \text{flat} \\ + \text{voiced} \end{array} \right] \left[ \begin{array}{l} + \text{vocalic} \\ - \text{consonantal} \\ - \text{strident} \\ + \text{compact} \\ + \text{grave} \\ + \text{continuant} \\ - \text{nasal} \\ + \text{tense} \\ - \text{diffuse} \\ + \text{flat} \\ + \text{voiced} \end{array} \right] \left[ \begin{array}{l} - \text{vocalic} \\ + \text{consonantal} \\ - \text{strident} \\ - \text{compact} \\ + \text{grave} \\ - \text{continuant} \\ - \text{nasal} \\ - \text{tense} \\ - \text{diffuse} \\ - \text{flat} \\ + \text{voiced} \end{array} \right] \quad (13)$$

This representation contains an excessive number of features. As can be seen in (14), English vowels—i.e., segments that are  $\left[ \begin{array}{l} + \text{vocalic} \\ - \text{consonantal} \end{array} \right]$ —are all non-nasal, nonstrident, voiced, and continuant. Moreover, compact (low) vowels are

	u	o	ɔ	a	i	e	æ
vocalic	+	+	+	+	+	+	+
consonantal	-	-	-	-	-	-	-
nasal	-	-	-	-	-	-	-
continuant	+	+	+	+	+	+	+
strident	-	-	-	-	-	-	-
flat	+	+	+	-	-	-	-
compact	-	-	+	+	-	-	+
diffuse	+	-	-	-	+	-	-
grave	+	+	+	+	-	-	-
voiced	+	+	+	+	+	+	+

(14)

The distinctive feature composition of vowels in certain dialects of modern English. The feature of tenseness has not been specified since the system contains seven tense and seven nontense vowels.

ces will incidentally provide the Jakobsonian distinctive phonetic frameworks (IPA or

ing an order on the applica- which constitute the essence where order of application is the following four rules: and form the corresponding

ilar vowel or a diphthong, are vel, y or v or r ... (Section 129), d into its corresponding semi- s e (really af ... ) becomes ay,

2), two important economies: before a dissimilar vowel or a r at the point where rule (3) since rule (1) replaces all so- ver, rule (4) can be dispensed position before vowel into /y/ position before vowel will ever application of rule (2). Inas- nguage, there is now no need o/ into /ay/ and /av/ in those nd /o/ could not have arisen are handled properly without and /b<sup>h</sup>ava/ to which rule (2) , on the other hand, are not ater) rule (2), which converts

ossed ordering of the rules is ss to the rules or impose a it by admitting rule (4). Our ose the former solution.

y include a list of all actualy ge. Being part of the descrip- conventions and simplicity



sequences admitted in word initial position. This suggests immediately that in the dictionary representation of all items beginning with two consonants, we omit in the first consonant all but the features  $\begin{bmatrix} - \text{vocalic} \\ + \text{consonantal} \end{bmatrix}$ ; i.e., all features that differentiate that consonant from all other consonants of the language. The omitted features are then introduced by the following rule:

$$\begin{bmatrix} - \text{vocalic} \\ + \text{consonantal} \end{bmatrix} \rightarrow \begin{bmatrix} + \text{strident} \\ - \text{compact} \\ - \text{grave} \\ + \text{tense} \\ + \text{continuant} \end{bmatrix} \text{ in env. } \# \left[ \text{---} \right] \begin{bmatrix} - \text{vocalic} \\ + \text{consonantal} \end{bmatrix} \quad (17)$$

As a result of (17) the description is shortened by five features for every dictionary item beginning with two consonants. Thus, a very great saving is realized in the dictionary at the cost of the nine features mentioned in (17).<sup>4</sup> This saving has the additional effect of ruling out forms such as /vnig/, /tsaym/, and /gnayt/.

Consider now such sequences as /bik/, /θōd/, or /nis/. Like the aforementioned /saym/, /gnayt/, and /vnig/, none are actual English words. If, however, we attempted to exclude them by means of a rule like (17), we should discover that the cost of the rule—i.e., the number of features mentioned in the rule—would exceed that of the saving that might be effected in the dictionary. For instance, since *big*, *bin*, *bid*, *bit*, *bib*, *biff* are all English words, the rule that excludes /bik/ would have to read:

$$\begin{bmatrix} - \text{vocalic} \\ + \text{consonantal} \\ - \text{compact} \\ - \text{strident} \end{bmatrix} \rightarrow [- \text{tense}] \text{ in env. } \begin{bmatrix} - \text{vocalic} \\ + \text{consonantal} \\ - \text{strident} \\ + \text{grave} \\ - \text{compact} \\ - \text{nasal} \\ - \text{tense} \end{bmatrix} \left[ \begin{bmatrix} + \text{vocalic} \\ - \text{consonantal} \\ + \text{diffuse} \\ - \text{compact} \\ - \text{tense} \\ - \text{grave} \end{bmatrix} \right] \left[ \text{---} \right] \quad (18)$$

And at the cost of the 18 features mentioned in (18), we could effect a saving of one feature in the dictionary. The simplicity criterion, therefore, does not allow us to include (18) in a description of English.

The presence of (17) and the absence of (18) in a description of English mirrors the English speaker's intuition about his language. The presence of (17) corresponds to the fact that speakers of English will regard /vnig/, /tsaym/, and /gnayt/ as not only meaningless, but also as totally unEnglish; impossible by the rules of their language. The absence of (18) and a host of similar rules corresponds to the fact that English speakers will accept the equally meaningless /bik/, /θōd/, and /nis/ as possible English words, perhaps as words found in an unabridged dictionary rather than in the vocabulary of the average speaker.

In attempting to satisfy the simplicity criterion, we are, thus, forced to incorporate

<sup>4</sup>We may note that the idea of representing segments in a given form by less than their normal complement of features is essentially identical with the "archiphoneme" concept that was first proposed by Jakobson in *Travaux du Cercle Linguistique de Prague II* (1928) and was used for a time by the Prague School. Since the Prague School did not operate consistently with features but rather regarded the phoneme as the ultimate phonological entity, great difficulties were soon experienced with this concept, which ultimately led to its official abandonment.

v. [ +vocalic  
-consonantal ] (15)

given (15), the vowel in (13)

(16)

procedure be followed in the  
us to shorten the dictionary.  
reds of features at the slight  
utilized in (15). In general,  
whenever these can be intro-  
ducts.

e those where the appearance  
ned. Thus, it is generally true  
consonants, the first is invari-  
onant—i.e. [ -vocalic  
+consonantal ]

des and to make them more per-  
the form:

D]

[ - D ]

arbitrary coefficient; i.e., where  
ere the minus is to be inserted.

into every complete generative grammar a characterization of the distinction between admissible and inadmissible segment sequences. This fact effectively cuts the ground out from under the recent suggestion that generative grammars be supplemented with special phonological grammars,<sup>5</sup> since the sole purpose of these special grammars is to characterize the distinction between admissible and inadmissible segment sequences.

## V

In the study of dialects, it has been common in recent years to focus primary attention on the facts of the utterance and to concern oneself primarily with such questions as the mutual intelligibility of two dialects, the similarities and differences of cognate utterances, of their phoneme repertoires, distributional constraints, and so on. Instead of following this procedure, we propose to focus here on the grammars of the dialects, i.e., on the ordered set of statements that describe the data, rather than on the data directly.

That the two approaches are distinct in quite fundamental ways can be seen if we examine the manner in which "Pig Latin," a "secret" language popular among schoolchildren in the United States, would be described from these two points of view. If we compared utterances in Pig Latin with their cognates in General American, we should be struck by the extreme differences between them:

General American	Pig Latin
/str'it/	/'itstrē/
/str'its/	/'itstrē/
/k'æt/	/'ætkē/
/k'æts/	/'ætskē/
/r'ōz/	/'ōzrē/
/r'ōziz/	/'ōzizrē/

We observe that the distribution of phonemes in Pig Latin differs radically from that in General American, for in the former all words end in the vowel /ē/, and very unusual consonant clusters abound. We note also that infixation rather than prefixation and suffixation is the major morphological device. In view of this, we are hardly surprised to find that Pig Latin is incomprehensible to the uninitiated speaker of General American. Since these are precisely the observations we would expect to make if we compared the utterances in two totally unrelated languages, we are led to conclude that Pig Latin and General American are unrelated, or, at best, only remotely related tongues; a conclusion which is patently false.

The picture would be radically different if instead of "hugging the phonetic ground closely" we were to compare the grammars of General American and Pig Latin. From this point of view, the difference between the two is that Pig Latin contains a morphophonemic rule that is absent in the more standard dialects:

Shift initial consonant cluster to end of word and add /ē/ (19)

<sup>5</sup>Cf. F. Householder, "On Linguistic Primes," *Word*, 15 (1959), 231-39; and H. Contreras and S. Saporta, "The Validation of a Phonological Grammar," *Lingua*, 9 (1960), 1-15.

Since (19) is the one of General American, we can, a somewhat special. But this result follows primary attention to the

Since grammars consist of one or more different rules; (b) difference of Pig Latin exemplified by M. Joos in *English*.<sup>17</sup> In certain Caribbean varieties. One . . . fortis consonant with zero in all other contexts: . . . in singular and plural of difference, Joos suggests

"/a/ is a fortis consonant.

Moreover, like many other varieties in intervocalic

Joos notes that the speaker's pronunciation of words like [tɔɪpraɪdɔ]. . . . G. . . . by the choice of the diphthong [ai] before all vowels alike in both the phonemic alternants [tɔɪ] to [ai]."

The dilemma referred to in the sequence of the fact that in the grammar of C.

"Secret languages like Pig Latin are a dialect of English," *Word*, 15 (1959), 231-39; and H. Contreras and S. Saporta, "The Validation of a Phonological Grammar," *Lingua*, 9 (1960), 1-15.

/ba'iy/  
/di'/?/  
/day'/?/  
/pey'/?r/  
/key'/?

*Language*, 18 (1942), 141-4

Since (19) is the only difference between the grammars of Pig Latin and General American, we conclude that Pig Latin is a *ciphered* form of General American, a somewhat special dialect of the latter, a conclusion which is obviously right. But this result follows only if instead of concentrating on the utterances, we shift primary attention to the grammars that underlie the utterances.<sup>6</sup>

## VI

Since grammars consist of ordered sets of statements, differences among grammars are due to one or both of the following: (a) different grammars may contain different rules; (b) different grammars may have differently ordered rules. The case of Pig Latin exemplifies difference (a). An interesting example of difference (b) was discussed by M. Joos in a paper entitled "A Phonological Dilemma in Canadian English."<sup>7</sup> In certain Canadian dialects "the diphthongs /aj/ and /aw/ . . . each have two varieties. One . . . begins with a lower-mid vowel sound; it is used before any fortis consonant with zero juncture . . . *white, knife, shout, house*. The other is used in all other contexts: . . . *high, find, knives; how, found, houses*. Note the difference in singular and plural of irregular nouns, including *wife: wives*." To account for this difference, Joos suggests the rule:

"/a/ is a lower-mid vowel . . . in diphthongs followed by fortis consonants" (20)

Moreover, like many other American dialects, these dialects contain the rule that:

in intervocalic position /t/ is voiced and lenis /d/ (21)

Joos notes that the speakers of these dialects "divide into two groups according to their pronunciation of words like *typewriter*. Group A says [tɪpɹɪdɪɹ] while Group B says [tɪpɹaɪdɪɹ]. . . . Group A distinguishes *writer* from *rider*, *clouting* from *clouding* by the choice of the diphthong alone. . . . Group B has shifted the articulation of all vowels alike before the new /d/ from earlier /t/ . . . from *write* to *writer* there is both the phonemic alternation from /t/ to /d/, and the phonetic alternation from [t] to [d]."

The dilemma referred to in the title of Joos' paper is, therefore, a lawful consequence of the fact that in the grammar of Group A, Rule (20) precedes Rule (21), while in the grammar of Group B, the reverse order obtains. Hence, in the speech of

<sup>6</sup> Secret languages like Pig Latin are extremely common. J. Applegate in "Phonological Rules of a Subdialect of English," *Word*, 17 (1961), 186-93 has described a "secret language" spontaneously created by some children in Cambridge, Mass. The difference between the grammar of this "language" and standard English consisted of the two ordered rules: (1) in a word containing several identical stop consonants, all but the first of these is replaced by a glottal stop; and (2) all consonants are replaced by the cognate stops. As a result of these two rules, we find in the language of the children the following deviations from standard English:

/ba ?iy/	Bobby	/dɔd/	does
/di ?/	did	/tɔkt/	talks
/day ?/	died	/teykt/	takes
/pey ?r/	paper		
/key ?/	cake		

<sup>7</sup> *Language*, 18 (1942), 141-44.

zation of the distinction between these two grammars. This fact effectively cuts the two grammars to the sole purpose of these between admissible and in-

cent years to focus primary attention on oneself primarily with such the similarities and differences distributional constraints, and to focus here on the grammars that describe the data, rather

lamental ways can be seen if "ret" language popular among these two points of view cognates in General American between them:

Pig Latin

/tstrē/

/tstrē/

/ætkē/

/ætskē/

/ōzrē/

/ōzizrē/

Pig Latin differs radically from standard English in the vowel /ē/, and very much in that infixation rather than pro- device. In view of this, we are surprised to find that the uninformed speaker of these languages would expect to find cognates in related languages, we are led to believe that these are unrelated, or, at best, only very distantly related.

If "hugging the phonetic ground" between standard American and Pig Latin, the main difference between the two is that Pig Latin contains a vowel which is not found in standard dialects:

If word and add /ē/ (19)

(1959), 231-39; and H. Contreras and J. H. Greenberg, *Linguistics*, 9 (1960), 1-15.

Group *A* /taɪpraɪtə/ is converted by Rule (20) into [təɪprɛtə] which then is turned by Rule (21) into [təɪprɛɪdə]. In the speech of Group *B*, on the other hand, /taɪpraɪtə/ is first turned by Rule (21) into [taɪpraɪdə] and then by Rule (20) into [təɪprɛɪdə].<sup>9</sup>

Since ordered rules are all but unknown in present day synchronic descriptions, the impression has spread that the imposition of order on statements in a synchronic description is always due to an oversight, to an unjustifiable confusion of synchronic and diachronic.<sup>10</sup> I must therefore stress that, in the preceding examples, order is determined by the simplicity criterion alone and that no historical considerations have entered in establishing it.

## VII

A complete scientific description of a language must pursue one aim above all: to make precise and explicit the ability of a native speaker to produce utterances in that language. We can, therefore, enquire how the acquisition of this ability is viewed within the framework of a generative grammar. It has been suggested by Chomsky that language acquisition by a child may best be pictured as a process of constructing the simplest (optimal) grammar capable of generating the set of utterances, of which the utterances heard by the child are a representative sample.<sup>10</sup> The ability to master a language like a native, which children possess to an extraordinary degree, is almost completely lacking in the adult. I propose to explain this as being due to deterioration or loss in the adult of the ability to construct optimal (simplest) grammars on the basis of a restricted corpus of examples. The language of the adult—and hence also the grammar that he has internalized—need not, however, remain static: it can and does, in fact, change. I conjecture that changes in later life are restricted to the addition of a few rules in the grammar and that the elimination of rules and hence a wholesale restructuring of his grammar is beyond the capabilities of the average adult.

The addition of rules may—although it need not invariably—result in a grammar

<sup>9</sup>Joos notes that in the speech of Group *A*, the observed phenomenon is restricted to certain classes of words. This restriction does not affect the point illustrated here, viz., that data of the kind described by Joos can best be accounted for by postulating different orders of rules in grammars of different dialects.

<sup>10</sup>Thus, for example, Hockett confesses to being unable to conceive of ordered statements in terms other than historical: "... if it is said that the English past tense form *baked* is "formed" from *bake* by a "process" of "suffixation," then no matter what disclaimer of historicity is made, it is impossible not to conclude that some kind of priority is being assigned to *bake* as against *baked* or the suffix. And if this priority is not historical, what is it?" ("Two Models of Linguistic Description," *Word* 10 [1954], 233). Synchronic ordering was used by both Bloomfield and Sapir and to a certain extent also by younger linguists (Joos, *op. cit.*, Voegelin, Swadesh) who later abandoned it, however.

<sup>11</sup>This view of language learning was once almost a commonplace among linguists. I have found clear statements to this effect in the writings of linguists as diverse as Humboldt, Hermann Paul, and Meillet. Cf. for example, the following comment made by Meillet in 1929: "... chaque enfant doit acquérir par lui-même la capacité de comprendre le parler des gens de son groupe social et de l'employer. La langue ne lui est pas livrée en bloc, tout d'une pièce. Il n'entend jamais autre chose que des phrases particulières, et ce n'est qu'en comparant ces phrases entre elles qu'il arrive à saisir le sens des paroles qu'il entend et à parler à son tour. Pour chaque individu, le langage est ainsi une récréation totale faite sous l'influence du milieu qui l'entoure." *Linguistique historique et linguistique générale*, II (Paris 1952), 74.

that is not optimal (the example, consider the con

- a. [+compact]
- b. [X]
- c. [+flat]
- d. [-flat  
-compact]
- e. [-flat  
+compact]

As can be readily seen from the presence of /a/ → /æ/. The order is determined, and (22) must be the most conservative (features):

- a. [+compact]
- b. [X]
- c. [+flat]

Observe that (22e), which is not optimal in (23), which nevertheless is the most conservative. Since every child constructs a grammar to which he has access, and since his parents have identical grammars, I should expect that the most conservative grammar can be generated by more than one grammar. To the extent that the grammar is maximally conservative, we would expect that the child would have grammars with different orders of rules in the grammars of success in the further evolution of the language.

<sup>12</sup>For a discussion of further examples, see X to XII.

<sup>13</sup>The significance of discontinuity has been discussed over fifty years ago by Meillet. Il est essentiellement discontinu de la langue toute faite: il doit être acquis par l'enfant. Cette discontinuité de la langue, sans elle, toutes les causes de la langue ne seraient pas les mêmes. Le sens des mots aussi racine de la langue. D'ailleurs, la discontinuité de la langue est une possibilité et les modalités de son acquisition sont étudiées dans *Linguistique générale*, I (Paris, 1948), p. 100-101. See also the quoted passage.

[pɹeɪtɹ] which then is turned  
 up *B*, on the other hand,  
 ] and then by Rule (20) into

day synchronic descriptions,  
 on statements in a synchronic  
 iable confusion of synchronic  
 preceding examples, order is  
 no historical considerations

t pursue one aim above all: to  
 r to produce utterances in that  
 ition of this ability is viewed  
 s been suggested by Chomsky  
 ed as a process of constructing  
 the set of utterances, of which  
 sample.<sup>10</sup> The ability to master  
 extraordinary degree, is almost  
 is as being due to deterioration  
 il (simplest) grammars on the  
 e of the adult—and hence also  
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 r life are restricted to the admi-  
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that is not optimal (the simplest) for the set of utterances that it generates. As an  
 example, consider the consequences of expanding (15) by the addition of subpart (e):

$$\left. \begin{array}{l} \text{a. } [+ \text{compact}] \rightarrow [- \text{diffuse}] \\ \text{b. } [X] \rightarrow \left[ \begin{array}{l} - \text{nasal} \\ - \text{strident} \\ + \text{continuant} \\ + \text{voiced} \end{array} \right] \\ \text{c. } [+ \text{flat}] \rightarrow [+ \text{grave}] \\ \text{d. } \left[ \begin{array}{l} - \text{flat} \\ - \text{compact} \end{array} \right] \rightarrow [- \text{grave}] \\ \text{e. } \left[ \begin{array}{l} - \text{flat} \\ + \text{compact} \end{array} \right] \rightarrow [+ \text{grave}] \end{array} \right\} \text{ in the env. } \left[ \begin{array}{l} + \text{vocalic} \\ - \text{consonantal} \end{array} \right] \quad (22)$$

As can be readily seen from (14), the addition of subpart (e) amounts to a coales-  
 cence of /a/ → /æ/. The distribution of gravity in vowels is, therefore, completely  
 determined, and (22) must be replaced by the following, simpler rule (16 vowels 11  
 features):

$$\left. \begin{array}{l} \text{a. } [+ \text{compact}] \rightarrow [- \text{diffuse}] \\ \text{b. } [X] \rightarrow \left[ \begin{array}{l} - \text{nasal} \\ - \text{strident} \\ + \text{continuant} \\ - \text{grave} \\ + \text{voiced} \end{array} \right] \\ \text{c. } [+ \text{flat}] \rightarrow [+ \text{grave}] \end{array} \right\} \text{ in the env. } \left[ \begin{array}{l} + \text{vocalic} \\ - \text{consonantal} \end{array} \right] \quad (23)$$

Observe that (22e), which was the cause of the whole upheaval, does not even figure  
 in (23), which nevertheless generates precisely the same set of utterances as (22).<sup>11</sup>

Since every child constructs his own optimal grammar by induction from the  
 utterances to which he has been exposed, it is not necessary that the child and his  
 parents have identical grammars, for, as we have just seen, a given set of utterances  
 can be generated by more than one grammar. In the case where (22e) was added  
 to the grammar, I should therefore postulate that the adult, who of necessity is  
 maximally conservative, would have a grammar containing (22), whereas his children  
 would have grammars with the simpler rule (23). It is clear that such discontinuities  
 in the grammars of successive generations must exercise a profound influence on the  
 further evolution of the language.<sup>12</sup>

<sup>10</sup>For a discussion of further consequences of the addition of rules such as Eq. (22e), see Sections  
 X and XII.

<sup>11</sup>The significance of discontinuities in the transmission of language from generation to generation  
 was discussed over fifty years ago by A. Meillet: "Il faut tenir compte tout d'abord du caractère  
 manifestement discontinu de la transmission du langage: l'enfant qui apprend à parler ne reçoit  
 pas le langage toute faite: il doit le recréer tout entière à son usage d'après ce qu'il entend autour  
 de lui. ... Cette discontinuité de la transmission du langage ne suffirait à elle seule à rien expliquer,  
 sans elle, toutes les causes du changement auraient sans doute été impuissantes à trans-  
 former le sens des mots aussi radicalement qu'il l'a été dans un grand nombre de cas: d'une manière  
 générale d'ailleurs, la discontinuité de la transmission est la condition première qui détermine la  
 possibilité et les modalités de tous les changements linguistiques." *Linguistique historique et linguis-  
 tique générale*, I (Paris, 1948), p. 236. I am indebted to E. S. Klima for drawing my attention to the  
 quoted passage.

## VIII

Linguistic change is normally subject to the constraint that it must not result in the destruction of mutual intelligibility between the innovators—i.e., the carriers of the change—and the rest of the speech community. Except in such special cases as "secret languages" like Pig Latin or different varieties of thieves' argot, all changes must preserve comprehensibility for the rest of the speech community. This restriction clearly affects the content of the rules to be added; e.g., a rule such as (19) has little chance of survival under normal conditions, for it renders the utterances incomprehensible to the rest of the community. It is equally obvious that the number of rules to be added must also be restricted, for very serious effects on intelligibility can result from the simultaneous addition of even two or three otherwise innocuous rules.

It may be somewhat less obvious that the requirement to preserve intelligibility also restricts the place in the order where rules may be added. All other things being equal, a rule will affect intelligibility less if it is added at a lower point in the order than if it is added higher up. I am unable at present to characterize the place in the order where rules may be added with a minimum impairment of intelligibility. Such additions, however, seem characteristically to occur at points where there are natural breaks in the grammar.<sup>13</sup>

Because of the intelligibility constraint the type of change most likely to survive is the one involving the addition of a single, simple rule at the end of certain natural subdivisions of the grammar. It can readily be seen that in cases where the addition of such a rule does not affect the over-all simplicity of the grammar, the order of rules established by purely synchronic considerations—i.e., simplicity—will mirror properly the relative chronology of the rules. This fact was noted by Bloomfield in his important "Menomini Morphophonemics":

The process of description leads us to set up each morphological element in a theoretical *basic* form and then to state the deviations from this basic form which appear when the element is combined with other elements. If one starts with the basic forms and applies our statements . . . in the order in which we give them, one will arrive finally at the forms of words as they are actually spoken. Our basic forms are not ancient forms, say of the Proto-Algonquian parent language, and our statements of internal sandhi are not historical but descriptive and appear in a purely descriptive order. However, our basic forms do bear some resemblance to those which would be set up for a description of Proto-Algonquian, some of our statements of alternation . . . resemble those which would appear in a description of Proto-Algonquian, and the rest . . ., as to content and order, approximate the historical development from Proto-Algonquian to present-day Menomini.<sup>14</sup>

<sup>13</sup>E.g. before the first morphophonemic rule involving immediate constituent structure of the utterance (i.e., at the end of the morpheme structure (MS) rules); at the end of the cyclical rules which eliminate the immediate constituent structure of the utterance from the representation; before the phonological rules that eliminate boundary markers (junctures) from the representation.

<sup>14</sup>*Travaux du Cercle linguistique de Prague VIII* (1939) 105–15. This study is unaccountably omitted in C. F. Hockett's "Implications of Bloomfield's Algonquian Studies," *Language*, 24 (1949), 117–31. Cf. also Bloomfield's comments on "descriptive order" in his *Language* (New York: Holt, Rinehart & Winston, Inc., 1933), pp. 213, 222.

It has been proposed for the addition of rules to the grammar, then it follows the proposed simplicity of the language, for it allows the absence of external evidence in or from other language studies in historical phonology of the evolution of the Indo-European languages. The impressive achievement of the proposed simple statements; this order

My point can perhaps be called "Laws" of Grimm among the cornerstones of stages in the evolution of language, stages, which it is. The Indo-European primitive continuant consonant *s*, voiced noncontinuants (*g, k*) and only one series, namely the Law that is of interest here

in certain environments need not correspond to continuants a

i.e.  $p \rightarrow f, t \rightarrow \theta, k \rightarrow x, k'$  have been subjected to Verner's

in certain environments replaced by th

i.e.  $f \rightarrow v, \theta \rightarrow \delta, x \rightarrow \gamma, x'$

If we choose to believe in the Law (or at least the part of it) we assume that at the stage Verner's voiceless continuants from the Indo-European and the voiced continuants from the Law. The fact that Verner's Law is from both sources is always the Law later than Grimm's

## IX

It has been proposed here that the primary mechanism of phonological change is the addition of rules to the grammar with special (although not exclusive) preference for the addition of single rules at the ends of different subdivisions of the grammar. If we now assume that rules are added always singly and always at a given spot in the grammar, then it follows that the synchronic order of the rules will reflect the relative chronology of their appearance in the language. Moreover, under this condition the proposed simplicity criterion can be used as a tool for inferring the history of the language, for it allows us to reconstruct various stages of a language even in the absence of external evidence such as is provided by written records or by borrowings in or from other languages. It seems to me that such an assumption is made in many studies in historical phonology. In fact, I should like to argue that the reconstruction of the evolution of the Indo-European language family, which is perhaps the most impressive achievement of nineteenth-century linguistics, was possible only by making use of the proposed simplicity criterion to establish an order among the descriptive statements: this order was then taken to reflect their relative chronology.

My point can perhaps be illustrated most graphically by a discussion of the so-called "Laws" of Grimm and of Verner, which, with good reason, are considered among the cornerstones of Indo-European reconstruction. The "Laws" describe stages in the evolution of the Germanic languages from the Indo-European proto-language; stages, which it should be noted, are not attested by any external evidence.

The Indo-European proto-language is supposed to have had a single strident continuant consonant *s*, which was voiceless; and a fairly complex system of nonstrident noncontinuants (stops), of which for present purposes we need to consider only one series, namely the voiceless one consisting of *p, t, k, kʷ*. The part of Grimm's Law that is of interest here can be formulated as follows:

in certain environments  $C_G$ , the precise nature of which need not concern us here, voiceless, nonstrident noncontinuants are replaced by their cognate continuants (24)

$p \rightarrow f, t \rightarrow \theta, k \rightarrow x, k^w \rightarrow x^w$ . At a later time Germanic is supposed to have been subjected to Verner's Law, which can be formulated as follows:

in certain environments  $C_V$ , all voiceless continuants are replaced by their voiced cognates (25)

$f \rightarrow v, \theta \rightarrow \delta, x \rightarrow \gamma, x^w \rightarrow \gamma^w$ , and, n.b.,  $s \rightarrow z$ .

If we choose to believe with the majority that Verner's Law was later than Grimm's Law (or at least the part of Grimm's Law that was cited here), then we must also assume that at the stage Verner's Law came into the language the language possessed voiceless continuants from two sources: the *s* which descended unchanged from the Indo-European and the voiceless, nonstrident continuants produced by Grimm's Law. The fact that Verner's Law applies without distinction to voiceless continuants from both sources is always cited as the crucial evidence in favor of regarding Verner's Law later than Grimm's Law. This evidence, however, carries weight only if we

aint that it must not result in novators—i.e., the carriers of except in such special cases as of thieves' argot, all changes each community. This restricted; e.g., a rule such as (19), for it renders the utterances usually obvious that the number serious effects on intelligibility or three otherwise innocuous

ment to preserve intelligibility added. All other things being a lower point in the order than characterize the place in the order of intelligibility. Such additions where there are natural

change most likely to survive at the end of certain natural hat in cases where the addition of the grammar, the order of —i.e., simplicity—will mirror et was noted by Bloomfield in

ach morphological element in a ions from this basic form which ments. If one starts with the basic in which we give them, one will y spoken. Our basic forms are not language, and our statements of ad appear in a purely descriptive mblance to those which would be f our statements of alternation on of Proto-Algonquian, and the istorical development from Proto-

mediate constituent structure of the rules); at the end of the cyclical rule utterance from the representation s (junctures) from the representation 5. This study is unaccountably omitted in *Language*, 24 (1949), "Proto-Algonquian Studies," *Language* (New York)

accept a criterion of simplicity much like the one that was stated above, for the facts can also be accounted for fully by a set of unordered rules:

in the environment where both  $C_G$  and  $C_V$  are satisfied,  
voiceless, nonstrident, noncontinuants are replaced by their  
cognate, voiced continuants (26a)

in the environment where  $C_G$  but not  $C_V$  is satisfied,  
voiceless nonstrident, noncontinuants are replaced by  
their cognate (voiceless) continuants (26b)

in the environment  $C_V$ ,  $s \rightarrow z$  (26c)

By the proposed simplicity criterion we must reject the unordered rules, for they are evidently more complex than the ordered alternative. Since there is no external evidence that the language in fact passed through a stage at which it was subject only to Grimm's Law and was not subject to Verner's Law, the acceptance of the traditional chronology of these "laws" is based wholly on considerations of simplicity.

## X

It was noted in Section VIII that as a result of the requirement that linguistic change not disrupt mutual intelligibility between the innovators and the rest of the speech community, the new rules are ordinarily added at the end of the grammar or of one of its major subdivisions. The addition of rules at other places, is not, however, completely excluded. In such instances the order of rules in the synchronic description will not properly mirror their relative chronology. This situation is well illustrated by the Middle English dialects in which both tense (long) /æ/ and /ā/ became /ē/ simultaneously with tense (long) /ɔ/ becoming /ō/.<sup>15</sup> The tense vowel system of these dialects was originally like that in (14) and was also subject to the phonetic rules given in (15). The change in question can be accounted for very elegantly if we assume that (15) was modified as shown in (27) by the addition of subpart (e\*) before subpart (c) rather than after subpart (d); i.e., at a place other than the end of the grammar:

a.	[+compact]	→	[-diffuse]	}	in the env.	[+vocalic -consonantal +tense	(27)
b.	[X]	→	<div style="display: inline-block; vertical-align: middle;">           [-nasal -strident +continuant +voiced]         </div>				
e*.	[X]	→	[-compact]				
c.	[+flat]	→	[+grave]				
d.	<div style="display: inline-block; vertical-align: middle;">           [-flat -compact]         </div>	→	[-grave]				

<sup>15</sup>Some scholars believe that the change /ā/ → /ē/ was later by 50 years than the changes /æ/ → /ē/ and /ɔ/ → /ō/. If they are right, my example is a hypothetical, rather than an actually attested instance. This does not affect its validity, however, since the example does not violate any known constraints on the structure or on the evolution of language.

Part (e\*) of (27) converts compact (mid) cognates; i vowels are still subject together of /ā/ and /æ/ in /ā/ → /æ/, provided that w the grammar or the end of

In discussing (22) the ε was observed that the adε simplest for the set of utte may be generated by a sin (22) eliminates also the pf utterances of the dialect, th phonetic contrast necessar words, since /æ/ and /a/ ar eliminated from the dictio is to answer this question feature complexes to repre ably. And yet there are case tions force us to maintain trast phonetically.

In certain Russian diale consonants in pretonic pos under the accent. Of inter so-called "seven vowel sy presented in (14).<sup>16</sup> In so vowel is governed by the r

after sharp co tion are pron (/ɔ a æ/), othe

In these dialects, which ar jakan'e of the Obojansk t; pronounced [s,al'o], where

<sup>16</sup>The phoneme that derives /e/ and the reflex of the so-call /o/ and /e/ and of the strong / therefore the distinction betwe compact, rather than as one of to justify this departure from shall also try to show that case of (28). See now my "Ak Russian dialects," (in press).

that was stated above, for the ordered rules:

1.  $C_V$  are satisfied, replaced by their (26a)

$C_V$  is satisfied, are replaced by (26b)

(26c)

the unordered rules, for they are. Since there is no external change at which it was subject only to  $V$ , the acceptance of the traditional considerations of simplicity.

the requirement that linguistic rules be added at the end of the list of rules at other places, is the order of rules in the syntactic chronology. This situation, which both tense (long) /æ/ and /ɔ̄/.<sup>15</sup> The tense vowel /ɔ̄/ and was also subject to the change can be accounted for very elegantly in (27) by the addition of part (d); i.e., at a place other

the env. 

+ vocalic
- consonantal
+ tense

 (27)

50 years than the changes /æ/ → /ɛ/ and /ɔ̄/ → /ɔ̄/, rather than an actually attested sample does not violate any known

Part (e\*) of (27) converts the three compact nondiffuse (low) vowels to their noncompact (mid) cognates; i.e., /æ/ → /ɛ/, /ā/ → /ɛ/, and /ɔ̄/ → /ɔ̄/. Since the resulting vowels are still subject to (27c), /ɛ/ is immediately fronted to /ɛ̄/. Thus, the falling together of /ā/ and /æ/ in /ɛ̄/ does not require us to assume a separate fronting of /ā/ → /ǣ/, provided that we allow rules to be added to places other than the end of the grammar or the end of its major subdivisions.

## XI

In discussing (22) the effects of the addition of subpart (e) in Section VII, it was observed that the addition of rules may result in a grammar which is not the simplest for the set of utterances it generates and that the identical set of utterances may be generated by a simpler grammar. Since the addition of subpart (e) to (22) eliminates also the phonetic contrast between the phonemes /a/ and /æ/ in all utterances of the dialect, the question naturally arises whether such a suppression of a phonetic contrast necessarily leads also to simplifications in the dictionary. In other words, since /æ/ and /a/ are not in contrast phonetically, must this contrast also be eliminated from the dictionary representation of lexical items? One's first reaction is to answer this question in the affirmative, for it seems pointless to use different feature complexes to represent segment-types that are never distinguished phonetically. And yet there are cases where this would not be so, where simplicity considerations force us to maintain distinct representations of segment-types that never contrast phonetically.

In certain Russian dialects, nondiffuse (nonhigh) vowels preceded by sharp (soft) consonants in pretonic position are actualized as /i/ or as /a/ depending on the vowel under the accent. Of interest here are those among the dialects which possess the so-called "seven vowel system," a system that is substantially identical with that presented in (14).<sup>16</sup> In some of these dialects, the distribution of the pretonic vowel is governed by the rule:

after sharp consonants, nondiffuse vowels in pretonic position are pronounced /i/ if the accented vowel is compact (/ɔ̄ a æ/), otherwise they are pronounced /a/ (28)

In these dialects, which are subject to what is technically known as "dissimilative jakan'e of the Obojansk type," we find, therefore, that /s,ɔ̄l'ɔ/ *village* (nom. sg.) is pronounced [s,al'ɔ], whereas /s,ɔ̄l'ɔm/ *village* (instr. sg.) is pronounced [s,il'ɔm]. In

<sup>15</sup>The phoneme that derives historically from /o/ under rising tone is represented in (14) as /ɔ̄/ and the reflex of the so-called "jat'" is represented in (14) as /ɛ/. Other reflexes of Old Russian /o/ and of the strong *jers* are represented in (14) by /ɔ/ and /æ/, respectively. I regard therefore the distinction between the two types of /ɛ/ and of /e/, as one of noncompact versus compact, rather than as one of tense versus lax, as is done in most dialectological studies. I hope to justify this departure from tradition in a study now in preparation, in which, incidentally, I shall also try to show that the "dissimilative jakan'e of the Žizdra type" is a special case of (28). See now my "Akan'e: the treatment of nondiffuse unstressed vowels in Southern Russian dialects," (in press).

some of these dialects, the distinction between compact /ɔ/ and /æ/ and noncompact /o/ and /e/ is lost, yet the vowels in pretonic position are treated as before; e.g. [s,il'om] but [s,al'ɔ]. In such dialects, therefore, phonetically identical segments —[ɔ]— produce distinct results in the distribution of the pretonic vowel. If the distinction between these etymologically distinct yet phonetically identical vowels were to be eliminated from the representation of morphemes, the statement of the distribution of the pretonic vowel (28) would become hopelessly complex.<sup>17</sup> Considerations of simplicity would dictate that the distinction between the respective segment-types be maintained and that their phonetic coalescence be accounted for by adding to the end of the grammar the rule:

$$[- \text{compact}] \rightarrow [+ \text{compact}] \text{ in the environment } \left[ \begin{array}{l} + \text{vocalic} \\ - \text{consonantal} \\ - \text{diffuse} \end{array} \right] \quad (29)$$

## XII

The two possibilities discussed in Sections X and XI—that of adding rules to the grammar at places other than the end and that of maintaining a phonemic distinction in the dictionary even when the distinction is not directly present in any utterance—suggest that phonemes that have fallen together at one stage in the evolution of a language may at a later stage emerge again as completely distinct entities. The point being made here is that it is not only that phoneme types that have merged at one stage may re-appear at a later stage, but that the re-emerging phonemes correspond precisely to their historical antecedents which had previously coalesced. The latter development has usually been regarded as impossible on theoretical grounds, yet if our theory is correct such developments are anything but impossible.

As an hypothetical example, consider a language containing the seven vowel system shown in (14) which is subject to the phonetic rule (23) causing all reflexes of

<sup>17</sup>These phenomena have recently been discussed by K. F. Zaxarova "Arxaičeskie tipy dissimiljativnogo jakan'ja v govorax Belgorodskoj i Voronežskoj oblasti," *Materialy i issledovanija po ruskoj dialektologii* (Moscow, 1959), with the significant comment that "jakan'e of the Obojansk type can continue to exist in dialects in which the system of stressed vowels corresponding to [this type of jakan'e—M. H.] is being or has already been lost." (p. 21).

Cases where distinct morphophonemic processes take place in what from a phonetic point of view are indistinguishable contexts are by no means rare. An intricate example is discussed by N. Chomsky and me in our forthcoming *Sound Pattern of English*. We show that, in order to account for the different stress patterns of such pairs as *hyperbola* and *avocado*, for the difference in vowel length in such pairs as *balm* and *bomb*, and for a few other phenomena, it is necessary to maintain a distinction between lax /ɔ/ and tense /ā/ even in General American where these two segment types are phonetically never distinct.

A third example is provided by those Northern Russian dialects in which the affricate /c/ has become /s/. The distinction between affricate and continuant must, however, be marked in the dictionary in order to account for the fact that in position before /e/, the /s/ which is the reflex of the affricate /c/ is not sharpened, whereas the reflex of the continuant is sharpened; e.g. (prep. sg.) [lis'e/fox and [lic'e/face are implemented phonetically as [lis,'e] and [lis'e], respectively. Cf. V. G. Orlova, *Istorija affrikat v ruskom jazyke* (Moscow, 1959), especially pp. 164-166.

/a/ to merge into /æ/. Such the addition of subpart (d

- a. [+compact]
- b. [X]
- d\*.  $\left[ \begin{array}{l} - \text{flat} \\ + \text{compact} \\ - \text{grave} \end{array} \right]$
- c. [+flat]

Observe that before the phonetically actualized as

As a result of adding (d\*), implemented as follows:

Observe that the changes eliminates the phonetic di in the representation of all to (23) is that given in 1 accounting for the chan in Section XI, /a/ and /æ/ r ned phonetically as /æ/.

The example just review puzzles of historical lingu bethan English, the reflex Middle English long /ā/, t times with *late* rather than in found; reflexes of /æ/ no account for this, we assum

<sup>18</sup>We are not taking into consi considerations may lead us to 1 and to revise radically Rule (3C but only that of their children. consequences for the speech of generations are of no relevance

/ɔ/ and /æ/ and noncompact are treated as before; e.g., phonetically identical segments of the pretonic vowel. If the phonetically identical vowels schemes, the statement of the scheme hopelessly complex. The distinction between the respective coalescence be accounted

$$\left[ \begin{array}{l} + \text{vocalic} \\ - \text{consonantal} \\ - \text{diffuse} \end{array} \right] \quad (29)$$

—that of adding rules to maintaining a phonemic distinction is present in any utterance—stage in the evolution of a set of distinct entities. The point is that types that have merged at one stage correspond to previously coalesced. The latter is on theoretical grounds, yet it is but impossible.

containing the seven vowel system (23) causing all reflexes of

rova "Arxaičeskie tipy dissimiljatsii. Materialy i issledovanija po russkoj" at "jakan'e of the Obojansk type vowels corresponding to (this type

in what from a phonetic point of view this intricate example is discussed by N. We show that, in order to account for the difference in vowel quality, for the difference in vowel length, it is necessary to maintain a system where these two segment types

dialects in which the affricate /tʃ/ has must, however, be marked in the reflex /e/, the /s/ which is the reflex of /tʃ/ is sharpened; e.g. (prep. sg.) /iʃ'e/ and [i, i's'e], respectively. Cf. V. G. G. originally pp. 164-166.

to merge into /æ/. Suppose that (23) were to be modified as shown in (30) by the addition of subpart (d\*) before subpart (b) rather than after subpart (c):

$$\left. \begin{array}{l} \text{a. } [+ \text{compact}] \rightarrow [- \text{diffuse}] \\ \text{b. } [X] \rightarrow \left[ \begin{array}{l} - \text{nasal} \\ - \text{strident} \\ + \text{voiced} \\ + \text{continuant} \\ - \text{grave} \end{array} \right] \\ \text{d*} \left[ \begin{array}{l} - \text{flat} \\ + \text{compact} \\ - \text{grave} \end{array} \right] \rightarrow [- \text{compact}] \\ \text{c. } [+ \text{flat}] \rightarrow [+ \text{grave}] \end{array} \right\} \text{in the env. } \left[ \begin{array}{l} + \text{vocalic} \\ - \text{consonantal} \end{array} \right] \quad (30)$$

Observe that before the addition of subpart (d\*) the original seven vowels are phonetically actualized as follows:

$$\begin{array}{ccccccccc} i & e & \text{æ} & a & \text{ɔ} & o & u & & \\ | & | & \vee & | & | & | & & & \\ i & e & \text{æ} & \text{ɔ} & o & u & & & \end{array} \quad (31)$$

As a result of adding (d\*), which coalesces /æ/ → /e/, the original seven vowels are actualized as follows:

$$\begin{array}{ccccccccc} i & e & \text{æ} & a & \text{ɔ} & o & u & & \\ | & | & / & / & | & | & | & & \\ i & e & \text{æ} & \text{ɔ} & o & u & & & \end{array} \quad (32)$$

Observe that the changes cannot be explained if it is assumed that because (23) eliminates the phonetic distinction between /æ/ and /a/, this distinction is also lost in the representation of all morphemes, so that the phonemic system corresponding to (23) is that given in the lower row of (31). No difficulties are experienced in accounting for the change if we postulate that, for reasons of the kind discussed in section XI, /a/ and /æ/ remained distinct entities even though every /a/ was actualized phonetically as /æ/. Subpart (d\*), which was introduced at a later point in time, could then affect the original seven vowels as shown in (32).<sup>18</sup>

The example just reviewed suggests a possible solution to some of the traditional puzzles of historical linguistics. Thus, for example, it is well known that in Elizabethan English, the reflexes of Middle English long /æ/ rime with the reflexes of Middle English long /ā/, both of which are assumed to have become /ē/; e.g., *beat* rimes with *late* rather than with *feet*. In the late seventeenth century, a radical change occurred; reflexes of /æ/ now rime with those of /ē/ rather than with those of /ā/. To account for this, we assume that Middle English had a tense vowel system like that

<sup>18</sup>We are not taking into consideration here the fact that after the addition of subpart (d\*), simplicity considerations may lead us to postulate a six vowel system like that in the lower row of Eq. (32) and to revise radically Rule (30). This would not affect the grammar of the carriers of the change, but only that of their children. Since it is the change itself that is of interest here, rather than its consequences for the speech of the next generation, the simplifications in the grammar of the later generations are of no relevance.

in (14) and, moreover, that in the Early Modern English period, this tense vowel system was subject to (23), now appropriately modified to affect tense vowels only, which caused /ā/ → /æ/ [cf. (31)]. We then postulate that the Great Vowel Shift operated on this system, thereby yielding the following reflexes of the original seven vowels:

i	e	æ	a	ɔ	o	u	(33)
		/					
aj	i	e	o	u	aw		

which are the long vowels of Shakespeare and his contemporaries. Assume further that the various morphophonemic processes of English, in particular the shortening of long vowels which played such a major role in derivational morphology, required the maintenance of the original seven vowel system in spite of the rather radical transformations effected by the phonetic rules which now include not only (23) but also the analogue of the Great Vowel Shift. The changes in the late seventeenth century can then be accounted for by postulating the addition of (d\*) to (23); i.e., the replacement of (23) by (30). Operating on the original seven vowel system of (14), (30) followed by the Vowel Shift rule yields the following correspondences:

i	e	æ	a	ɔ	o	u	(34)
	/	/					
aj	i	e	o	u	aw		

which are the reflexes of the Middle English long vowels in the language of today.<sup>11</sup>

<sup>11</sup>The comments on the history of English are meant to be merely suggestive. A detailed study of this topic is being planned by my colleague S. J. Keyser.

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