Phonology in Generative Grammar

Morris Halle

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A generative grammar is formally a collection of statements, rules or axioms which describe, define or generate all well-formed utterances in a language and only those. The theory of generative grammars consists of a set of abstract conditions which determine the form of the statements admitted in such grammars and which govern the choice among alternative descriptions of a given body of data.[1]

In the part of the grammar that is of interest here, all statements are of the form

(1a)   A→B in the environment X____Y
                                                Z

where A, B, X, Y, Z are symbols of a particular alphabet or zero, and"→" can be read "is to be rewritten as". The statements are, moreover, subject to a special notational convention which allows us to coalesce partly identical statements by factoring the parts that are identical. For instance, (1a) and

(1b)   C→D in the environment X____Y
                                                Z

can be coalesced into

(1c) $\begin{Bmatrix} A{\to}B \\ C{\to}D \end{Bmatrix}$ in the environment X____Y
                                                Z

[1] For more detailed discussions of generative grammars see:
    N. Chomsky, *Syntactic Structures* (The Hague, 1957);
    M. Halle, *The Sound Pattern of Russian* (The Hague, 1959);
    R. B. Lees, *A Grammar of English Nominalizations* (Bloomington, Indiana, 1960);
    N. Chomsky and M. Halle, *The Sound Pattern of English* (in preparation).

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 (1a)–(1c) 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.

1. 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, etc. 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:

(2)   /a/ is replaced by /æ/ if followed by /i/

is evidently simpler than the statement:

(3)   /a/ is replaced by /æ/ if followed by /i/ and preceded by /i/.

Translating into the standard form of (1), and regarding phonological segments as indivisible entities, we obtain

(2′)   /a/→/æ/ in the env._____/i/

(3′)   /a/→/æ/ in the env. /i/_____/i/

Alternatively, if we regard phonological segments as complexes of properties,[2] we obtain

(2″)

$$[+\text{grave}]\rightarrow[-\text{grave}] \text{ in the env. } \left[\begin{array}{c} \overline{} \\ +\text{vocalic} \\ -\text{consonantal} \\ -\text{diffuse} \\ +\text{compact} \\ -\text{flat} \end{array}\right] \left[\begin{array}{c} +\text{vocalic} \\ -\text{consonantal} \\ +\text{diffuse} \\ -\text{compact} \\ -\text{flat} \\ -\text{grave} \end{array}\right]$$

(3″)

$$[+\text{grave}]\rightarrow[-\text{grave}] \text{ in the env. } \left[\begin{array}{c} +\text{vocalic} \\ -\text{consonantal} \\ +\text{diffuse} \\ -\text{compact} \\ -\text{flat} \\ -\text{grave} \end{array}\right] \left[\begin{array}{c} \overline{} \\ +\text{vocalic} \\ -\text{consonantal} \\ -\text{diffuse} \\ +\text{compact} \\ -\text{flat} \end{array}\right] \left[\begin{array}{c} +\text{vocalic} \\ -\text{consonantal} \\ +\text{diffuse} \\ -\text{compact} \\ -\text{flat} \\ -\text{grave} \end{array}\right]$$

Either reformulation of statement (2) is to be preferred by the proposed simplicity criterion over the corresponding reformulation of statement (3), since the equivalents of (2) utilize three (respectively 13) symbols, vs. four (respectively, 19) symbols utilized in the equivalents of (3).

Consider, however, the following pair of statements for a language possessing the three front vowels /æ/ /e/ /i/:

(2)   /a/ is replaced by /æ/, if followed by /i/

(4)   /a/ is replaced by /æ/, if followed by any front vowel.

Here (4) is the more general rule, and is, therefore, to be preferred over (2). Translating the two statements into the standard form, and viewing phonemes as indivisible entities; we obtain

(2′)   /a/→/æ/ in the env._____/i/

---

[2] I shall use here the Jakobsonian distinctive features as the properties in terms of which segments are to be characterized. The choice of a different phonetic framework, however, would not affect the outcome of the present comparison. In view of the decision to operate with the distinctive feature framework, all references below to segments as "/s/" or as "labial stops" are to be understood as unofficial circumlocutions introduced only to facilitate the exposition, but lacking all systematic import.

(4') $/a/\rightarrow/\text{æ}/$ in the env. —— ---$\left\{\begin{matrix} /i/ \\ /e/ \\ /\text{æ}/ \end{matrix}\right\}$

Regarding phonemes as complexes of features, we obtain

(2")

[+grave]→[−grave] in the env. $\begin{bmatrix} \overline{} \\ +\text{vocalic} \\ -\text{consonantal} \\ -\text{diffuse} \\ +\text{compact} \\ -\text{flat} \end{bmatrix}$ $\begin{bmatrix} +\text{vocalic} \\ -\text{consonantal} \\ +\text{diffuse} \\ -\text{compact} \\ -\text{flat} \\ -\text{grave} \end{bmatrix}$

(4")

[+grave]→[−grave] in the env. $\begin{bmatrix} \overline{} \\ +\text{vocalic} \\ -\text{consonantal} \\ -\text{diffuse} \\ +\text{compact} \\ -\text{flat} \end{bmatrix}$ $\begin{bmatrix} +\text{vocalic} \\ -\text{consonantal} \\ -\text{grave} \end{bmatrix}$

The alternative reformulations of (2) and (4) are not consistent with each other: statement (2') utilizes fewer symbols than (4'), whereas (2") utilizes more symbols than (4"). Since we know on independent grounds that (4) is more general than (2) and must, therefore, be preferred over the latter, the results obtained in the reformulations (2') and (4') are also inconsistent with the results obtained in (2') and (3'), 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.

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 phonetic properties. 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, etc.)

2. 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:

(5) "Two similar simple vowels, short or long, coalesce and form the corresponding long vowel . . . (§126)

(6) "An *a*-vowel combines with a following *i*-vowel to *e*; with a *u*-vowel, to *o* . . ." (§127)

(7) "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*." (§129)

(8) "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 *av* . . . (§131)

If the first three rules are applied in the order (5) (7) (6), two important
economies can be effected. First of all, in rule (7), the qualification "before
a dissimilar vowel or a diphthong" can be simplified to "before a vowel",
for at the point where rule (7) applies only sequences of dissimilar vowels
remain, since rule (5) replaces all sequences of identical vowel by single
long vowels. Moreover, rule (8) can be dispensed with altogether. Since
rule (7) converts /i/ and /u/ in position before vowel into /y/ and /v/, re-
spectively, 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 (6). Inasmuch as rule (6) is the only source of /e/ and /o/ in the lan-
guage, there is now no need for rule (8), 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 (8) are handled properly without it: /naia/ and
/bʰaua/ are turned by rule (7) into /naya/ and /bʰava/ to which rule (6) does
not apply. The same stems without the suffix /a/, on the other hand, are not
subject to rule (7) and are, therefore, affected by (the later) rule (6), which
converts /nai/ into /ne/ and /bʰau/ into /bʰo/.

In sum, rule (8) 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 (8). Our simplicity criterion leaves us no alternative but to
choose the former solution.

3. 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 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 /dɔg/, our
dictionary might contain the entry

(9)

$$
\begin{bmatrix} -\text{vocalic} \\ +\text{consonantal} \\ -\text{strident} \\ -\text{compact} \\ -\text{grave} \\ -\text{continuant} \\ -\text{nasal} \\ -\text{tense} \\ -\text{diffuse} \\ -\text{flat} \\ +\text{voiced} \end{bmatrix}
\begin{bmatrix} +\text{vocalic} \\ -\text{consonantal} \\ -\text{strident} \\ +\text{compact} \\ +\text{grave} \\ +\text{continuant} \\ -\text{nasal} \\ +\text{tense} \\ -\text{diffuse} \\ +\text{flat} \\ +\text{voiced} \end{bmatrix}
\begin{bmatrix} -\text{vocalic} \\ +\text{consonantal} \\ -\text{strident} \\ +\text{compact} \\ +\text{grave} \\ -\text{continuant} \\ -\text{nasal} \\ -\text{tense} \\ -\text{diffuse} \\ -\text{flat} \\ +\text{voiced} \end{bmatrix}
$$

This representation contains an excessive number of features. As can be seen in (10), English vowels—i.e., segments that are $\begin{bmatrix} + \text{vocalic} \\ - \text{consonantal} \end{bmatrix}$— are all non-nasal, non-strident, voiced and continuant. Moreover, compact

(10)

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

The distinctive feature composition of vowels in certain dialects of modern English. The feature of tenseness has not been specified since the system contains 7 tense and 7 non-tense vowels.

(low) vowels are always non-diffuse (non-high); while all flat (rounded) vowels are always grave (back). Non-flat (unrounded) vowels, on the other hand, are invariably non-grave (front) only if they are also non-compact (non-low). This suggests that the redundant features be omitted in all dictionary entries in which the respective vowels figure and be introduced by a special rule[3]:

$$
(11) \begin{cases}
\text{a.} & [+\text{compact}] \rightarrow [-\text{diffuse}] \\
\text{b.} & [X] \rightarrow \begin{bmatrix} -\text{nasal} \\ -\text{strident} \\ +\text{continuant} \\ +\text{voiced} \end{bmatrix} \\
\text{c.} & [+\text{flat}] \rightarrow [+\text{grave}] \\
\text{d.} & \begin{bmatrix} -\text{flat} \\ -\text{compact} \end{bmatrix} \rightarrow [-\text{grave}]
\end{cases} \quad \text{in the env.} \begin{bmatrix} \overline{+\text{vocalic}} \\ -\text{consonantal} \end{bmatrix}
$$

where [X] represents an arbitrary feature complex.

[3] In order to shorten the formulaic representations of the rules and to make them more perspicuous, expressions in the form

$$[X] \rightarrow [A] \text{ in the env. } [B] \begin{bmatrix} \underline{\quad\quad} \\ C \end{bmatrix} [D]$$

Given (11), the vowel in (9) can be represented by the feature complex

$$\begin{bmatrix} +\text{vocalic} \\ -\text{consonantal} \\ +\text{compact} \\ +\text{flat} \\ +\text{tense} \end{bmatrix}$$

i.e., by five instead of eleven features.

The simplicity criterion clearly demands that this procedure be followed in the representation of every dictionary entry, for it allows us to shorten the dictionary, which is an integral part of a grammar, by many hundreds of features at the slight additional cost represented by the 13 features utilized in rule (11). In general, we must omit features in all dictionary representations, whenever these can be introduced by a rule that is less costly than the saving it effects.

4. Among the redundancies that must be eliminated are those where the appearance of a given feature in a segment is contextually determined. Thus, for instance, /tsaym/, /gnayt/ and /vnig/ are not English words, since English words do not begin with the sequences /ts/, or /gn/, or /vn/. As a matter of fact, it is generally true that if an English word begins with a sequence of two consonants, the first is invariably /s/: /st/, /sp/ /sk/, /sm/, /sn/ are the only two-consonant—i.e. $\begin{bmatrix} -\text{vocalic} \\ +\text{consonantal} \end{bmatrix}$—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:

(12) $\begin{bmatrix} -\text{vocalic} \\ +\text{consonantal} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{strident} \\ -\text{compact} \\ -\text{grave} \\ +\text{tense} \\ +\text{continuant} \end{bmatrix}$ in env. $\#[\underline{\hspace{2cm}}]\begin{bmatrix} -\text{vocalic} \\ +\text{consonantal} \end{bmatrix}$

As a result of rule (12) the description is shortened by five features for every dictionary item beginning with two consonants. Thus, a very great saving

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where X is an arbitrary feature complex, and A, B, C, D are specific feature complexes or zero, will usually be given in the following form:

[C] → [A] in the env. [B] [————] [D]

is realized in the dictionary at the cost of the nine features mentioned in rule (12).[4]

Consider now such sequences as /bik/, /θōd/, or /nis/. Like the afore-mentioned /tsaym/, /gnayt/, and /vnig/ none are actual English words. If, however, we attempted to exclude them by means of a rule like (12), 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:

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

And at the cost of the 18 features mentioned in rule (13), we could effect a saving of one feature in the dictionary. The simplicity criterion, therefore, does not allow us to include rule (13) in a description of English.

The presence of rule (12) and the absence of rule (13) in a description of English mirrors the English speaker's intuition about his language. The presence of rule (12) corresponds to the fact that speakers of English will regard /vnig/, /tsaym/ and /gnayt/ as not only meaningless, but also as totally un-English; impossible by the rules of their language. The absence of rule (13) and a host of similar rules corresponds to the fact that English speakers will accept the equally meaningless /bik/, /θōd/ and /nis/ as pos-sible English words, perhaps as words found in an unabridged dictionary rather in the vocabulary of the average speaker.

In attempting to satisfy the simplicity criterion, we are, thus, forced to incorporate 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,[5] since the sole purpose of phonological grammars is to charac-

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[4] This saving has the additional effect of ruling out forms such as /vnig/, /tsaym/, and /gnayt/. It may be noted that the idea of representing segments in a given form by less than their normal complement of features is essentially identical with the "archi-phoneme" 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.

[5] Cf. F. Householder, "On Linguistic Primes," *Word* XV (1959) 231–239 and H. Contreras and S. Saporta, "The Validation of a Phonological Grammar," *Lingua* IX (1960) 1–15.

terize the distinction between admissible and inadmissible segment sequences.

5. 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 repertories, distributional constraints, etc. 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; e.g.

General American	Pig Latin
/str'īt/	/'ītstrē/
/str'īts/	/'ītstrē/
/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:

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

Since rule (14) 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.

6. 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."[6] 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

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

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

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

Joos notes that the speakers of these dialects "divide into two groups according to their pronunciation of words like *typewriter*. Group A says [tɐɪprɐɪdɚ] while group B says [tɐɪpraɪdɚ]... 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 [ɐɪ] to [aɪ]."

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 (15) precedes rule (16), while in the grammar of group B, the reverse order obtains. Hence in the speech of group A /taɪpraɪtɚ/ is converted by rule (15) into [tɐɪprɐɪtɚ] which then is turned by rule (16) into [tɐɪprɐɪdɚ]. In the speech of group B, on the other hand, /taɪpraɪtɚ/ is first turned by rule (16) into [taɪpraɪdɚ] and then by rule (15) into [tɐɪpraɪdɚ].[7]

[6] *Language* XVIII (1942) 141–144.¹

[7] 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.

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.[8] 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.

7. 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.[9] 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 or elimination of a few rules in the grammar, and that a wholesale restructuring of his grammar is beyond the capabilities of the average adult.

[8] 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* X [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.

[9] 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 recréation totale faite sous l'influence du milieu qui l'entoure." *Linguistique historique et linguistique générale* II (Paris, 1952), p. 74.

The addition of rules may—though it need not invariably—result in a grammar that is not optimal (the simplest) for the set of utterances that it generates. As an example, consider the consequences of expanding rule (11) by the addition of subpart (e):

$$
(11') \quad
\begin{cases}
\text{a.} & [+\text{compact}] \rightarrow [-\text{diffuse}] \\
\text{b.} & [X] \rightarrow \begin{bmatrix} -\text{nasal} \\ -\text{strident} \\ +\text{continuant} \\ +\text{voiced} \end{bmatrix} \\
\text{c.} & [+\text{flat}] \rightarrow [+\text{grave}] \\
\text{d.} & \begin{bmatrix} -\text{flat} \\ -\text{compact} \end{bmatrix} \rightarrow [-\text{grave}] \\
\text{e.} & \begin{bmatrix} -\text{flat} \\ +\text{compact} \end{bmatrix} \rightarrow [-\text{grave}]
\end{cases}
\quad \text{in the env.} \begin{bmatrix} +\text{vocalic} \\ -\text{consonantal} \end{bmatrix}
$$

As can be readily seen from (10), the addition of subpart (e) amounts to a coalescence of /a/→/æ/. The distribution of gravity in vowels is, therefore, completely determined, and rule (11' a—e) must be replaced by the following, simpler rule (12 vs. 10 features):

$$
(17) \quad
\begin{cases}
\text{a.} & [+\text{compact}] \rightarrow [-\text{diffuse}] \\
\text{b.} & [X] \rightarrow \begin{bmatrix} -\text{nasal} \\ -\text{strident} \\ +\text{continuant} \\ -\text{grave} \\ +\text{voiced} \end{bmatrix} \\
\text{c.} & [+\text{flat}] \rightarrow [+\text{grave}]
\end{cases}
\quad \text{in the env.} \begin{bmatrix} +\text{vocalic} \\ -\text{consonantal} \end{bmatrix}
$$

Observe that rule (11'e), which was the cause of the whole upheaval, does not even figure in (17), which nevertheless generates precisely the same set of utterances as (11' a—e).[10]

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 rule (11'e) was added to the grammar, I should therefore postulate that the adult, who of necessity is maximally conservative, would have a grammar containing rule (11' a—e), whereas his children would have grammars with the simpler rule (17). It is clear that such discontinuities in the grammars of successive generations must exercise a profound influence on the further evolution of the language.[11]

[10] For a discussion of further consequences of the addition of rules such as (11e), see sections **10-12**.

[11] 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 essentiellement discontinu de la transmission du langage: l'enfant qui apprend à parler ne reçoit pas la langue toute faite: il doit la recréer tout entière à son usage d'après ce qu'il entend autour de lui . . . Cette discontinuité de la transmission

3—w.

8. 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. Ex-
cept 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 (14) 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 intelli-
gibility 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.[12]

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 sim-
plicity of the grammar, the order of rules established by purely synchronic
considerations—i.e., simplicity—will mirror properly the relative chrono-
logy 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

du langage ne suffirait à elle seule à rien expliquer, mais, sans elle, toutes les causes du
changement auraient sans doute été impuissantes à transformer le sens des mots aussi
radicalement qu'il l'a été dans un grand nombre de cas: d'une manière générale d'ail-
leurs, la discontinuité de la transmission est la condition première qui détermine la
possibilité et les modalités de tous les changements linguistiques." *Linguistique historique
et linguistique générale*, I (Paris, 1948), p. 236. I am indebted to E. S. Klima for drawing
my attention to the quoted passage.

12 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.

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."[13]

9. It has been proposed here that the primary mechanism of phonological change is the addition of rules to the grammar with special (though not exclusive) preference for the addition of single rules at the ends of different subdivisions of the grammar. It seems to me that this view is implicit in much of the work in historical linguistics; in fact, I believe that the successes and failures of linguistics in its attempts to reconstruct the history of different languages can best be understood in the light of the model discussed here.

As is well known, in reconstructing the history of a language, it is customary to postulate a proto-language from which subsequent (documented) stages are derived by the operation of "phonetic laws"[14] and a few other processes which need not concern us here. In the terms of this study, reconstructing the history of a language would be described as deriving the grammars of later (attested) languages from that postulated for the proto-language by the addition of new rules. I have tried to show elsewhere that considerations of simplicity (in the precise sense defined here) usually play an important role in reconstruction.[15] The all but universal agreement on the relative chronology of Grimm's and Verner's Laws is no doubt due to the fact that simplicity considerations clearly demand that Verner's Law apply after Grimm's Law. When simplicity considerations do not dictate a particular order, there is often also no agreement about the relative chronology. For instance, the chronological position within Grimm's Law of the shift of Indo-European voiced aspirate stops to voiced non-strident

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[13] *Travaux du Cercle Linguistique de Prague* VIII (1939) 105–115. This study is unaccountably omitted in C. F. Hockett's "Implications of Bloomfield's Algonquian Studies," *Language* XXIV (1949) 117–131. Cf. also Bloomfield's comments on "descriptive order" in his *Language* (New York, 1933) pp. 213 and 222.

[14] "Pour tous les groupes actuellement établis et étudiés d'une manière méthodique, le moyen de faire le rapprochement est de poser une 'langue commune' initiale." A. Meillet, *La méthode comparative en linguistique historique* (Oslo, 1925), p. 12.

[15] "On the Role of Simplicity in Linguistic Descriptions," *Structure of Language and Its Mathematical Aspects: Proceedings of Symposia on Applied Mathematics*, vol. XII (Providence, 1961) pp. 89–94.

continuants (bh→β; dh→ð; gh→γ) is still under discussion[16] and is likely to remain so for a long time, since no particular order for this rule is dictated by the simplicity criterion, which, in view of the absence of documentary or other external evidence, is the only remaining basis for establishing the chronology.

10. It was noted in **8** 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) /ɔ̄/ becoming /ō/.[17] The tense vowel system of these dialects was originally like that in (10), and was also subject to the phonetic rules given in (11). The change in question can be accounted for very elegantly if we assume that (11) was modified as shown in (18) by the addition of subpart (e*) before rather than after subpart (d); i.e., at a place other than the end of the grammar:

$$(18) \quad \left\{ \begin{array}{lll} \text{a.} & [+\text{compact}] & \rightarrow [-\text{diffuse}] \\ \text{b.} & [X] \rightarrow & \left[\begin{array}{l} -\text{nasal} \\ -\text{strident} \\ +\text{continuant} \\ +\text{voiced} \end{array} \right] \\ \text{c.} & [+\text{flat}] & \rightarrow [+\text{grave}] \\ \text{e*.} & [+\text{compact}] & \rightarrow [-\text{compact}] \\ \text{d.} & \left[\begin{array}{l} -\text{flat} \\ -\text{compact} \end{array} \right] \rightarrow [-\text{grave}] \end{array} \right\} \text{ in the env.} \left[\begin{array}{l} \overline{} \\ +\text{vocalic} \\ -\text{consonantal} \\ +\text{tense} \end{array} \right]$$

Rule (18e*) converts the three compact non-diffuse (low) vowels to their non-compact (mid) cognates; i.e., /æ/→/ē/, /ā/→/ɐ̄/, and /ɔ̄/→/ō/. Since the resulting vowels are still subject to (18d), /ɐ̄/ is immediately fronted to /ē/. Thus the falling together of /ā/ and /æ/ in /ē/ does not require us to assume a separate fronting of /ā/→/æ/, provided that we allow rules to be added to places other than the end of the grammar or the end of its major subdivisions.

[16] For a review of this problem see W. G. Moulton "The Stops and Spirants of Early Germanic," *Language* XXX (1954) 1–42 and L. L. Hammerich, "Die germanische und die hochdeutsche Lautverschiebung," *Beiträge zur Geschichte der deutschen Sprache und Literatur* LXXVII (1954) 1–29.

[17] Some scholars believe that the change /ā/→/ē/ was later by 50 years than the changes /æ/→/ē/ and /ɔ̄/→/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.

11. In discussing (under 7) the effects of the addition of subpart (e) in rule (11'), 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 rule (11') 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, non-diffuse (non-high) 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 (10.).[18] In some of these dialects, the distribution of the pretonic vowel is governed by the rule:

(19) After sharp consonants, non-diffuse vowels in pretonic position are pronounced /i/ if the accented vowel is compact (/ɔ a æ/), otherwise they are pronounced /a/.

In these dialects, which are subject to what is technically known as "dissimilative jakan'e of the Obojansk type", we find, therefore, that /s,ɔl'o/ 'village' (nom. sg.) is pronounced [s,al'o], whereas /s,ɔl'ɔm/ 'village' (instr. sg.) is pronounced [s,il'ɔm]. In some of these dialects, the distinction between compact /ɔ/ and /æ/ and non-compact /o/ and /e/ is lost, yet the vowels in pretonic position are treated as before; e.g., [s,il'ɔm] 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

[18] The phoneme that derives historically from /o/ under rising tone is represented in (10) as /o/ and the reflex of the so-called *jat'* is represented in (10) as /e/. Other reflexes of Old Russian /o/ and /e/ and of the strong *jers* are represented in (10) by /ɔ/ and /æ/ respectively. I regard therefore the distinction between the two types of /o/ and of /e/, as one of non-compact vs. compact, rather than as one of tense vs. 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 in the so-called seven vowel dialects, only five vowels are actually distinctive.

vowels were to be eliminated from the representation of morphemes, the statement of the distribution of the pretonic vowel (rule (19)) would become hopelessly complex.[19] 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:

(20)   [−compact]→[+compact] in the environment $\begin{bmatrix} +\text{vocalic} \\ -\text{consonantal} \\ -\text{diffuse} \end{bmatrix}$

12. The two possibilities discussed in **10** and **11**—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 reappear 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.
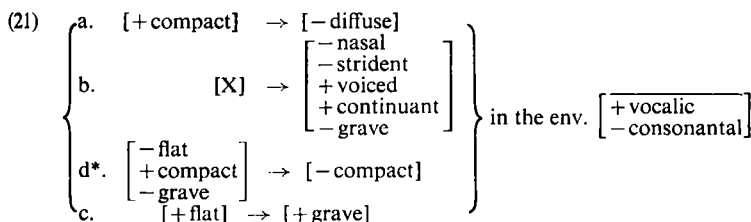
As an hypothetical example, consider a language containing the seven

[19] These phenomena have recently been discussed by K. F. Zaxarova "Arxaičeskie tipy dissimiljativnogo jakan'ja v govorax Belgorodskoj i Voronežskoj oblastjax," *Materialy i issledovanija po russkoj 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).
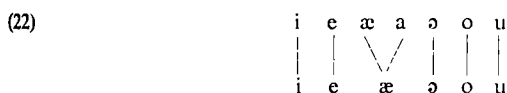
Cases where distinct morphophonemic processes take place in what from a phonetic point of view are indistinguishable contexts are by no means rare. An intricate example is discussed by N. Chomsky and me in our forthcoming *Sound Pattern of English*. We show that, in order to account for the different 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 /ŏ/ and tense /ä/ 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 sharped, whereas the reflex of the continuant is sharped; e.g. prep. sg. /l,is'e/ "fox" and /l,ic'e/ "face" are implemented phonetically as [l,is,'ɛ] and [l,is'ɛ], respectively. Cf. V. G. Orlova, *Istorija affrikat v russkom jazyke* (Moscow, 1959), especially pp. 164–166.

vowel system shown in (10) which is subject to the phonetic rule (17) caus-
ing all reflexes of /a/ to merge into /æ/. Suppose that rule (17) were to be
modified as shown below in (21) by the addition of subpart (d*) before
subpart (b) rather than after subpart (c):

(21)
$$
\left\{
\begin{array}{lll}
\text{a.} & [+\text{compact}] & \rightarrow [-\text{diffuse}] \\
\text{b.} & [\text{X}] \rightarrow & \begin{bmatrix} -\text{nasal} \\ -\text{strident} \\ +\text{voiced} \\ +\text{continuant} \\ -\text{grave} \end{bmatrix} \\
\text{d*.} & \begin{bmatrix} -\text{flat} \\ +\text{compact} \\ -\text{grave} \end{bmatrix} \rightarrow [-\text{compact}] \\
\text{c.} & [+\text{flat}] \rightarrow [+\text{grave}]
\end{array}
\right\} \text{ in the env. } \begin{bmatrix} +\text{vocalic} \\ -\text{consonantal} \end{bmatrix}
$$

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

(22)
$$
\begin{array}{ccccccc}
\text{i} & \text{e} & \text{æ} & \text{a} & \text{ɔ} & \text{o} & \text{u} \\
| & | & \searrow & \swarrow & | & | & | \\
\text{i} & \text{e} & \text{æ} & & \text{ɔ} & \text{o} & \text{u}
\end{array}
$$

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

(23)
$$
\begin{array}{ccccccc}
\text{i} & \text{e} & \text{æ} & \text{a} & \text{ɔ} & \text{o} & \text{u} \\
| & |\swarrow & \swarrow & & | & | & | \\
\text{e} & \text{e} & \text{æ} & & \text{ɔ} & \text{o} & \text{u}
\end{array}
$$

Observe that the changes cannot be explained if it is assumed that because
rule (17) eliminates the phonetic distinction between /æ/ and /a/, this dis-
tinction is also lost in the representation of all morphemes, so that the
phonemic system corresponding to (17) is that given in the lower row of
(22). No difficulties are experienced in accounting for the change if we
postulate that, for reasons of the kind discussed in section **11**, /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 (23).[20]

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 /ǣ/

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[20] 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 (23) and to revise radically rule (21). 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 must be disregarded.

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 is found; reflexes of /ǣ/ 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 in (10) and, moreover, that in the Early Modern English period, this tense vowel system was subject to rule (17), now appropriately modified to affect tense vowels only, which caused /ā/→/ǣ/ [cf. (22)]. We then postulate that the Great Vowel Shift operated on this system, thereby yielding the following reflexes of the original seven vowels:

(24)   i   e   æ   a   ɔ   o   u
                  | | |/ | | |
                  | | |/ | | |
                  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 (17) 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 (17); i.e., the replacement of (17) by (21). Operating on the original seven vowel system of (10), (21) followed by the Vowel Shift rule yields the following correspondences:

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

which are the reflexes of the Middle English long vowels in the language of today.[21]

Massachusetts Institute of Technology,
Cambridge 39, Massachusetts

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[21] 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.