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FORMAL ASPECTS OF PHONOLOGICAL DESCRIPTION

by

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PREFACE

The present work is a revision of my doctoral dissertation, completed in 1970 under the supervision of Professor William S-Y. Wang. The revisions are minor, consisting largely in the correction of typographical errors, occasional rephrasing, and the addition here and there of further illustrative material.

I wish to thank all the members of my dissertation committee for the help they so willingly lent in both intellectual and administrative matters. I am especially grateful to the chairman, Professor Wang, for providing financial support out of National Science Foundation Grant No. GS-1430. I also wish to thank Mrs. Lois Sakamoto for a superb job of typing the original manuscript and my wife Edy for her patience and for the uncountable errands she performed.

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INTRODUCTION

The phonology of a language must provide a phonetic representation for each of the infinitely many sentences generated by the syntax. Hence the phonology as well as the syntax is a finite device that accounts for an infinite set of cases. To be sure, the phonology differs in several important respects from the syntax. Where the phrase-structure component takes a single symbol S as initial input and responds with one of an infinite set of alternative outputs, the phonology behaves as a mapping device accepting any of an infinite set inputs and responding in each case with one or at most a small set of alternative outputs. Under current views of syntax, the transformations too constitute a mapping device, though of a radically different sort from the phonology.

A phonological theory must characterize precisely the form of phonologies and the way they process strings. Among the results of such a theory will be a prediction as to what sorts of mappings can be effected by the phonologies of natural languages. Such a prediction would be analogous to a hypothesis in syntax that all natural languages are, say, context-sensitive. Although it has proven difficult to formulate and sustain strong hypotheses of this sort in syntax, we will try to show that in phonology we are somewhat more fortunate.

When confronted with several phonological formalisms with the same mapping capacity, there are several lines of action we could take. We could simply regard the formalisms as empirically equivalent and choose one of them on the basis of practical convenience. The standard view, however, is that formal theories of phonology carry an empirical burden far greater than the mere prediction of phonologically possible mappings and that there are therefore additional and perhaps even more important criteria for choosing among them. In particular, it has been held that the naturalness or plausibility of a phonological process ought to be reflected formally by a corresponding simplicity of formulation. Though this kind of consideration is much less well-defined than mapping capacity, it has played a central role in most discussions of notational devices in phonology and will serve as an important guide to our present investigation.

Our first step will be to examine, in Chapter 2, certain mechanisms for characterizing sets of phonological strings. Although the major focus of our attention will be on how such sets should be represented in the contextual portions of rules, some incidental consideration will be given to the problem of representing morpheme structure. The major result of Chapter 2 will be that the familiar schematic notation formalized in Chomsky and Halle (1968) is quite restricted in its capacity to represent sets of strings and consequently reflects a strong empirical claim concerning the nature of such sets as they occur in phonology. Specifically, we shall see that schemata can represent just the regular sets in the technical sense of automata theory. In Chapter 3 we consider some notational devices which do not add to the representational capacity of schemata but which seem to be necessary for linguistically satisfactory formulations. Most of these devices are already familiar from the literature, but we introduce them systematically to show how they fit into a formal system and to establish the notation to be employed in subsequent chapters. One new departure is suggested: the use of bracket notation to represent set intersection.

It is not until Chapter 4 that rules are formally introduced. There we consider some properties of two diametrically opposed types of rule, the iterative and the simultaneous. Our conclusion is that the iterative type is excessively powerful, being able to effect virtually any computable mapping, while the simultaneous type is highly restricted indeed, being able to effect only the sort of mapping known in automata theory as a finite-state transduction. Thus to confine phonological rules to the simultaneous type is to make another strong claim about phonology, a claim that is essentially correct as far as I can tell.

In Chapter 5 we consider some rule types that are equivalent to the simultaneous in mapping capacity but yield superior formulations in many cases. These new types of rules are called right-linear and left-linear. A body of empirical evidence is considered which leads us to the conclusion that right-linear and left-linear rules should both be allowed in phonological descriptions, although the simultaneous type can apparently be dispensed with.

Linear rules are formalizations of processes which proceed from left-to-right or from right-to-left through a string. Two other ways of formalizing these processes, the restricted iterative and the cyclic, are considered in Chapter 6 and rejected after a review of some empirical evidence.

Distinctive features, originally introduced in Chapter 3, are assumed to be binary up through Chapter 6. In Chapter 7 we consider the effects of allowing integers as feature coefficients. It seems clear that integer coefficients are necessary with at least certain prosodic features. The formal consequence is that certain rules are not strictly finite state and therefore stand as exceptions, albeit of a highly restricted nature, to one of our assertions in Chapter 4. A right-linear tone rule is discussed which manipulates an integrally-valued pitch feature, and it is shown that this rule cannot possibly be formulated with the standard notational devices if simultaneous application is presupposed; a right-linear formulation, on the other hand, seems quite satisfactory. We continue with a discussion of the stress feature, also integrally valued. Our general conclusion is that when stress is a culminative feature, being placed on at most one vowel in any given rule application, then it is either the rightmost or leftmost vowel fitting the structural description of the rule that is affected. Thus in particular we consider unnecessary the complex ordering relations among the subcases of the English Main Stress Rule as given by Chomsky and Halle. It is shown that an alternative formulation, due to Ross, fits quite neatly into the more restricted formalism that we propose.

Certain general conventions to be used throughout should be taken note of. We use $\emptyset$ to designate the null string; thus $X\emptyset Y = XY$ for all strings X and Y. Also, if X is any string then $X^0 = \emptyset$ and $X^i = X^{i-1}X$ for each positive integer i. Thus $X_1 = X$, $X^2 = XX$, $X^3 = XXX$, and so on. It is important to keep in mind that the notational devices just discussed will not be thought of as actually occurring in expressions that appear in phonological descriptions. Rather, they are part of the metalanguage we use to talk about such expressions. This practice is different from that of Chomsky and Halle (1968, Appendix to Chapter 8), who regard $\emptyset$ and superscript and subscript integers as part of the notation of phonological rules.

Certain portions of the text can be skipped without loss of continuity. The beginning and end of such a portion is signaled by (* and *), respectively.

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SCHEMATA

We will assume that the phonology of any natural language can be described in terms of a fixed universal alphabet of phonological units. For simplicity of exposition we will usually assume that all phonological units are segments, boundary symbols being usually excluded from consideration. A string of phonological units will be called a phonological string.

It is generally accepted that the phonological component of a generative grammar consists wholly or largely of rules which rewrite phonological strings. Each of these rules operates by appropriately altering short substrings (usually single segments) that satisfy certain conditions. Some of these conditions are contextual: a segment will be rewritten in the specified way only if the substring to the left belongs to a certain set (the left environment) and the substring to the right belongs to a certain set (the right environment). Consider, for example, the Sanskrit rule which changes a dental *n* into a retroflex *ṇ* when the *n* is

(a) preceded somewhere in the same word by a retroflex continuant without an intervening palato-alveolar, retroflex, or dental consonant, and
(b) followed immediately by a sonorant.[1]

[1] For other descriptions of the Sanskrit nasal retroflexion rule see Allen (1951), Emeneau and van Nooten (1968: 7), Langendoen (1968: 84), and Whitney (1889: 64-66). Our way of representing vowels and semivowels in underlying forms is similar to that of Zwicky (1965). I wish to thank Professor Murray Emeneau for personally clarifying certain points of Sanskrit grammar. Any errors that remain are entirely my own.