

COMPARE AND CONTRAST
STRUCTURALIST AND GENERATIVE PHONOLOGICAL THEORY,
WITH PARTICULAR REFERENCE TO
THEIR USEFULNESS TO LANGUAGE TEACHERS

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Introduction

Advances in our understanding of the world tend to proceed in cyclic phases of what could be called 'insight', 'consolidation' and 'divergence'. An individual or group more or less suddenly perceives a pattern in hitherto unrelated 'facts'; then s/he, and maybe others, amass further data to confirm the initial insight, to refine it, to extend its range of application; and thus, inevitably, the limitations (perhaps the utter wrongness!) of the original idea becomes clear, the momentum of enthusiasm abates, and the researchers reflect on the situation from new angles, hoping for an 'aha!' experience to begin the cycle anew - or another group which has been becoming increasingly impatient with the first group may seize the chance to present its views.

The history of language studies in the past two centuries gives us repeated examples of this cycle, and nowhere more clearly than in the cases of the 'structuralist' and 'generative' schools of phonology in America. The former, which is generally regarded as having been launched by the publication of Leonard Bloomfield's *Language* (1933), was extremely influential during the next thirty years: it was succeeded in the 1960's by the generativist school, especially after Noam Chomsky and Morris Halle published their *The Sound Pattern of English* in 1968; and the dominance and unity of this latter group has now begun to disintegrate, though as yet no single new group is seen as a replacement.

The overall intentions of both these schools of linguists were fairly similar: to analyse language data in a rigorous and systematic way - and particularly to correct the (to them) glaring shortcomings of their predecessors - though the specific concerns and procedures used were very different. Both the structuralists and the generativists have added greatly to our store of facts about individual languages and as well to our theoretical understandings of language in general (despite the often scathing criticisms of their respective detractors); though equally there were many lofty hopes which have even now not been fulfilled. Moreover both groups did to some extent avoid the traps into which they felt earlier linguists had fallen - indeed, not surprisingly, it was often these problem

areas which had been the initial stimuli to investigation and which were thus well dealt with by these schools - but, on the other hand, there were unforeseen traps and, perhaps worse, linguists of both persuasions seem to have unconsciously committed some of the very sins for which they had criticised others. However, modern linguists and language teachers alike have much to gain from an examination of both the successes and the failures of the structuralist and generative phonologists.

The Structuralist (or Descriptivist) School of Phonology

In the early part of the twentieth century, Franz Boas, an anthropologist, earned the title of 'father of the authentically scientific study of language in North America' (Anderson 1985: 198) for his insistence that each language should be studied on its own terms rather than in a single preconceived way, and that linguistic data should be recorded accurately, i.e. in as much phonetic detail as possible. Another anthropologist, Edward Sapir, who studied under Boas, also had considerable influence on the development of linguistics. He held a strongly psychological and cultural view of language; thus for him the phoneme or speech sound was of great interest as an abstract, mental construct, an 'intentionality' in the mind, rather than as a physical reality (Anderson 1985: 228), though of course he did not deny that it was realised phonetically.

The ideas of these and other researchers in America and elsewhere affected the direction that linguistics would take as an independent discipline; partly because they provided a rich source of data about language(s), but partly too because they provided viewpoints that could be reacted against.

Leonard Bloomfield, nowadays seen as a leading figure of the Descriptivist school, was well-placed to be a leader in the growing area of linguistics. He had studied with some of the neo-grammarians in Germany, and had been influenced by their views on 'the mechanical nature of linguistic change, and the possibility of a rigorous account of its operation' (Anderson 1985: 254). He was interested in both the comparative study of languages and in the synchronic description of individual languages, and had solid experience in analysing a wide variety of languages, including German, Indo-European, Sanskrit, Tagalog and (later) the Algonquian family of languages (Anderson 1985: 251-253). His study of Indo-European and Sanskrit could hardly have been a synchronic study, in the

light of which his comments in *Language* on the value of historical data in the study of a language are thought-provoking (Bloomfield 1935: 19-20):

In order to describe a language, one needs no historical knowledge whatever; in fact, the observer who allows such knowledge to affect his description, is bound to distort his data. Our descriptions must be unprejudiced, if they are to give a sound basis for comparative work.

Bloomfield moved from an earlier Wundtian view of the central role of psychology in understanding the nature of language to a point where he dismissed this perspective as 'mentalism' and fervently embraced the 'materialistic (or, better, mechanistic) theory' (1935: 33) (now called 'behaviourism'), where human behaviour, including language, is merely a complex sequence of physical causes and effects, and therefore 'language is a matter of training and habit' (1935: 32-34).

This 'positivist, mechanist philosophy of science' fitted well into the 'ideological' climate of academic research at that time; and, as linguists wanted to establish linguistics as a separate discipline, and as it seemed vital therefore to emphasise linguistics as a science, Bloomfield's background and beliefs gave him a central role in this endeavour. His 'scientific' approach comes through all his research and his writings, and brings both advantages and limitations; furthermore, because of his influential position, a whole generation of linguists (including Hockett, Trager, Hill, Joos, Harris, Nida, Pike and Fries) were more or less strongly identified as holding 'neo- or 'post-Bloomfieldian' views, though many of these also established their own positions over time.

Though it does not seem to be stated explicitly in *Language*, Bloomfield's overall concern is clearly to make it possible to capture the structure of a language in a systematic way, as fully as one can and as efficiently as is consistent with the other two goals. Ideally, this would involve (Bloomfield 1935: 74):

two main investigations: **phonetics**, in which we studied the speech-event without reference to its meaning, investigating only the sound-producing movements of the speaker, the sound-waves, and the action on the hearer's ear-drum, and **semantics**, in which we studied the relation of these features to the features of meaning, showing that a certain type of speech-sound was uttered in certain types of situations and led the hearer to perform certain types of response.

But he quickly acknowledges a difficulty: we can not yet accurately capture the full detail of speech-sounds.

The extent of observation is haphazard, its accuracy doubtful, and the terms in which it is reported are vague. Practical phonetics is a skill, for the student of languages often a very important skill, but it has little scientific value (1935: 127).

Moreover:

laboratory phonetics does not enable us to connect speech-sounds with meanings; it studies speech-sounds only as muscular movements or as disturbances in the air, without regard to their use in communication. On this plane, we find that speech-sounds are infinitely complex and infinitely varied (1935: 76).

Clearly, however, the speakers of a language could not communicate - use language - if every speech event were really so entirely novel:

Evidently the working of language is due to a resemblance between successive utterances. Utterances which in ordinary life we describe as consisting of 'the same' speech-forms - say, successive utterances of the sentence I'm hungry - evidently contain some constant features of sound-wave, common to all utterances of this 'same' speech-form. Only on this assumption can we account for our ordinary use of language (1935: 76).

These 'constant' or 'common' or recurrent features were to become the main focus of Bloomfield's attention, and that of the other structuralists.

The 'gross acoustic features' of any utterance contain some '**non-distinctive** features' - those which are immaterial for communication - and those which are 'connected with meanings and essential to communication (**distinctive**)' (1935: 77); for the latter he uses the term 'phoneme' which was already in use by earlier linguists, but which he defines in a somewhat new way. For Bloomfield, each phoneme is 'a minimum unit of distinctive sound-**feature**' (1935: 79); although later on the same page he confusingly suggests that each phoneme consists of **several** features ('These distinctive features occur in lumps or bundles, each one of which we call a phoneme'), most of his writings imply a non-divisible phoneme. Again: 'The phonemes of a language are not sounds, but merely features of sound which the speakers have been trained to produce and recognise in the current of actual speech sound'. However, this ambiguous use of the term 'feature' in relation to 'phoneme' - where at one moment it seems synonymous with 'phoneme' and at another to reflect a **sub**-component of a phoneme - caused

considerable debate even among fellow-structuralists, and is very possibly one reason why the generativists were so very explicit about features thirty years later.

How exactly are phonemes identified? In the classical phonemic analysis of a language, phonemes are determined initially by finding meaningful contrasts between very similar words: eg. tin/din, bet/bed, suggest that [t] and [d] are different in English, ie. that they are in contrastive distribution. Similar sounds are then examined for the possibility of complementary distribution: ie. does each occur regularly in a phonetic environment which is different from that of the other similar sounds? If such a relationship is found, these sounds are judged to be allophones of the phoneme to which they all seem to belong: eg. the aspirated initial [t^h] of tin, the non-aspirated [t] of stint, the flapped [ɾ] of better, etc, would all be regarded as 'belonging' to the phoneme /t/, in the sense of being members of a common 'family'. To be classed as allophones in this way, sounds must not only be in complementary distribution, but must have some phonetic similarity; hence [h] and [ŋ] are too different from one another to be regarded as allophones of a single phoneme, even though their distributions seem to complement each other ([h] never word-final, [ŋ] never word-initial). However, each language system classifies sounds in its own way, so that separate phonemes in one language may be allophones in another (eg. [l] and [r] are phonemes in English, but allophones of the same phoneme in many Asian languages).

Once the phonemes have been identified for a language, each will be represented by a consistent symbol - as close to alphabetic symbols as possible (ie. 'efficient' for linguist and printer alike) - and then grouped in relation to one another in such a way as to show the phonological structure of the language. Traditionally, phonemes have been described and grouped according to articulatory criteria (before and since Bloomfield); Bloomfield, however, devises his own to show more clearly, he considers, the contrasting roles played by the phonemes in the structure of English (Appendix A).

According to the structuralists, there should be a fairly direct and transparent relationship of 'bi-uniqueness' between the phonetic level of physical realisation (the allophones) and the slightly more abstract phonemic level (phonemes): given the phonemic representation and knowing the phonological structure of the language in question, the linguist should be able to work out the physical implementation of a phoneme in a particular environment, and vice versa. Other levels of analysis should not be brought in - should not **need** to be brought

in, indeed - as the relations between forms ought to be deducible from the phonetic facts alone. These relations correspond to something 'real' about language, in other words.

This ideal has not been attained, however. Bloomfield himself, having explicitly and strongly stated a behaviourist view of meaning, and claimed that it was not yet possible to investigate this in a full and scientific way, nonetheless has to depend on meaning for the most basic, initial steps in phonology, the determination of the phoneme. He admits as much:

The study of **significant** speech-sounds is **phonology** or **practical phonetics**. [Another 'loose use'; 'practical phonetics' seemed to be used in a different sense in the earlier quote on page 3 of this paper where it **contrasted** with phonology. Ed.] Phonology involves the consideration of meanings. The meanings of speech-forms could be scientifically defined only if all branches of science, including, especially, psychology and physiology, were close to perfection. Until that time, phonology and, with it, all the semantic phase of language study, rests upon an assumption, the fundamental assumption of linguistics: we must assume that **in every speech-community some utterances are alike in form and meaning** (1935: 78).

This is quite an assumption, especially for someone who denies the validity of mentalism and the worth of introspection in order to be scientific. Sampson (1980: 64) quotes the slogan: 'Accept everything a native-speaker says in his language, and nothing he says about it'; while it is not clear whether this is in fact attributable to Bloomfield, it would surely fit with the overall behaviourist stance of *Language*. But perhaps Sampson's (1980: 153) assessment is fair:

Even a Descriptivist uses introspection as a 'short cut', rather than attempting to document every single remark he makes about a language with which he is familiar; but if any particular remark is challenged, the Descriptivist will look for objective evidence to back up his claim (rather than waste time discussing the strength of his introspective feeling), and this is all we demand of an empirical science.

Such use of the native-speaker's knowledge of the language (or the linguist's) may perhaps open the way to other less conscious dependence on this knowledge. Some examples of linguistic assumptions which have appeared to recent investigators as rather questionable 'slides' into the unempirical include the following.

(1) **One word or two?** Should phrases like away/a way or a tall/at all, which are phonetically very similar (including lack of a pause in the middle of the phrase) be represented as one word or two? To Bloomfield, a word was a separate entity ('A minimum free form is a **word**': Bloomfield, 1926; quoted in Anderson 1985: 268); thus there was no question but that each word should be separated from others by a space each side. Not all structuralists agreed (Anderson 1985: 267; Sommerstein 1977: 24), but in practice this was the usual convention.

(2) **Contrasts between segments are not always situated solely (at all??) within the segment in question.** For instance, final [t] and [d] in English can sound very similar, especially when uttered at speed or in a noisy environment; and indeed the actual phonetic difference between, say, feet/feed or ant/and may lie more in the length of the preceding vowel or nasal than in the final segments themselves. Again, structuralists tended to use their 'knowledge' of English morphemes and their spellings, rather than mere phonetic aspects as valued by their overt principles, to record these words as [fit]/[fid] instead of, eg., [fit] vs. [fi:t].

(3) **Neutralisation.** Given the often very wide range of allophones for a given phoneme, some overlap between the realisations of certain phonemes can occur, such that, in certain situations, the usual contrast between them is no longer operating. For example:

3.1 The [t] of train in English is often pronounced like [tʃ], but most structuralists would represent this sound as [t] in a phonemic representation.

3.2 In German, voiced and voiceless plosives contrast in all positions except word-finally, where only voiceless plosives occur: eg.

gelb [gɛlp] 'yellow'

Gold [golt] 'gold'

Tag [tak] 'day'

By linking these to semantically-related words where the voiced phoneme is used (eg. gelbe, feminine form of the adjective; golden, adjective; täglich, adjective), structuralists assign voiced phonemes also to the final plosives.

3.3 Words such as cents/scents/sense may have very similar pronunciations, but structuralists will, again, argue that the 'underlying forms' differ from one word to the next, and will represent them accordingly.

3.4 The reduction of a wide range of unstressed vowels in English to [ə] is a particularly challenging case for the concept of the phoneme to fit. Is one entitled to call [ə] a phoneme, or merely a phonetic realisation of many other sounds? Bloomfield's treatment is interesting. He apparently does not use the symbol at all in the first (American) edition of *Language* (Anderson 1985: 268), but instead tends to write symbols for the unstressed vowels that are the same as those for full vowels in related words: eg.

protest (verb) [pro'test],
protest (noun) ['prowtest].

However, he is not entirely consistent in this; sometimes he writes non-corresponding forms: eg.

convict (verb) [kon'vikt],
convict (noun) ['kanvikt]

ie. much closer to the phonemic realisation. And in the U.K. edition, he does allow [ə], on the grounds that /ə/ exists as a phoneme in British English: eg. parrot ['pærət] (sic: is the first vowel truly British?). Thus he records:

convict (verb) [kən'vikt]
convict (noun) ['kənvikt]
protest (verb) [prə'test]
protest (noun) ['prətest/'prowtest].

Clark and Yallop (1990: 143) point out that:

[...] neutralisation sometimes creates alternate forms of a morpheme [...]. In this case, the phenomenon may be described as morphophonemic [...].

We discuss this further below.

(4) **Morphophonemic alternations.** These are varying phonetic forms of a single morpheme (later called 'allomorphs'), and can cause difficulties of analysis in phonology. Some examples:

4.1 French adjectives:

long (masc) [lɔ̃] / longue (fem) [lɔ̃g]
frais (m) [frɛ̃] / fraîche (f) [frɛʃ]
petit (m) [pəti] / petite (f) [pətit]

4.2 The English plural marker: [s] / [z] / [əz], as in

cats [kæts]
dogs [dɒgz]
horses [hɔ:sə:].

Bloomfield seems not to have found such variants a real problem. Since his main focus is basically the pragmatic one of the search for 'the simplest possible set of statements that will describe the facts of the English language' (Bloomfield 1935: 212), he finds a solution which seems appropriate in his terms: to regard the alternant forms as phonetic alternants, take as the 'basic' form the one which allows the others to be most easily predictable, and set out rules in the clearest sequence; viz:

for 4.1 we can predict the masculine form given the feminine (we merely have to drop the final consonant sound, but not vice versa (how could we predict the final consonant from the phonetic form of the masculine?). Thus, the feminine is the basic form; the masculine is 'derived' by means of a minus-feature, namely, loss of the final consonant (Bloomfield 1935: 217);

for 4.2, the [æz] form is the basic alternant, from which [z] is derived by dropping the vowel, and [s] by going one step further and replacing the [z] by [s] (Bloomfield 1935:212; interestingly, he does not express this in terms of **devoicing** the [z] but as a **replacement**).

However, bearing in mind the avowedly 'scientific' approach and the intention not to 'mix levels' (phonological and grammatical), such procedures as the above look a little like sleight of hand; at the very least they stretch 'phoneme' far beyond the agreed definition. Later, other structuralists would confront the problem more directly. Hockett (quoted in Anderson 1985: 298) argued that "'mixing levels" was a perfectly satisfactory expedient as a field procedure, as long as it left no traces in the grammar'. Pike considered that one might need grammatical information (eg. on boundaries) to achieve a good phonemic analysis; however, this necessitated the invention of new phonemic entities called 'junctures' before the majority of structuralists could accept it (Anderson 1985: 298-300). Harris developed the concept of morphophonemes which represent 'formulaic' base forms from which allomorphs are derived, rather than deriving one allomorph (surface form) from another, as Bloomfield had done. And Twaddell proposed the concepts of the 'micro-phoneme' and the 'macro-phoneme' which represented abstract sets of differential **relationships** rather than related **elements** (Anderson 1985: 290-295).

Overall, the structuralists tended to feel their main task was to collect facts about particular languages, and Anderson (1985: 282) notes that they preferred the term 'Descriptive Linguistics', 'to emphasise that the primary task was conceived as the gathering of unbiased information rather than the supposedly premature search for explanatory principles'. One could argue, as Anderson does (1985: 309), that language for the structuralists was:

basically a hierarchy of inventories: an inventory of phonemes, which could be concatenated to form morpheme alternants; an inventory of morphemes, which could be combined to form words and syntactic constructions which then selves formed further inventories. A description of language was fundamentally a definition and enumeration of the elements that made up these inventories.

Certainly a main focus was always on the relationship between the (relatively abstract) underlying representation, the phoneme, and the (relatively concrete) phonetic representation, of speech-forms.

To express these relationships, of course, rules were needed, and these were in general descriptive rather than explanatory in intent (recall the quotation from Bloomfield, page 9, first paragraph). Hence, their rules tended to be general principles such as could be derived inductively from the data collected, by the 'discovery procedures' which Chomsky attacked so roundly later on (Sampson 1980: 76-77). As Sampson puts it (1980: 74): 'The Descriptivists, then, thought of general linguistics more as a body of techniques of description than as a body of beliefs about the nature of language.' Anderson (1985: 275-276) suggests that, for Bloomfield, his rules were 'an elegant artefact, providing a uniform and concise account of a complex set of facts but not to be confused with the actual language capacity of speakers', and this seems to fit with the tone of *Language*. Hockett, it is true, saw parallels between the linguist's overt procedures and the (covert?) unconscious processes occurring in the central nervous system of a child learning his/her first language - '[...] the child in time comes to **behave** the language; the linguist must come to **state** it' (quoted in Anderson 1985: 284) - but few of his fellow structuralists seem to have thought of drawing such a parallel. It anticipates by twenty years, however, a similar-seeming view in a very different school of phonological analysis.

The Generative Model of Phonology

As noted earlier, the Generative group of phonologists came into prominence with the publication of Chomsky and Halle's *The Sound Pattern of English* (hereafter *SPE*) in 1968, but its antecedents go back a good deal further. Chomsky had studied with the strongly formal structuralist Harris, but had later become famous with his new approach to linguistics (evidenced in his *Syntactic Structures* (1957) and *Aspects of the Theory of Syntax* (1965); this approach is referred to as the Transformational-Generative Grammar (TGG) approach, where 'generative' means that the grammar rules devised by the approach 'generate' (in the mathematical sense) or 'define' all and only the syntactically well-formed sentences of a language. Generative phonology is so called because of its association with TGG linguistics, not because it is itself 'generative' in the above-defined way. The co-author of *SPE*, Morris Halle, had worked and published with Roman Jakobson, whose theories of distinctive features of sounds and of linguistic universals were to be highly influential in the evolution of generative phonology (and *SPE*'s dedication to Jakobson underlines this).

In conference papers and articles from 1956 on, Chomsky, Halle and others had begun to present and develop their ideas, which showed a clear divergence from those of the structuralists; so the publication of *SPE* itself was the culmination of fifteen years of thinking and ten years of writing (*SPE*: x). Despite the usual modest disclaimers in the Preface - '[...] an interim report [...] this study in its present intermediate stage in the hope that it will stimulate criticism and discussion [...]' (*SPE*: vii), the authors were fairly confident that 'the general outlines and major theoretical principles are fairly clear [...] a reasonable expectation that further investigation within the same general framework will not significantly alter the overall picture we have presented' (*SPE*: vii). Indeed, *SPE* did set the agenda for phonology in America (and elsewhere) from then on; though there have been many refinements and modifications, much of the original theoretical framework and many of the features have endured.

Although it was observed earlier in this paper that, overall, both structuralists and generativists shared a common expressed intention to study language data as fully and as scientifically as possible, the actual realisations of this general goal by the two schools could hardly have been more contrasting from most points of view. In summary:

(1) Where the structuralists described particular languages in order to understand and hence record these specific languages, the generativists examine data from any language 'for the light they shed on linguistic theory (on what, in any earlier period, would have been called 'universal grammar') and for what they suggest about the nature of mental processes in general' (*SPE*: viii).

(2) The facts of a language were paramount for the structuralists; and if, after sufficient facts had been collected, a pattern of relationships declared itself, or was found by inductive means, then a descriptive rule could be formulated to express the generalisation which had been found, as simply as possible, but without trying to strain the generalisation too far. The generativists, however, were interested in facts to the extent that these enabled a general framework or structure of language (the more general the better: 'We see no reason to give up rules of great generality because they are not of even greater generality, to sacrifice generality where it can be attained' (*SPE*: ix). Rules were thus a much more major focus. 'The person who has learned a language has internalised a system of rules that determines sound-meaning connections for indefinitely many sentences' (*SPE*: 3).

(3) The structuralists' definition of 'scientific' and its concomitant objectivity allowed them to connect with confidence only the closely-related areas of phonetics and phonemes; the bringing in of information from other 'levels' of language (eg. syntax or semantics) was frowned upon, although, as we have seen, morphological data occasionally did have to be dealt with for practical ends. The generativists, on the other hand, consciously viewed their task as the description of the total system of the language in all its relatedness.

The performance of the speaker or hearer is a complex matter that involves many factors. One fundamental factor involved [...] is his knowledge of the grammar that determines an intrinsic connection of sound and meaning for each sentence (*SPE*: 3).

Furthermore, 'a grammar is a theory of a language' (*SPE*: ix); the generativists were concerned to **explain** the data they found (*SPE*: 25).

(4) The rules of the structuralists were usually aimed at simplicity and clarity as an aid to recording procedures, were couched in ordinary prose form, and were inserted in language descriptions as the need arose. In contrast, one of the most evident innovations of generative phonological theory is the lengthy, formal

apparatus of rules expressed in mathematical-type symbols. This is quite deliberate:

It is obvious that any theory of a particular language or any general theory of language that can be proposed today will be far from adequate, in scope and in depth. One of the best reasons for presenting a theory of a particular language in the precise form of a generative grammar, or for presenting a hypothesis concerning general linguistic theory in very explicit terms, is that only such precise and explicit formulation can lead to the discovery of serious inadequacies and to an understanding of how they can be remedied (*SPE*: ix).

(5) The structuralists' main interest and tool was the phoneme or underlying representation of phonetic segments; the phoneme itself was treated as a segment, too, though at a slightly more abstract level than the physical realisations, and was thus represented in similar symbols and classified according to a few basically articulatory criteria. But the generativists rejected the phoneme as a useful level of analysis, focussing their attention rather on, first, a more detailed analysis of the features (articulatory and acoustic) of the phonetic level (termed the 'systematic phonetic level'), and second, an underlying level of greater abstractness than the phoneme, representing morphemes, which was called the 'systematic phonemic level' or the 'lexical representation'.

(6) Whereas the structuralists valued observable events in the external world as the only 'real' (in scientific terms) ones, shunning any mentalistic interest in what may go on in the minds of language-users, the generativists were centrally concerned to investigate mental processes, and furthermore were very happy to use the introspection of native-speakers as a reliable source of data (Sampson 1980: 150ff).

Although the courtesies of acknowledging past scholars in general are observed, therefore - '[...] it naturally owes very much to the important studies [...] during the past thirty or forty years [...] - it is quite clear that to a considerable extent generative phonology has developed as a reaction against structuralist theory. Tactfully (?) hidden away in the middle of the third page of the Preface, at the end of the paragraph quoted above discussing the generative theory of language and the need to express this in specific terms, we find the following (*SPE*: ix):

In contrast [with the generative approach], a system of transcription or terminology, a list of examples, or a rearrangement of the data in a corpus is not 'refutable' by evidence (apart from inadvertence - errors that are on the level of proofreading mistakes). It is for just this reason

that such exercises are of very limited interest for linguistics as a field of rational enquiry.

Chomsky and Halle, it is apparent, would not regard 'such exercises' as worthy of the classification 'theory'.

Their stated intention is to present a coherent account of language in general, and in *SPE* of English in particular, which because of its detail and rigour could be verifiable (or falsifiable); ie. has the status of true scientific theory. A major aspect of this is the closely detailed set of distinctive features formulated both to describe and to classify sounds at the systematic phonetic level as well as at the underlying systematic phonemic level (see Appendix B). Chomsky and Halle's features evolved from those of Jakobson and Halle's (see Appendix C), adding more features but retaining the preference for binary oppositions rather than the multi-valued terms of earlier theorists (and some more recent ones, too: see Appendix D); and also retaining some features which refer to acoustic or perceptual dimensions rather than just articulatory aspects.

Each sound unit is defined as a set of features, with plus or minus signs to indicate the presence or otherwise of the feature, and depicted as a matrix (Appendix E gives examples of these as well as some of the generative rules). Features thus serve a phonetic function - they describe aspects of sound units in some (though not exhaustive) phonetic detail - and they also allow sounds to be classed into groups sharing particular characteristics (natural classes), which also undergo similar phonological processes (Schane 1973: 25). Other classifications of sounds have always done this to a certain extent, of course, but the more detailed generative model does allow certain connections to be made which had perhaps not been obvious before. For example:

(i) [k] is specified as being

$$\begin{bmatrix} + \text{obstruent} \\ + \text{back} \\ + \text{high} \\ \text{continuant} \\ - \text{voice} \end{bmatrix}$$

which gives it membership of such groups as high vowels (because like them it is [+ high]), thus providing a degree of explanation for, say, the raising of vowels before velars (Lass 1984: 80-81).

(ii) Labials and velars share the feature [+grave], so again it is not surprising to see them behaving in similar ways on occasion (Lass 1984: 98).

Doubts have however been expressed about aspects of these features: eg. how 'natural' are the so-called natural classes? is the apparent 'slippage' between categories of description (articulatory /acoustic /perceptual) permissible? and is it in fact possible to construct a set of features which could apply to all languages? Scholars seem divided (eg. Clark and Yallop 1990: 315-320; Lass 1984: 80ff; Kenstowicz and Kisseberth 1979: 241).

The concept of the binarity of features in generative phonology has frequently been criticised. For Chomsky and Halle (as for Jakobson and Halle earlier), when classifying sound units, features are two-valued - they are either present or absent in a given unit; this formalism is considered necessary to capture as many generalisations as possible. Many other phonologists have argued, however, that certain features are not simply two-valued, and that for an adequate description for at least some languages, more than two values may need to be permitted. Vowel height is perhaps the most widely mentioned of such features, although for English the generativists are able to use a combination of both [-high] and [-low] to get around the difficulty. It has been suggested that binary features in fact reflect the hearer's task in the perception of sounds rather than the speaker's (e.g. Hyman 1975: 57; Sampson 1980: 193; Clark and Yallop 1990: 310-311); and that binarity is more tenable if it applies only to the classifying function of features, not to their role in a fuller phonetic description of a language (Schane 1973: 96; Ladefoged 1982: 246). It remains a contested issue, however.

Also strongly debated is the concept of naturalness in the sense of 'frequently-occurring in the world's languages' and/or 'phonetically well-motivated'. This can refer to both features and rules. If a feature or rule is natural, it is regarded as 'unmarked', whereas if it is not natural in one of the above senses, but is unusual in some way, it is said to be 'marked' (Katamba 1989: 98ff). The generativists considered that markedness allowed the explanation or prediction of certain phenomena (eg. the occurrence of some sounds more often than other sounds in a variety of languages; neutralisation of sounds; linguistic change generally), but some writers regard these concepts as less useful. Clark and Yallop (1990: 177) note that they fail 'to do justice to naturalness'; Lass (1984: 199) shows that 'markedness/naturalness are not explanations, but things to be explained'; and Katamba (1989: 115), while conceding that 'intuitively naturalness seems to

be a valid concept', nonetheless concludes: 'However, its predictive value and hence its place in a rigorous theory of phonology is still uncertain'.

Another point of contention is the permissible degree of abstractness of the underlying representation in generative phonology. The generativists posit a phonological system where the surface forms are derived by rules from an underlying form which, where possible, is close to the systematic phonetic level forms but which need not be exactly the same as any actual surface realisation if thereby significant relationships can be indicated, provided that certain criteria are still met. According to Hyman, these should be: predictability of all the surface forms from the underlying form; economy in the number of underlying forms; pattern congruity, ie. that the proposed solution fits in with the overall phonological system; and plausibility or rule naturalness. All the unpredictable aspects of a sound unit should belong to the underlying representation, so that the rules, while still possibly complex, need only list the predictable aspects of the relationship between underlying and surface forms. This goal, although worthy, has led to a number of procedures and arguments which many find questionable. For example, the preference for the fewest possible underlying forms is regarded by some as an aesthetic stance rather than a necessary theoretical premise; it is equally likely that we store a great number of different underlying forms, each linked by fewer rules to fewer surface forms, as that we have a few underlying forms linked by complex rules to their surface realisations (Sommerstein 1977: 12; Lass 1984: 214). And the desire to regularise systems can lead to a reluctance to deal with exceptions, excessive ingenuity in hypothesising the underlying forms, and the confusion of diachronic analysis (historical forms of the language) with claims about the native-speaker's knowledge of the synchronic system (Hyman 1975: 94-95; Lass 1984: 141, 155; Katamba 1989: 139, 150).

One of the best-known instances of the creative search for a satisfying underlying form is Chomsky and Halle's own example of 'righteous' (*SPE*: 233-234), where the final posited form is /rixɪt/, with a vowel that does not occur in the surface forms of this word and a consonant that does not exist in any surface forms of English at all. Here, as on so many occasions, we are given a hypothesised form which was clearly in the language at an earlier date - as the spelling attests - but where the justification given is that the underlying form is part of the contemporary native-speaker's knowledge (though possibly sub-conscious!). That the writers themselves are aware of the historical facts is evident - they have, after all, devoted forty pages of *SPE* to these considerations - so many other

writers have felt that their insistence on identifying these facts as aspects of the synchronic system is a dubious, if not wilful, projection (Lass 1984: 213-215; Hyman 1975: 97; Sampson 1980: 202-204); or as Katamba (1989: 140) comments: 'The issue is that not all regularities that can be identified by the linguist have the same status for speakers of a language'. Perhaps they had taken to heart Householder's well-known remark (quoted in Lass 1984: 60): 'A linguist who could not devise a better grammar than is present in any speaker's brain ought to try another trade'; or indeed Bloomfield's warning about the prejudicial use of historical knowledge (1935: 19-20 - quoted on page 2 of this paper).

For the generativists, however, the claim is that the native-speaker is in touch with, if not actually conscious of, the underlying forms and the rules of the language; furthermore, that these rules are more or less in the shape outlined by *SPE* (Preface; 3-4; 330-332); and that the native-speaker's introspection is a valid source of information about the language system. These claims do not meet with universal agreement. Sampson for instance, observes that, while Chomsky criticised the descriptivists for their refusal to acknowledge any value for introspection, their observations were at least able to be checked for accuracy, whereas introspection can not be verified in the same way (1980: 154); and later comments on Chomsky's 'mistake' of 'overestimating the ordinary man's knowledge of his language' (1980: 203). Katamba (already cited) and Lass (1984: 212-214) are likewise very critical of these claims.

The assertion that there are linguistic universals which indicate something about the structure of the human brain, and about the way not only adult native-speakers but also babies beginning to acquire their first language go about the task of using the language is another very strong claim; and while there is some supporting evidence from studies of varied languages, of speech pathology, of language errors, of language games, of language change and of language development, there is also a great deal of evidence supporting the opposing view of language differentiation. Sampson considers that the 'rush to universals' not infrequently runs the risk of ignoring 'particular concrete external facts in favour of postulating universal, abstract linguistic theories' (1980: 149). However, given Chomsky's views on the desirable generality of rules (*SPE*: ix - cited on page 12), it is quite likely that he would regard this as a compliment.

One can certainly maintain that the generativists have not yet realised their grand intentions of fully capturing the phonological system of English, let alone

those of other languages, in a succinct formal notation which would allow the comparisons and evaluations they would demand. Nor have they achieved their desire to explain phonological facts; though in some cases they seem to have gone a few layers deeper in description than their predecessors, they have not reached a truly explanatory level as yet. Chomsky expressed a desire - indeed a belief - that generative phonology would provide not only descriptive adequacy but also explanatory adequacy; ie. 'a model in which evaluation of the description is inherent in the description itself (Clark and Yallop 1990: 164) and this again is not yet a reality.

It would not matter too much if the claims of a theory were found to be wrong; as Lass (1984: 33) remarks:

What counts is not how 'right' a theoretical claim is, but how testable it is, and what we can learn from trying to push it as hard as possible. Strong claims, even if untenable, can be heuristics: methodological guidelines or strategies for analysis.

Thus it could be argued that generative phonology has made strong claims, and that in testing these to their limits we have learnt more about human language. Some writers are unwilling to go even so far, however. Lass himself (1984: 233) claims that:

the tradition of abstract analysis and phonology/ morphophonemics conflation will be seen as an aberrant episode in the history of the discipline, and MP alternations will stay firmly in morphology, where they belong.

Others echo this view: 'This has been simply a wrong track taken by linguistics' (Sampson 1980: 165), though he later notes the positive value (as a warning to subsequent scholars) of recording the errors of any group of researchers. Again: 'although both structuralist and generative phonology have a well-developed methodology, neither of them is a theory in the true sense, since neither is genuinely open to falsification by data' (Donegan and Stampe (1979), cited in Clark and Yallop (1990: 343).

The Usefulness of These Theories to the Language Teacher

The language teacher is perhaps in a more fortunate situation than these researchers in that, even where a theory is not fully adequate, individual insights

can be used, where these seem to serve the learning purposes. Just as our daily life is lived as if we still believed the sun does go around the earth, and literally rises in the east each morning, so the teacher can make use of approximate concepts and interim truths, while still of course keeping an alert eye on current research.

The benefits to the language teacher can be in the form either of enhancements of the teacher's own expertise, confidence, knowledge or skills, or of actual explanations or facts which can be brought into the classroom and used directly with the students.

1. Concept of the phoneme

Bloomfield et al used this very successfully for recording the basics of languages, and it does seem to correspond to something psychologically 'real' for most people - once they become aware of the concept. Even the generativists, critical though they were of the phoneme as a theoretical construct, used the symbols quite unabashedly as a convenient shorthand representation of the systematic phonemic level. Dictionaries and most texts on pronunciation, as well as contrastive studies, use phonemic transcription to indicate the pronunciations under discussion, and many teachers, similarly, have found that the concept of the phoneme has enabled them to hear more clearly what they and other native speakers are saying, and therefore to know what their students are aiming at (rather than being tied to the image of language that most literate people are, which is very dependent on the written form of the language). The teacher can use phonemic script for noting student errors in a shorthand fashion; can read some (written) student errors more easily than teachers who are too tied to the usual conventional spelling forms (eg sosichs 'sausages', capofte 'cup of tea'); and understand why students may be making those errors (eg. because of the way they are hearing sounds, or because of the way they may be associating sounds and written symbols, especially students who come from a non-alphabetic script).

For the students, an awareness of the concept of the phoneme, and the use by the teacher of the visual representation of phonemes, can often help them to 'hear' sounds which, when presented only aurally, can be very elusive. Furthermore, because so many reference books, such as dictionaries, now use a form of phonemic script for recording pronunciation, a familiarity with these symbols can allow the student to have some autonomy in their learning, by checking the

pronunciation of unknown words for themselves. Some students even find it helpful to use phonemic symbols themselves, for example when they hear an unknown word and can not immediately verify its spelling or meaning; keeping a record in phonemic script helps them retain the sound more or less accurately until such time as they can find out more. Some are interested to examine the contrasting phonological systems of their own language and the language they are learning, for which phonemic awareness is helpful. Finally, because English spelling is to a degree phonemic (though the sound-symbol correspondence is highly variable), tackling the pronunciation of unknown words 'cold' on the assumption that symbols usually approximate sounds will give learners one useful strategy that will take them a certain distance, at least.

2. Concept of the allophone

This grants the teacher an even more refined view of the sound-symbol correspondence, and a greater understanding of many student errors, in listening, speaking, reading and writing. It is especially illuminating on the subject of the student who has apparently mastered a sound in some contexts but not others, which often confuses the non-alerted teacher. These facts, too, can be explained to students, giving them insights and thus some control over the language they produce. In addition, the teacher can often learn to control his/her own language with this knowledge, so as to produce a clearer or more consistent model for the student, and can isolate target sounds better when these need clear modelling.

If useful, the phonetic facts can be made explicit to the students, too, giving them insights into the phonological structure of the language they are tackling, and thus some control over the language they produce or that they seek to comprehend. It has been said (Fraser, personal communication) that, for second-language learners, the more phonetic an explanation of pronunciation, the better; it is certainly clear that an understanding of allophonic differences between the first and the second languages, and within the target language, helps the learner to feel less stupid about possible mishearings or mispronunciations.

3. Distinctive Features (at the [systematic] phonetic level)

The teacher who has grappled with the concept of distinctive features has taken his/her phonological awareness to even more subtle depths (why do we say /sɒsɪdʒ/ for 'sausage' etc?) and will have a very healthy respect for the complexity

of language and the task of the learner (and of the teacher). The fact that both articulatory and perceptual phenomena are included in the features reminds teachers that both these dimensions are utilised by listeners/speakers, and can perhaps be exploited by the learner, too. Just as different native-speakers seem to get the same 'acoustic impression' by differential emphases or combinations of these aspects, so too may the learner approach the target sounds of the language concerned in various individual ways.

It is not so clear that the learner needs to be made consciously aware of the detail of the features, however, unless to underline the idea of allophonic variation; it seems an unnecessarily detailed level at which to operate consciously all the time, but some analytically inclined learners do profit from being made aware at critical moments of the detail at which they are aiming.

4. The underlying representation (systematic phonemic level) and phonological rules

The idea that there is a concept of a sound in the speaker's mind which can be realised in speech in a variety of ways depending on its phonological and grammatical context etc. is illuminating to the teacher, as it 'explains' certain phenomena which are not satisfactorily explicable solely by referring to phonetic or phonemic facts. One example would be the differential length of such apparently similar words as 'sat', 'lad' and 'sad': the vowel in the first word is shorter than the vowels in the other two words for phonological reasons (vowels are shorter before unvoiced final consonants than before voiced final consonants); the vowel in 'lad' is shorter than that of 'sad' because vowels in monosyllabic nouns in English tend to be shorter than those in monosyllabic adjectives. (The words 'explain' and 'because' beg many questions, of course.) Another example might be the fact that the negative prefixes [in], [im], [il] and [ir], though all slightly different on the surface, clearly seem to be related to one another at a deeper level; and the explanation that they are all realisations of an underlying common form /in/ seems satisfying intuitively and allows a helpful generalisation to be made. Both teacher and student can gain from such descriptions; and we can also conceive of the speaker's brain 'computing' the appropriate phonetic form in a series of steps or rules.

Even related words whose surface forms seem a little further distant from one another can be accepted as having a common underlying representation,

especially of course where a similar spelling connects them in our minds, and where a number of similar pairs form a pattern: eg. 'cone/conic', 'coal/collier', 'divine/divinity', 'vine/vineyard', 'resign/resignation', 'electric/electricity', etc. When the underlying form posited by the linguist becomes too abstract, however - too far removed in its distinctive features from one of the surface forms or even from all the surface forms - our credulity is strained and the description no longer seems to fit our sense of what happens when we go to say a word or phrase. In the well-known example of 'right/righteous', *SPE* suggests an underlying form of /rixt/, with an ingenious justification, but this seems a rather implausible picture of what is in the mind of the modern native-speaker, and certainly an unhelpful description for the second-language learner. Since the historical development of the language has caused the sounds to change over time (cp. words like 'nature', etc), why not admit this openly? And indeed, in the experience of many language teachers, explanations in terms of history often fascinate students and reconcile them to quite difficult modern surface 'irregularities' of this kind - especially if these explanations are linked in to the notion of 'language universals' (or at least 'commonalities'). Similarities of spelling are then welcomed as showing a continuing morphological link between words, even where the previous similar pronunciations have diverged, instead of the former being resented for not indicating the current pronunciations in a more directly phonetic fashion.

It would seem therefore that while the hypothesising of some very abstract underlying representations is still somewhat ahead of the verifiable evidence, it is more helpful to both teacher and student to be aware of the historical evolution of language than to posit forms which may not in fact be part of even the native-speaker's conscious synchronic repertoire.

6. Language Universals

Although much research still needs to be done in this area, it does seem that there are repeated patterns of phonological phenomena and directions of linguistic change which are to be found across languages, even if these are not all completely universal. It is helpful for the teacher, when faced with learners from a first language with many surface differences from the target language, to bear in mind that there will be many aspects of pronunciation which will actually take care of themselves, because of these common tendencies. For the learners too! And if the teacher can cite specific instances of these as they arise (eg. 'You don't need to remember whether the final 's' after a consonant is pronounced [s] or [z];

just make sure you say the previous consonant sound correctly voiced or unvoiced and the 's' will pronounce itself' - though alas, this is easier said than done), so much the better.

Thus, every new insight into the nature of language and of specific languages adds to our ability to look closely and from different angles at the way language functions, and hence, as teachers, to consider new ways to facilitate the learning of our students. As yet, no one school of phonology has given us all the answers, or even entirely superseded all previous schools; we would be surprised if this were the case, indeed, although sometimes the purveyors of newer ideas may seem to give the impression that they anticipate turning the known world on its ear. Each step forward makes the next one both possible and inevitable. We inch towards knowledge.

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**APPENDIX A: 'Traditional' and 'Bloomfieldian' classifications of phonemes
(Bloomfield 1935: 129-131)**

8. 2. A list or table of the phonemes of a language should therefore ignore all non-distinctive features. Such lists or tables are usually made on the basis of practical-phonetic classifications, thus:

	STANDARD ENGLISH			
stops, unvoiced	p	t	k	
voiced	b	d	g	
affricate, unvoiced		tʃ		
voiced		dʒ		
spirants, unvoiced	f	θ	s	ʃ
voiced	v	ð	z	ʒ
nasals	m	n		ŋ
lateral		l		
trill		r		
semivowels		j	w	
vowels, high		i	u	
higher mid		e	ə	ɔ:
lower mid		ɛ	ɒ	
low		ʌ	ɑ:	
secondary phonemes:				
stress	" ' ˈ			
syllabic-stress				
pitch	. ˩ ? ! ,			

Tables like these, even when they exclude non-distinctive features, are nevertheless irrelevant to the structure of the language, because they group the phonemes according to the linguist's notion of their physiologic character, and not according to the parts which the several phonemes play in the working of the language. Our table does not show, for instance, that [l, n] sometimes serve as syllabics in unstressed syllables (§ 7.10). It does not show which vowels are the syllabic correspondents of the semivowels [j] and [w], or the peculiarity of articulation, thanks to which these semivowels figure as separate phonemes, in contrast with the simpler distribution of [ə:] versus [r]. It does not show which vowels and semivowels combine into compound phonemes. To show these structural facts, we should need a supplementary table something like this:

I. *Primary phonemes:*

A. *Consonants*, always or sometimes non-syllabic:

1. *Mutes*, always non-syllabic: [p t k b d g ʃ ʒ f θ s ʃ h v ð z ʒ m ŋ]
2. *Sonants*, sometimes syllabic:
 - a. *Consonantoids*, syllabicity determined partly by syllabic-stress; not diphthong-forming: [n l]
 - b. *Vocaloids*, diphthong-forming:
 - (1) *Semi-consonant*, syllabicity determined entirely by surroundings: [r-ə:]
 - (2) *Semivowels*, syllabicity determined also by manner of articulation:
 - (a) *Non-syllabic*: [j w]
 - (b) *Syllabic*: [i u]

B. *Vowels*, always syllabic:

1. *Diphthongs and triphthong*, compound phonemes: [iː uː eɪ oʊ aɪ aw əj juw iə uə eə oə]
2. *Simple vowels*: [e ɛ ʌ ɔ ɔ: ɑ:]

II. *Secondary phonemes:*

- A. *Syllabic-stress*, applied to semi-consonants: [ɹ]
- B. *Form-stress*, applied to meaningful forms: [ˈ ˈ ˈ]
- C. *Pitch*, relating to end of utterance:
 1. *Medial*: [ˌ]
 2. *Final*: [˩ ? !]

8. 3. The parts which our phonemes play in the structure of our language are in reality much more diverse than this; in fact, we can easily show that no two of them play exactly the same part.

Since every utterance contains, by definition, at least one syllabic phoneme, the simplest way to describe the phonetic structure of language is to state which non-syllabic phonemes or groups of non-syllabic phonemes (*clusters*) appear in the three possible positions: *initial*, before the first syllabic of an utterance; *final*, after the last syllabic of an utterance; and *medial*, between syllabics.

In this respect the diphthongs and triphthong play in English the same part as do the simple vowels; it is precisely this fact that compels us to class them as compound phonemes and not as mere successions of phonemes.

For convenience, I shall place a number before each phoneme or group of phonemes that shows any peculiarity in its structural behavior.

Taking first the initial non-syllabics, we find at the outset that two phonemes never begin an utterance; they are (1) [ŋ, ʒ]. We ignore foreign forms, such as the French name *Jeanne* [ʒæn].

Further, six of the non-syllabics that occur in initial position never appear as members of an initial cluster: (2) [v, ð, z, ʃ, ʒ, j].

The initial clusters all begin with one of the following non-syllabics: (3) [p, t, k, b, d, g, f, θ, s, ʃ, h]. Here we find an accord between the structural grouping and our physiologic description since our structural group (3) embraces exactly the physiologic groups of stops and unvoiced spirants.

If the first consonant of the cluster is (4) [s], it may be followed by one of the set (5) [p, t, k, f, m, n], as in *spin, stay, sky, sphere, snail, snail*.

All the initials of group (3) and the combinations of (4) [s] with (6) [p, t, k] may be followed by one of the set (7) [w, r, l], with the following restrictions:

(8) [w] never comes after (9) [p, b, f, ʃ], and never after the combination of (4) [s] with (10) [t]. The actual clusters, then, are illustrated by the words *twin, quick, dwell, Gwynne, thwart, swim, when* [hwɛn], *squall*.

(11) [r] never comes after (12) [s, h]. The clusters, therefore, are those which begin the words *pray, tray, crow, bray, dray, gray, fray, three, shrink, spray, stray, scratch*.

(13) [l] never comes after (14) [t, d, θ, ʃ, h], and never after the combination of (4) [s] with (15) [k]. The clusters, accordingly, are those which appear in *play, clay, blue, glue, flew, slew, split*.

APPENDIX B: Chomsky & Halle's universal set of phonetic features (Clark & Yallop 1990: 365-366)

The features are described principally in articulatory terms, although Chomsky and Halle also refer (occasionally) to acoustic and perceptual correlates. Each feature is a 'physical' scale defined by two points, e.g. sonorant–nonsonorant. The features are binary for linguistic description – e.g. all sounds are functionally either [+voiced] or [–voiced] – but may have several values when taken as physical or phonetic scales. Where only one of the two functional values is given below, the other is a simple negative – e.g. nonvocalic, nonconsonantal.

<i>Feature</i>	<i>Articulatory description</i>
<i>Major class features</i>	
1 Sonorant (Nonsonorant = obstruent)	Produced with vocal tract cavity configuration in which spontaneous voicing is possible.
2 Vocalic (Syllabic)	Constriction does not exceed that of high vowels, and position of vocal cords allows spontaneous voicing. (Proposed renaming of vocalic)
3 Consonantal	Radical obstruction in mid-sagittal region of vocal tract.
<i>Cavity features</i>	
4 Coronal	Produced with blade of tongue raised from neutral position
5 Anterior	Produced with obstruction in front of palato-alveolar region
6 High	Tongue body above neutral position
7 Low	Tongue body below neutral position
8 Back	Tongue body retracted from neutral position
9 Round(ed)	Narrowing of lip orifice
10 Distributed	Constriction extends for some distance along direction of airflow
11 Covered	Pharynx walls narrowed and tensed and larynx raised (in vowel production)
12 Glottal constriction	Constriction of vocal cords
13 Nasal	Lowered velum
14 Lateral	Lowered side(s) of mid-section of tongue
<i>Manner of articulation features</i>	
15 Continuant (Noncontinuant = stop)	Primary constriction in vocal tract does not block air flow.
16 Instantaneous release	Instantaneous release (of stops)
<i>(Chomsky and Halle's discussion, 1968, pp. 18–22, suggests two release features:</i>	
16a Instantaneous versus delayed release of primary closures	
16b Instantaneous versus delayed release of secondary closures	
17 Velar(ic) suction	Velar closure producing suction (clicks)
18 Implosion	Glottal closure producing suction (implosives)
19 Velar(ic) pressure	(Velar closure producing pressure – no evidence of use in language)
20 Ejection	Glottal closure producing pressure (ejectives)
21 Tense (Nontense = lax)	Deliberate, accurate, maximally distinct articulation (of supraglottal musculature)
<i>Source features</i>	
22 Heightened subglottal pressure	Tenseness in subglottal musculature producing greater subglottal pressure
23 Voiced (Nonvoiced = voiceless)	Vocal cord vibration (induced by appropriate glottal opening and airflow)
24 Strident	Turbulence (in fricatives and affricates) caused by nature of surface, rate of airflow and angle of incidence at point of articulation
<i>Prosodic features</i> (listed but not discussed in Chomsky and Halle 1968)	
25 Stress	
26 Pitch (high, low, elevated, rising, falling, concave)	
27 Length	

**APPENDIX C: Jakobson & Halle's distinctive features
(Clark & Yallop 1990: 367)**

The features are defined in both acoustic and articulatory terms. Each feature is an opposition between two relative values; for example, vocalic sounds have a *relatively* clear formant structure in comparison with nonvocalic sounds.

<i>Feature</i>	<i>Opposed to</i>	<i>Acoustic description</i>	<i>Articulatory description</i>
1 Vocalic	Nonvocalic	Sharply defined formant structure	Voiced, with free passage of air through vocal tract
2 Consonantal	Nonconsonantal	Low total energy	Obstruction in vocal tract
3 Compact	Diffuse	Energy concentrated in central area of spectrum	High ratio of front resonance chamber to back
4 Tense	Lax	High energy with greater spread across spectrum and longer duration	Greater deformation of vocal tract from its rest position
5 Voiced	Voiceless	Periodic low frequency excitation	Vocal cord vibration
6 Nasal	Oral	Additional formants and less intensity in existing formants	Coupling of nasal cavity
7 Discontinuous	Continuant	Interruption or abrupt transition	Rapid closure and opening of vocal tract
8 Strident	Mellow	High intensity noise	'Rough-edged' effect at point of articulation
9 Checked	Unchecked	Higher rate of energy discharge	Glottalized
10 Grave	Acute	Energy concentrated in lower frequencies	Peripheral (towards front or back of vocal tract)
11 Flat	Plain	Downward shift or weakening of upper frequencies	Narrowed aperture (e.g. by lip rounding)
12 Sharp	Plain	Upward shift of upper frequencies	Reduced oral cavity and widened pharynx

**APPENDIX D: Traditional features, with Ladefoged's phonetic values
(Ladefoged 1982: 256-257)**

Traditional features.

Feature name	Abbreviated definition of physical scale	Phonologica terms	Exemplification				% value
			symbols	language	word	gloss	
1 Glottalic	Rate of upward movement of the glottis	[ejective]	t'	Uduk	t'é	lick	100
		[pulmonic]	t	Uduk	tér	collect	50
		[implosive]	ɗ	Uduk	ɗek	lift	0
2 Velaric	Degree of suction of air in mouth	[+click]	ɿ	Zulu	ɿáá	climb	100
		[-click]	t	Zulu	tátú	third	0
3 Voice	Degree of approximation of the arytenoid cartilages	[glottal stop]	ʔ	Javanese	bukaʔ	open	100
		[laryngealizing]	ɓ	Hausa	ɓè:rá:	rat	80
		[voice]	b	Hausa	bè:rà	girl	60
		[murmur]	ɓ ^h	Hindi	ɓ ^h al	forehead	20
		[voiceless]	p	Hindi	pal	take care of	0
4 Aspiration	Time of onset of voicing with respect to release of the articulation	[aspirated]	p ^h	Thai	p ^h á:	splít	100
		[unaspirated]	p	Thai	pà:	forest	50
		[voiced]	b	Thai	bá:	shoulder	0
5 Place	Distance from the glottis to the first constriction of the vocal tract	[bilabial]	β	Ewe	éβé	Ewe	100
		[labiodental]	v	Ewe	évè	two	95
		[dental]	ɟ	Malayalam	kuɟti	stabbed	90
		[alveolar]	t	Malayalam	kutti	peg	85
		[retroflex]	ɖ	Malayalam	kuɖti	child	80
		[palato-alveolar]	ʃ	English	ʃip	sheep	75
		[palatal]	ʃ	Hungarian	moʃer	Hungarian	70
		[velar]	k	Quechua	kara	expensive	60
		[uvular]	q	Quechua	qara	skin	50
		[pharyngeal]	ħ	Arabic	ħad	someone	30
6 Labial	Degree of approximation of the centers of the lips	[glottal]	ʔ	Arabic	ʔalta	God	0
		[+labial]	k ^ɓ	Igbo	ák ^ɓ á	bag	100
		[-labial]	k	Igbo	áká	hand	0
7 Stop	Degree of approximation of the articulators	[stop]	t	English	taɪ	tie	100
		[fricative]	s	English	saɪ	sigh	90
		[approximant]	h	English	haɪ	high	0
8 Nasal	Degree of lowering of the soft palate	[+nasal]	n	English	noʊ	know	100
		[-nasal]	d	English	doʊ	dough	0
9 Lateral	Amount of airstream flowing over the side of the tongue	[+lateral]	l	English	loo	low	100
		[-lateral]	d	English	doo	doe	0
10 Trill	Degree of vibration of an articulator	[+trill]	r	Spanish	pero	dog	100
		[-trill]	ɾ	Spanish	pero	but	0
(11 Flap)	Rate of articulatory movement?	[+flap]	r	Tamil	əram	saw	100
12 Sonorant	Amount of acoustic energy	[+sonorant]	ɿ	Tamil	a:ɿəm	depth	0
		[-sonorant]	j	English	'sʌnɿən	sunnier	80
13 Sibilant	Amount of high frequency (over 3000 Hz.) energy	[+sibilant]	j	English	'ʌnʃən	onion	70
		[-sibilant]	s	English	sɪn	sin	100
14 Grave	Ratio of low to high frequency energy	[+grave]	θ	English	θɪn	thin	20
		[-grave]	p, k	English	pɪn, kɪn	pin, kin	90
15 Height	Inverse of frequency of the first formant	[4 height]	t	English	tɪn	tin	60
		[3 height]	i	Danish	vi:ðə	know	95
		[2 height]	e	Danish	ve:ðə	wheat	65
		[1 height]	æ	Danish	væ:ðə	wade	50
16 Back	Difference between frequency of formant two and formant one	[+back]	u	English	hu	who	80
		[-back]	i	English	hi	he	5
17 Round	Inverse of distance between corners of the lips	[+round]	y	French	ly	read	90
		[-round]	i	French	li	bed	0
18 Wide	Degree of advancement of tongue root	[+wide]	i	Igbo	óbi	heart	100
		[-wide]	ɿ	Igbo	ùbɿ	poverty	20
19 Rhotacized	Lowering of the frequency of the third formant	[+rhotacized]	ʁ	English	bɔ:rd	bird	100
		[-rhotacized]	ɹ	English	bɪd	bid	0
20 Syllabic	(No agreed physical scale)	[+syllabic]	ŋ	English	s.ɪdn	sudden	100
		[-syllabic]	n	English	s.ɪn	sun	0

**APPENDIX E: Examples of feature matrices and rules from Chomsky & Halle
(1968: 332-333, 336-341, 386-387)**

The rules that we assign to the phonological component have generally been presented in terms that can be symbolized by the formula:

$$(1) \quad A \rightarrow B / X \text{---} Y$$

where A and B represent single units of the phonological system (or the null element); the arrow stands for "is actualized as"; the diagonal line means "in the context"; and X and Y represent, respectively, the left- and right-hand environments in which A appears. These environments may be null, or may consist of units or strings of units of various sorts, and may also include labeled brackets representing the syntactic category of the string to which the rule is applied.

Consider the hypothetical languages A and B which have identical phonological systems consisting of the vowels /i u æ a/ and the other phonological units shown in Table 1. Assume that language A has the rules of (2), whereas language B has the rules of (3).

TABLE 1. *The sound systems of languages A and B**

	i	u	æ	a	r	l	p	t	k	s	m	n	y	w
vocalic	+	+	+	+	+	+	-	-	-	-	-	-	-	-
consonantal	-	-	-	-	+	+	+	+	+	+	+	+	-	-
high	+	+	-	-	(-)	(-)	(-)	(-)	(+)	(-)	(-)	(-)	(+)	(+)
back	-	+	-	+	(-)	(-)	(-)	(-)	(+)	(-)	(-)	(-)	-	+
anterior	(-)	(-)	(-)	(-)	-	+	+	+	-	+	+	+	(-)	(-)
coronal	(-)	(-)	(-)	(-)	(+)	(+)	-	+	(-)	+	-	+	(-)	(-)
continuant	(+)	(+)	(+)	(+)	(+)	(+)	(-)	-	(-)	+	(-)	(-)	(+)	(+)
nasal	(-)	(-)	(-)	(-)	(-)	(-)	-	-	(-)	(-)	+	+	(-)	(-)
strident	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(+)	(-)	(-)	(-)	(-)

* The meaning of the parenthesization will be discussed directly.

$$(2) \quad \begin{array}{l} \text{RULES OF LANGUAGE A} \\ i \rightarrow y / \text{---}p \\ i \rightarrow y / \text{---}r \\ i \rightarrow y / \text{---}y \\ i \rightarrow y / \text{---}a \end{array}$$

$$(3) \quad \begin{array}{l} \text{RULES OF LANGUAGE B} \\ i \rightarrow y / \text{---}p \\ r \rightarrow l / \text{---}r \\ t \rightarrow p / \text{---}y \\ s \rightarrow n / \text{---}a \end{array}$$

The difference between (2) and (3) lies in the fact that the statements in (2) are partially identical, whereas those in (3) are totally different from one another. This difference, which is clearly of linguistic interest, would be expressed if we introduced into our formalism a device akin to conjunction in ordinary English, which would permit us to coalesce two partially identical rules into a single rule without repeating the parts that are identical. We therefore establish the convention (4):

$$(4) \quad \text{Two partially identical rules may be coalesced into a single rule by enclosing corresponding nonidentical parts in braces: } \{ \}.$$

This convention enables us to rewrite (2) as (5):

$$(5) \quad i \rightarrow y / \text{---} \left\{ \begin{array}{l} p \\ r \\ y \\ a \end{array} \right\}$$

However, it does not permit (3) to be similarly abbreviated.

(10)

$$\begin{array}{ccc}
 \begin{bmatrix} +\text{voc} \\ -\text{cons} \\ +\text{high} \\ -\text{back} \\ -\text{ant} \\ -\text{cor} \\ +\text{cont} \\ -\text{nasal} \\ -\text{strid} \end{bmatrix} & \rightarrow & \begin{bmatrix} -\text{voc} \\ -\text{cons} \\ +\text{high} \\ -\text{back} \\ -\text{ant} \\ -\text{cor} \\ +\text{cont} \\ -\text{nasal} \\ -\text{strid} \end{bmatrix} \\
 & & \begin{array}{l} \begin{bmatrix} -\text{voc} \\ +\text{cons} \\ -\text{high} \\ -\text{back} \\ +\text{ant} \\ -\text{cor} \\ -\text{cont} \\ -\text{nasal} \\ -\text{strid} \end{bmatrix} \\ \begin{bmatrix} +\text{voc} \\ +\text{cons} \\ -\text{high} \\ -\text{back} \\ -\text{ant} \\ +\text{cor} \\ +\text{cont} \\ -\text{nasal} \\ -\text{strid} \end{bmatrix} \\ \begin{bmatrix} -\text{voc} \\ -\text{cons} \\ +\text{high} \\ -\text{back} \\ -\text{ant} \\ -\text{cor} \\ +\text{cont} \\ -\text{nasal} \\ -\text{strid} \end{bmatrix} \\ \begin{bmatrix} +\text{voc} \\ -\text{cons} \\ -\text{high} \\ +\text{back} \\ -\text{ant} \\ -\text{cor} \\ +\text{cont} \\ -\text{nasal} \\ -\text{strid} \end{bmatrix} \end{array}
 \end{array}$$

conventions governing the representation of units as feature complexes and their utilization in rules. Among these conventions are the following:

- (11) Two units U_1 and U_2 are distinct if and only if there is at least one feature F such that U_1 is specified $[\alpha F]$ and U_2 is specified $[\beta F]$ where α is plus and β is minus; or α and β are integers and $\alpha \neq \beta$; or α is an integer and β is minus. Two strings X and Y are distinct if they are of different lengths, that is, if they differ in the number of units that they contain, or if the i^{th} unit of X is distinct from the i^{th} unit of Y for some i . (We assume "distinct" to be symmetrical.)
- (12) A rule of the form $A \rightarrow B / X \text{---} Y$ applies to any string $Z = \dots X' A' Y' \dots$, where X', A', Y' are not distinct from X, A, Y , respectively; and it converts Z to $Z' = \dots X' B' Y' \dots$, where B' contains all specified features of B in addition to all features of A' not specified in B .

With these conventions we can replace (10) with a higher-valued representing schema, in ways which are empirically significant, as can be seen by the following considerations.

Notice first that we have specified more features in (10) than are necessary to identify the four environments unambiguously. In particular, all the features that are parenthesized in Table 1 may be omitted without in any way affecting the operation of the rule. In accordance with conventions (11) and (12), we can reformulate (10) as (13), which has the same empirical content as (10):

$$(13) \quad \begin{bmatrix} +\text{voc} \\ -\text{cons} \\ +\text{high} \\ -\text{back} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{voc} \\ -\text{cons} \\ -\text{back} \end{bmatrix} / \left\{ \begin{array}{l} \begin{bmatrix} -\text{voc} \\ +\text{cons} \\ +\text{ant} \\ -\text{cor} \\ -\text{nasal} \end{bmatrix} \\ \begin{bmatrix} +\text{voc} \\ +\text{cons} \\ -\text{ant} \end{bmatrix} \\ \begin{bmatrix} -\text{voc} \\ -\text{cons} \\ -\text{back} \end{bmatrix} \\ \begin{bmatrix} +\text{voc} \\ -\text{cons} \\ -\text{high} \\ +\text{back} \end{bmatrix} \end{array} \right.$$

The conventions that permit us to replace (10) by (13) are quite natural; they imply that the value of a rule, as a measure of the linguistically significant degree of generalization it achieves, increases as the number of features required to identify the contexts in which it applies decreases.

The schema (13), however, is still not empirically adequate. Putting aside the question of the context of the rule, the conventions (11) and (12) permit the change that the rule effects to be formulated as (14), without any alteration of meaning:

$$(14) \quad \begin{bmatrix} +\text{voc} \\ -\text{cons} \\ +\text{high} \\ -\text{back} \end{bmatrix} \rightarrow [-\text{voc}]$$

Thus the change effected by rule (13) is minimal, involving only a single feature. But compare the change $i \rightarrow y$ effected by (10) (i.e., (14)) with the changes $i \rightarrow w$ and $i \rightarrow r$. These, in terms of our conventions, must be stated as (15) and (16), respectively:

$$(15) \quad \begin{bmatrix} +\text{voc} \\ -\text{cons} \\ +\text{high} \\ -\text{back} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{voc} \\ +\text{back} \end{bmatrix}$$

$$(16) \quad \begin{bmatrix} +\text{voc} \\ -\text{cons} \\ +\text{high} \\ -\text{back} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{cons} \\ +\text{cor} \\ -\text{high} \end{bmatrix}$$

The rules (15) and (16) have a lower value than (14), reflecting the fact that the changes $i \rightarrow w$ and $i \rightarrow r$ are more radical, that is, less to be expected in the grammar of a language, than is the change $i \rightarrow y$. Here too, then, the conventions have the natural and desired consequences. We return in Chapter Nine to a further discussion of this sort of distinction.

Two further comments must be made here concerning the formulation of the schema (13). First we note that if we omit the feature $[-\text{vocalic}]$ on the left-hand side of the arrow, then the schema will also apply to the glide $/y/$. Since in the cases under discussion the application of the rule to this glide is vacuous, the minimal representing schema will make no reference to the feature "vocalic" in this position.

Notice that the class containing the glide /y/ and the vowel /i/ is a more natural class in our terms than the class containing the vowel /i/ alone. In fact, this class plays a role in the grammars of numerous languages—for example, all Slavic languages, in which velars undergo precisely the same type of palatalization before the glide /y/ as before the front (nonback) vowels.³ We have noted a similar phenomenon in English, with velar softening before nonback nonlow vowels and glides.

Returning to schema (13), we may make a second observation: it would be quite reasonable to modify our conventions so that any part of the feature complex on the left-hand side of the arrow can be transferred to the environment by being placed under the dash that indicates the location of the segment subject to the rule. In accordance with this revision, the facts expressed in (13) may be alternatively formulated as (17):

$$(17) \quad \left[\begin{array}{l} -\text{cons} \\ +\text{high} \end{array} \right] \rightarrow [-\text{voc}] / \left[\begin{array}{c} \text{---} \\ -\text{back} \end{array} \right] \left\{ \begin{array}{l} \left[\begin{array}{l} -\text{voc} \\ +\text{cons} \\ +\text{ant} \\ -\text{cor} \\ -\text{nasal} \end{array} \right] \\ \left[\begin{array}{l} +\text{voc} \\ +\text{cons} \\ -\text{ant} \end{array} \right] \\ \left[\begin{array}{l} -\text{voc} \\ -\text{cons} \\ -\text{back} \end{array} \right] \\ \left[\begin{array}{l} +\text{voc} \\ -\text{cons} \\ -\text{high} \\ +\text{back} \end{array} \right] \end{array} \right.$$

The possibility of moving features in this way from the left of the arrow into the environment has significant empirical consequences, for it allows us to express partial identities between rules that could not otherwise be captured (but see also the discussion in Chapter Nine). For example, assume that the language under discussion, in addition to containing (13) (= (17)), also contains (18):

$$(18) \quad /w/ \text{ and } /u/ \text{ are actualized as } [u] \text{ before } /p \ r \ y \ a/$$

This rule could be formulated as (19):

$$(19) \quad \left[\begin{array}{l} -\text{cons} \\ +\text{high} \\ +\text{back} \end{array} \right] \rightarrow [+ \text{voc}] / \text{---} \left\{ \begin{array}{l} p \\ r \\ y \\ a \end{array} \right.$$

Rule (19) shows only a limited resemblance to (13). Suppose, however, that, taking advantage of the possibility of transferring part of the feature complex from the left-hand side of the arrow to the environment, we write the relevant parts of (13) and (19) as (20a) and (20b), respectively:

$$(20) \quad \begin{array}{l} \text{(a)} \left[\begin{array}{l} -\text{cons} \\ +\text{high} \end{array} \right] \rightarrow [-\text{voc}] / \left[\begin{array}{c} \text{---} \\ -\text{back} \end{array} \right] \\ \text{(b)} \left[\begin{array}{l} -\text{cons} \\ +\text{high} \end{array} \right] \rightarrow [+ \text{voc}] / \left[\begin{array}{c} \text{---} \\ +\text{back} \end{array} \right] \end{array}$$

The formulation (20) brings out the fact, previously obscured, that both (13) and (19) affect the natural class $\left[\begin{array}{l} -\text{cons} \\ +\text{high} \end{array} \right]$. This can now be readily captured by a double use of the brace notation:

³ In many of the standard handbooks of Slavic this fact is overlooked, and palatalization before the glide /y/ is treated in a separate chapter from palatalization before front vowels. See, e.g., Leskien (1919), Bräuer (1961); see also comments on page 422.

$$(21) \quad \begin{bmatrix} -\text{cons} \\ +\text{high} \end{bmatrix} \rightarrow \left\{ \begin{array}{l} [-\text{voc}] / \left[\begin{array}{c} \text{---} \\ -\text{back} \end{array} \right] \\ [+ \text{voc}] / \left[\begin{array}{c} \text{---} \\ +\text{back} \end{array} \right] \end{array} \right\} \begin{pmatrix} \text{p} \\ \text{r} \\ \text{y} \\ \text{a} \end{pmatrix}$$

To be precise, we must specify an order of expansion for the two sets of braces (see the Appendix to this chapter) and add the notational convention (22):

$$(22) \quad \text{Where } C \text{ is a unit,}^4 \text{ the schema (a) is equivalent to (b):}$$

$$(a) \quad A \text{ --- } B / X \left[\begin{array}{c} \text{---} \\ C \end{array} \right] Y$$

$$(b) \quad \left[\begin{array}{c} A \\ C \end{array} \right] \rightarrow B / X \text{---} Y$$

Consider, now, a language that differs from the language subject to rule (2) (or, equivalently, (17)) in that it is instead subject to rule (23):

$$(23) \quad i \rightarrow y / \text{---} \begin{pmatrix} i \\ u \\ \text{æ} \\ a \end{pmatrix}$$

An important difference between (17) and (23) is that in (23) the environment is a highly natural class of segments, that is, all vowels of the language, whereas the environment in (17) is a very unnatural class. This distinction must, of course, be brought out formally by an adequate linguistic theory. In fact, the theory as developed to this point is adequate in this respect. An examination of Table 1 shows that the four segments in the context of (23) can be uniquely identified in the language in question by specifying the two features $\begin{bmatrix} +\text{vocalic} \\ -\text{consonantal} \end{bmatrix}$; and in view of the evaluation criterion (9), it is this most abbreviated schema that determines the value of the rules summarized by (23). In short, the theory requires that these rules be formally represented by the minimal schema (24):

$$(24) \quad \begin{bmatrix} -\text{cons} \\ +\text{high} \\ -\text{back} \end{bmatrix} \rightarrow [-\text{voc}] / \text{---} \begin{bmatrix} +\text{voc} \\ -\text{cons} \end{bmatrix}$$

The required empirical distinction is thereby expressed, as a comparison of (24) and (17) readily shows.

3. The ordering of the rules

Consider again a language with a sound system such as that in Table 1. Assume that in this language:

- $$(25) \quad \begin{array}{l} (a) \text{ The plosives } /p \ t \ k/ \text{ are actualized as their (nonstrident) voiceless continuant} \\ \text{congeners } [\varphi \ \theta \ x] \text{ if preceded by but } \textit{not} \text{ followed by a vowel.} \\ (b) \text{ The plosives } /p \ t \ k/ \text{ are actualized as their (nonstrident) voiced continuant} \\ \text{congeners } [\beta \ \delta \ \gamma] \text{ if preceded by } \textit{and} \text{ followed by a vowel.} \\ (c) \text{ The continuant } /s/ \text{ is actualized as its voiced congener } [z] \text{ if followed by a} \\ \text{vowel.}^5 \end{array}$$

Compare this language to another language having the same sound system as the former (Table 1) in which instead of (25), the very similar allophonic alternations (26) obtain:

⁴ By the term "unit" we now and henceforth refer to any feature matrix with just a single column, and not necessarily a matrix which is specified with respect to each feature. Thus [+vocalic] is a unit, for example.

- (26) (a) Same as (25a).
 (b) The plosives /p t k/ are actualized as their (nonstrident) voiced congeners [β δ γ] if preceded by a consonant and followed by a vowel.
 (c) The continuant /s/ is actualized as its voiced congener [z] if preceded by a liquid.

The essential difference between (25) and (26) is that in (25), but not (26), the alternations occur in partially identical environments; that is, in (25) alternation (b) shares one part of its environment with (a) and another part of its environment with (c), whereas in (26) the environments are quite unrelated. This difference between (25) and (26) must somehow be reflected in their respective grammars.

A more formal statement of (25) and (26) would be given as (27) and (28), respectively:

$$(27) \quad \begin{array}{l} \left[\begin{array}{l} -\text{voc} \\ +\text{cons} \\ -\text{nasal} \end{array} \right] \rightarrow \left\{ \begin{array}{l} [+cont] / \left[\begin{array}{l} +\text{voc} \\ -\text{cons} \end{array} \right] \left[\begin{array}{l} \# \\ [-\text{voc}] \\ [+cons] \end{array} \right] \\ [+coit] / \left[\begin{array}{l} +\text{voc} \\ -\text{cons} \end{array} \right] \left[\begin{array}{l} \text{---} \\ [-cont] \end{array} \right] \left[\begin{array}{l} +\text{voc} \\ -\text{cons} \end{array} \right] \\ [+voice] / \left[\begin{array}{l} \text{---} \\ +cont \end{array} \right] \left[\begin{array}{l} +\text{voc} \\ -\text{cons} \end{array} \right] \end{array} \right\} \begin{array}{l} \text{(a)} \\ \text{(b)} \\ \text{(c)} \end{array} \end{array}$$

$$(28) \quad \begin{array}{l} \left[\begin{array}{l} -\text{voc} \\ +\text{cons} \\ -\text{nasal} \end{array} \right] \rightarrow \left\{ \begin{array}{l} [+cont] / \left[\begin{array}{l} +\text{voc} \\ -\text{cons} \end{array} \right] \left[\begin{array}{l} \# \\ [-\text{voc}] \\ [+cons] \end{array} \right] \\ [+coit] / \left[\begin{array}{l} -\text{voc} \\ +\text{cons} \end{array} \right] \left[\begin{array}{l} \text{---} \\ [-cont] \end{array} \right] \left[\begin{array}{l} +\text{voc} \\ -\text{cons} \end{array} \right] \\ [+voice] / \left[\begin{array}{l} +\text{voc} \\ +\text{cons} \end{array} \right] \left[\begin{array}{l} \text{---} \\ +cont \end{array} \right] \end{array} \right\} \begin{array}{l} \text{(a)} \\ \text{(b)} \\ \text{(c)} \end{array} \end{array}$$

It is obvious that the above-noted differences between the two sets of rules are not formally brought out in (27) and (28). We propose, therefore, the convention (29):

- (29) Rules are applied in linear⁶ order, each rule operating on the string as modified by all earlier applicable rules.

Now rule (27) can be significantly abbreviated without affecting the results produced by it:

$$(30) \quad \begin{array}{l} \left[\begin{array}{l} -\text{voc} \\ +\text{cons} \\ -\text{nasal} \end{array} \right] \rightarrow \left\{ \begin{array}{l} [+cont] / \left[\begin{array}{l} +\text{voc} \\ -\text{cons} \end{array} \right] \text{---} \\ [+voice] / \left[\begin{array}{l} \text{---} \\ +cont \end{array} \right] \left[\begin{array}{l} +\text{voc} \\ -\text{cons} \end{array} \right] \end{array} \right\} \begin{array}{l} \text{(a)} \\ \text{(b)} \end{array} \end{array}$$

Applying (30) to sequences such as those in the first line of (31), we obtain the required results:

$$(31) \quad \begin{array}{lll} \#ap\# & ;\#apa\# & \#sa\# \\ \#a\varphi\# & ;\#a\varphi a\# & \text{RULE 30a} \\ & ;\#a\beta a\# & \#za\# \text{ RULE 30b} \end{array}$$

Rule (26) (= (28)), on the other hand, cannot be abbreviated in a corresponding fashion; but this is precisely the result that we wish to obtain, for an adequate theory of grammar should allow for abbreviations where an actual generalization is to be observed and should prevent abbreviations when no true generalizations are to be found. Given the phenomena described in (25) and (26), any linguist would understand (25) but not (26) to express a linguistically significant generalization, and this distinction is accurately reflected by convention (29); the generalizations in the present instance are the result of taking explicit account of partial identities in the rules. A theory of grammar which fails to provide for the expression of such regularities must clearly be judged unsatisfactory.

The requirement that redundancy rules apply simultaneously is attractive in several respects. For one thing, no good examples have been discovered of empirically significant generalizations that result from ordering these rules. Hence any ordering that has been presented has actually been rather unmotivated. In contrast, the ordering of phonological rules has generally been discovered to be well motivated, and very narrowly constrained. Furthermore, there are difficulties beyond those just mentioned that can be avoided if the redundancy rules are regarded as unordered. As a case in point, Stanley (1967) cites the restrictions on obstruents in Indo-European obstruent-vowel-obstruent roots. Since Indo-European possessed the three series of obstruents in (153), we expect to find nine distinct types of roots of the form obstruent-vowel-obstruent, as in (154):

$$(153) \quad \begin{bmatrix} -\text{voice} \\ -\text{aspirated} \end{bmatrix} \quad \begin{bmatrix} +\text{voice} \\ -\text{aspirated} \end{bmatrix} \quad \begin{bmatrix} +\text{voice} \\ +\text{aspirated} \end{bmatrix}$$

$$(154) \quad \begin{array}{ccc} \text{tek} & \text{te} & *te^h \\ \text{dek} & *de^h & de^hg^h \\ *d^hek & d^hg & d^heg^h \end{array}$$

As is well known, forms of the types starred in (154) are not found. With ordered redundancy rules, we might express these facts as in (155)

$$(155) \quad [-\text{son}] \rightarrow \left\{ \begin{array}{l} [-\text{asp}] / + \begin{bmatrix} -\text{son} \\ -\text{voice} \end{bmatrix} \begin{bmatrix} +\text{voc} \\ -\text{cons} \end{bmatrix} \text{---} + \\ [\alpha\text{voice}] / + \begin{bmatrix} -\text{son} \\ +\text{voice} \\ -\text{asp} \end{bmatrix} \begin{bmatrix} +\text{voc} \\ -\text{cons} \end{bmatrix} \begin{bmatrix} \text{---} \\ \alpha\text{asp} \end{bmatrix} + \\ [+voice] / + \begin{bmatrix} -\text{son} \\ +\text{asp} \end{bmatrix} \begin{bmatrix} +\text{voc} \\ -\text{cons} \end{bmatrix} \text{---} + \end{array} \right\}$$

There is, however, no reason to assume that the restriction has directionality, i.e., should be formalized to operate from left to right. Equivalently we could propose restrictions where the last obstruent determines the first:

$$(156) \quad [-\text{son}] \rightarrow \left\{ \begin{array}{l} [-\text{asp}] / + \text{---} \begin{bmatrix} +\text{voc} \\ -\text{cons} \end{bmatrix} \begin{bmatrix} -\text{son} \\ -\text{voice} \end{bmatrix} + \\ [\alpha\text{voice}] / + \begin{bmatrix} \text{---} \\ \alpha\text{asp} \end{bmatrix} \begin{bmatrix} +\text{voc} \\ -\text{cons} \end{bmatrix} \begin{bmatrix} -\text{son} \\ +\text{voice} \\ -\text{asp} \end{bmatrix} + \\ [+voice] / + \text{---} \begin{bmatrix} +\text{voc} \\ -\text{cons} \end{bmatrix} \begin{bmatrix} -\text{son} \\ +\text{asp} \end{bmatrix} + \end{array} \right\}$$

As Stanley correctly remarks, the facts sketched in (154) can be expressed more naturally by stating that items of the form (157) are excluded:

$$(157) \quad \begin{bmatrix} -\text{son} \\ \alpha\text{voice} \\ \beta\text{asp} \end{bmatrix} \quad \begin{bmatrix} +\text{voc} \\ -\text{cons} \end{bmatrix} \quad \begin{bmatrix} -\text{son} \\ -\beta\text{voice} \\ -\alpha\text{asp} \end{bmatrix}$$

Equivalently, this constraint can be stated as a positive condition requiring that every item of the type in question be of the form:

$$(158) \quad \begin{bmatrix} -\text{son} \\ \alpha\text{voice} \\ \beta\text{asp} \end{bmatrix} \quad \begin{bmatrix} +\text{voc} \\ -\text{cons} \end{bmatrix} \quad \begin{bmatrix} -\text{son} \\ \gamma\text{voice} \\ \delta\text{asp} \end{bmatrix}$$

where $\alpha = \delta$ or $\beta = \gamma$

We have no notion of "simplicity" available that has any bearing on the choice between these alternative and equivalent formulations. We therefore adopt the positively stated condition (158), in conformity with our general practice.

The redundancy rules of the type considered heretofore (e.g., (150)) express certain "if-then" constraints: they state that if some segment (or configuration) of a matrix is specified in accordance with condition C_1 , then some segment (or configuration) must be specified in accordance with condition C_2 . Thinking of a redundancy rule in this way, we may say that (158) expresses an "if-and-only-if" constraint: it states that the first segment meets a certain condition if and only if the last segment meets a corresponding condition, there being four possibilities, all told. Hence such examples indicate that "biconditional constraints" exist alongside of the "conditional constraints" expressed by redundancy rules of the form discussed earlier