

# Generative phonology: its origins, its principles, and its successors

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## Introduction

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The story of the rise of generative phonology, both in the United States and abroad, is one of continuity and of rupture. That there has been rupture has been emphasized by commentators and historians alike, as also by the originators of generative phonology; the continuity has been less clearly treated in the recorded history of this period. It will be our task in this paper to sketch *both* of these sides of the story.

But it is not an easy task even to decide where this story should begin, nor where it ends. The simple answer to the question as to where it begins is with Noam Chomsky's efforts to describe the morphophonemics of modern Hebrew (Chomsky 1951), but the historical roots of generative phonology lie deeper and earlier, as we shall see. Where generative phonology ends is a much harder question to answer: should the theories of phonological representations studied in the 1980s be considered generative phonology?—most phonologists would agree that they should: certainly from a methodological, epistemological or theoretical point of view, they share the flavor, the spirit, the mood of generative phonology; but many of the core questions asked in the 1980s had stronger historical roots in pre-generative than in generative phonology. In the final analysis, decisions about when generative phonology should be said to have begun or ended are too crude and brittle to merit our attention for long. We will focus, instead, on characterizing as best we can the core beliefs and values of various moments in the development of phonological theory during the period under consideration, on characterizing the genealogy of the themes that are common to two or more such moments, and, to a lesser degree, on understanding how the broader intellectual and social context within which these developments occurred played a significant role.

## Questions of philosophy of science

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As always in the history of science, the movements in phonological theory, and linguistic theory more generally, through the twentieth century developed hand in hand with changes in the interpretation of the meaning and role of science. This linkage holds quite generally throughout the period.

Influential throughout much of the first half of the century (and ultimately deeply related to the development of cognitive science and to the view of linguistics as cognitive research) were three related arenas of philosophical thought: positivism, empiricism, and logical positivism. Empiricism, as a self-conscious tradition, is by far the oldest of these, and its classical sources lie in the works of John Locke (Locke 1690) and David Hume (Hume 1739); its fundamental claim is that all human knowledge has its origins in the human senses, and solely in them; it is

essentially epistemological in character. Though inspired by the Enlightenment, positivism was a later tradition, with its origins in the 19<sup>th</sup> century work of August Comte (Comte 1830) and Ernst Mach (Mach 1886), and its goal was to sweep away what it perceived as the dusty cobwebs of metaphysics left behind by philosophers who had waxed eloquent about ideas that sounded magnificent but were simply fantasies of the imagination (gods, souls, essences, and so on.). Positivism prided itself on its hard-headed and practical (indeed, pragmatic) character. It called for skepticism of scientific concepts (famously, those of Newtonian space and time, and the atom, and later a range of psychological notions), but was fundamentally committed to the primacy of scientific knowledge; indeed, given the central role it assigned to scientific knowledge, the demands that it placed on scientific concepts were due to its belief that scientific reasoning and scientific discourse needed to police itself—so to speak—in the most serious way possible. Positivism was nourished by the stunning successes of scientists and mathematicians who had challenged some of the concepts and categories that had been taken to be unchallengeable in the late 19<sup>th</sup> and early 20<sup>th</sup> century: the work of Riemann, Poincaré, Einstein, and others. Logical positivism was the development of the intellectual heirs of Ernst Mach, working principally in Vienna just before the rise of Hitler. In Berlin, a view which shared many sympathies with the logical positivists of Vienna grew up under the principal influence of Hans Reichenbach (see Reichenbach 1938, for example) who in effect brought it with him to the United States when he moved to UCLA in 1938. This latter-day positivism was considerably less rejectionist than the Viennese logical positivists, whose metaphysical views—that is, whose views on what actually exists—were radical and based on Ernst Mach’s position that the foundation of knowledge can only be couched in reports of perceptions. Positivism, as it developed, dropped this radical (and from a modern-day view, rather implausible) position, and attempted to reconstruct an understanding of science which recognized the reality of scientific constructs quite above and beyond human perceptions of red, green, and meter readings.

It is critical, if one attempts to understand the influence of positivism and empiricism on the linguists during the period under discussion, to bear in mind that the attraction of these movements was their promise of liberation from the shackles – one might even say: the dead weight – of earlier scholarship. From the vantage point of the cognitive movement of the 1960s and later, the high barrier that empiricism and positivism raised to the postulation of scientific entities might give the appearance of cranky conservatism, but that was not at all the original intention of the adherents of these movements. It is not difficult to see that a scientific movement which could dethrone the dead hand of Isaac Newton and his view of space and time, and allow a young Einstein to recast our understanding of the nature of space and time, could appeal to a group of young linguists who wanted to cast off the domination of grammatical categories passed down from classical grammarians for the treatment of European languages, and to establish scientific observation (and not hoary classical tradition) as the essential test that a linguistic theory must pass in order to be taken seriously.

Positivism, as a theory of science, and empiricism, as a theory of the origin of human knowledge, fit together well to motivate a conception of linguistic practice in which the most important thing a linguist could do was to do field work with informants: not only would the field of linguistics be enriched by the accretion of additional knowledge about a particular language, but the linguist would be helped in his struggle to overcome his early “indoctrination” in the ways of his own native language.

We turn now to the first of the two linguistic traditions that had a strong influence on the character of generative phonology, that which flowed from the European tradition of Nicolai Trubetzkoy and Roman Jakobson.

### The Trubetzkoy - Jakobson legacy

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In Europe, the new science of language that emerged in the middle of the 1920s with the Prague Circle defined itself with respect to an emerging discipline of phonology,<sup>1</sup> which provided its concepts and its theoretical framework, as well as its methodology and rhetoric in the most basic sense. By succeeding in establishing a new scientific approach in the analysis of language, structuralism positioned itself in such a way that it dominated social sciences up to the 1970s with virtually no competitors (Milner 2002). For half a century, structuralist phonology was to constitute the source of conceptual inspiration as well as the overarching framework for virtually all of linguistics, and it did this by imposing a new conception of science.

This phonological *imperium* was marked from its very start both by rupture and by an absence. The rupture was the violent break with classical philology, descriptive linguistics, comparativism, and diachronic thought, all of which together formed the linguistic echo of a naturalistic and Darwinian conception of science, an essential moment of 19<sup>th</sup> century thought (Laks 2002), (Bergounioux 2002). The absence was that of Ferdinand de Saussure, whose death in 1913 left the emerging perspective with only the notes and interpretations provided by students published posthumously in the epoch-making *Cours de linguistique générale* (Saussure 1916).

The critical rupture took place at the first International Congress of Linguistics at The Hague in 1928. Roman Jakobson, who formulated what came to be known as the Prague theses, took the opportunity to answer the question posed by the organizers, “What are the most appropriate methods for a complete and practical description of a language?” In his answer, Jakobson laid out a sharp and detailed account of the concepts and methods of synchronic, functional linguistics as it was applied to phonology. He defended vigorously the notions of the phoneme as an abstract entity, of phonological opposition as the basis of the semantic distinction, of a structured organization of these oppositions forming a structural system. The goal was clear enough: Jakobson sought to separate “those who are with us and those who are against us”<sup>2</sup> in the movement to construct a new science of language.

But if the young linguists of the Prague Circle already had a new vision of a scientific practice, it could not be said that they yet had a fully articulated theoretical model. In what Sériot (Sériot 1999) has called *la pensée de la totalité* (which is to say, a world-view rejecting conceptual and ideological pluralism) which was developing in the western Europe, there was a marked rupture with Darwinism and positivism, but the notion of *structure* that was substituted for the organicism of the 19<sup>th</sup> century was still in need of theoretical development and refinement with a clear linguistic formulation. The Prague Circle linguists found this necessary element in

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<sup>1</sup> The Prague Linguistic Circle (or *Cercle Linguistique de Prague*) was officially established in October of 1926, and its first salvo was Proposition 22, submitted by Jakobson, Trubetzkoy and Karcevski to the first international congress of linguists in The Hague in 1928 (Jakobson 1928).

<sup>2</sup> Correspondence between Jakobson and Trubetzkoy cited by Anderson (1985).

their interpretation, and appropriation, of Saussurian thought, and with it, they and their students found their scientific program, their theoretical paradigm, and the legitimacy that they needed. Jakobson would devote a large part of his later work to a reinterpretation of the great dichotomies that grew out of discussions inspired by Saussure's *Cours* and formulated within European structuralism: *langue/parole*, synchrony/diachrony, function/realization, syntagmatic/paradigmatic, system of oppositions, the principle of minimal difference, and the law of differential value; see (Jakobson 1986), (Jakobson and Waugh 1979).

Nonetheless, at this point in time, a rupture with the Darwinian conception of science and its evolutionary-based thought and taxonomic structures was not an easy act to accomplish. Linguistics was certainly still dominated by the feats of Indo-European reconstruction, and the focus of linguistics was phonetic evolution, with concern for whether it was in some sense *natural*, and whether a mechanistic conception of such evolution was feasible. The end of the 19<sup>th</sup> and the beginning of the 20<sup>th</sup> century saw a spectacular growth in the technologies necessary for both acoustic and articulatory and motor phonetics (Asher, Henderson and Abercrombie 1981). The descriptive needs of dialectology, of ethnography, and of linguistic geography, combined with a socially and politically based demand for orthographic reform, led Passy and Jones to found in 1886 what was to become, in 1897, the International Phonetic Association (MacMahon 1986). Phonetics was thus to become at this early point in time the new scientific model which linguists were seeking. But this was not the perspective of the later Prague linguists who, with Saussure's writings in hand, challenged the role and the importance of phonetics and of naturalism for the sciences of language.

### **Legacy of American structuralism**

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By the time of the establishment of the Linguistic Society of America in 1924, linguistics in the United States had become largely autonomous, from a professional point of view, from European linguistics. Where an earlier generation of linguists had gone to Europe to study historical linguistics with the masters, now linguists would be trained and taught at American universities. Professional links between the continents were by no means absent during the 1930s; one can see the correspondence between Sapir and Trubetzkoy concerning Hopi that is cited in (Trubetzkoy 1939). But the links were indeed weak, and linguistics on the two sides of the Atlantic developed theoretical and practical differences that only grew over time, and of course, the war in Europe from 1939 to 1945 left no time for academic research there.

For mainstream American linguists of the 1940s and 1950s, it was axiomatic that linguistics was not just the systematic study of language: it was the *scientific* study of language, and much of the development of the theory of phonology during this period was a series of attempts to define and characterize a theory of language which was truly scientific. There was still something of a feeling of wonder in the air that in recent times a way had been established (and here Bloomfield's name was often invoked) which was both scientific and capable of dealing with facts of language. Linguists would turn to the physical sciences, or to empiricist and positivist philosophers who took the physical sciences to be the paradigm example of reliable scientific knowledge, and, in effect, ask what they as linguists could do without overstepping the borders of legitimate science, and what they needed to do to deserve being called a science. The answers that they found—or that they thought they found—had a major impact on how they conceived of phonology

American linguists during this period missed few opportunities to underscore the notion that linguistics was—finally—a science, and would then criticize each other for not being

“scientific”. Bloomfield (Bloomfield 1933) waits no longer than his third paragraph to declare that “[i]t is only within the last century or so that language has been studied in a scientific way, by careful and comprehensive observation”. Einar Haugen and W. F. Twaddell published a scathing critique (Haugen and Twaddell 1942) of Trager and Bloch’s (Trager and Bloch 1941) analysis of the syllabics of English:

To us, in all sobriety, the processes whereby Trager and Bloch combine sound-types into phonemes appear more akin to artistic composition than to scientific classification; and the pleasure of watching their operations with the material is rather esthetic satisfaction than scholarly conviction.

At the risk of oversimplifying (and (Hymes and Fought 1981) is a salutary antidote to oversimplification in this respect), the choice that linguistic theory faced during this period was one between following the image of Sapir and that of Bloomfield, if by “Sapir” we mean a science of language rooted in the study of culture and anthropology (“all linguistics is anthropological,” wrote Kenneth Pike (Pike 2001), and by “Bloomfield” a study of language rooted in linguistic structure analyzed distributionally, and with as little appeal to culture as possible.

American structuralist phonology in the 1950s (indeed, American linguistics more generally) was thus experiencing a tension that grew out of a desire both to be grounded in the social sciences, in which the scientist was an acknowledged participant and the objects of study were taken to be human beings, and to be a fully formalized and even mathematical discipline. In this, linguistics was not alone; a rich body of secondary historical literature now exists on the importance of the cybernetics movement in American thought, ranging from engineering through the physical and the social sciences (Heims 1991, Dupuy 2000).

We return to this theme briefly below. But we leave now the period preceding the rise of generative phonology to treat the movement itself.

## **Generative Phonology**

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Generative phonology was the creation of Noam Chomsky and Morris Halle, both to be professors in the Department of Modern Languages and Linguistics (and later the Department of Linguistics and Philosophy) at MIT. Their work became known to linguists outside of MIT proper through a series of publications, including most notably Halle (Halle 1962; Halle 1964), Chomsky (Chomsky 1964) and (Chomsky and Halle 1965): but most of all, the *magnum opus* of the movement, *The Sound Pattern of English*, henceforth *SPE* (Chomsky and Halle 1968). Morris Halle had been the student of Roman Jakobson at Harvard University; Noam Chomsky had been the student of Zellig Harris at the University of Pennsylvania, and more recently a junior fellow in the prestigious Society of Fellows at Harvard University.

In several ways, the development of generative phonology (and generative grammar more generally) was born of a disciplinary rupture, and brought with it rifts in the field. Proponents of generative grammar (ironically, in light of the similar views of the earlier generation of linguists noted above) believed that generative grammar was the first truly scientific account of language, the first to develop something that could be called a *theory*. But the rifts were social as well, in the broadest sense of the term, and while it is not difficult today to see patterns of deep continuity linking the phonology of American structuralism (and, indeed, the Prague School as well) to generative and post-generative phonology, there was a widespread perception that deep

substantive and philosophical divides separated the generations. Some have focused on the personal divides; others have focused on a shift from a positivist and empiricist philosophy associated with the structuralists to a rationalist position associated with the generativists. Space does not here permit all of the discussion that this question merits.

There were four central and distinctive tenets of the research program presented in *SPE*:

First, the goal of the working phonologist was to develop fully explicit, algorithmic phonologies which generate the surface forms of a language and only those. In case of multiple accounts of the same data—an unavoidable situation—formal simplicity was to be used to choose among the accounts, once a satisfactory means had been established for measuring formal simplicity. In the meantime, considerable thought and effort should be given to determining what these measures of formal simplicity were to be. The centrality of this notion of simplicity is made explicitly in *SPE* in several places (e.g., pp. 296, 331), and its effects are virtually everywhere. Nonetheless, the broader theoretical picture that would provide a clearer justification was not to be found in *SPE*, but rather in Chomsky's Logical Structure of Linguistic Theory, circulated in the 1950s and published in 1975. Some older linguists explicitly rejected the idea, a small number of younger linguists (such as James McCawley (1973)) embraced it and used it to develop the *SPE* model further, and it was eventually abandoned in the late 1970s without any explicit fanfare in favor of perspectives informally dubbed “principles and parameters”.

Second, the explicit phonologies developed should employ derivational means (that is, sequential, processual analyses) to generate the forms of a language. The observed forms that the linguist wishes to account for are to be the output of a sequence of phonological rules which act upon an underlying form. Linguists had already begun to employ explanations which included the ordering of phonological rules (see Goldsmith 2008 for a discussion of Wells 1949 in this regard), but generative phonology took the position that derivations were widely used in the phonologies of natural languages.

Third, the phonological representations used were linear sequences of matrices of feature values. No structure beyond the linear structure of these matrices or segments was included; in particular, there were no syllables included in the model. Segments—phones—were to be represented as bundles of binary features, in a fashion very similar in character to what had been proposed by Jakobson, much of that in collaboration with Halle (Jakobson, Fant and Halle 1952; Jakobson and Halle 1956).

Finally, discovering deep rule ordering was a high priority of the theory, in the following sense. For each pair of rules, one would attempt to determine that one and only one ordering of the rules was consistent with the data, and one attempted to establish that a total ordering of the rules could be established which was consistent with each pairwise ordering empirically established. For example, if a language has a phonological rule that lengthens vowels before voiced consonants (which would be written  $V \rightarrow [+long] / \_ [C, +voice]$ ), and a rule that voices intervocalic obstruents ( $[-sonorant] \rightarrow [+voice] / V \_ V$ ), then the language must *also* contain a statement as to which of those two rules applied “before” the other, because the predictions of the grammar would vary depending on this rule ordering. Not all pairs of rules would need ordering in this sense, in a given language, but a generative phonological account of a language with  $n$  rules would provide a single strict ordering of them, and this strict ordering would make  $\frac{1}{2}n(n-1)$  claims about ordering being pairs of rules. If rule A can be shown to be ordered before rule B, and B before C, and C before D, then the depth of the rule ordering from A through D is four, and it was a desideratum of the framework to determine a large depth for a given language.

Equally importantly, one of the questions that were central to work in structuralist phonology essentially disappeared in the *SPE* program—that of determining under what conditions a phonological contrast exists in a language. Perhaps that is putting it too strongly; but within the *SPE* program, there was essentially no cost paid by the analyst who proposed (so to speak) the establishment of a new segment in the analysis of a given language. The rigorous conditions placed within structuralist frameworks on the postulation of a phonological contrast (that is, on the introduction of a phoneme in the analysis of a language) were replaced by a relatively low barrier to such analyses. Differences in inflectional paradigms or other general phonological shape could be accounted for, within an *SPE* analysis, by the postulation of phonological contrasts (i.e., the postulation of “new” underlying segments), thus simplifying the morphology of the language, and such analyses were in general preferred. For example (*SPE* p. 151), one could account for the final stress on *caress* (unlike the word *Paris*) by positing an underlying geminate *ss* in *caress*, or one might posit a “new phonological segment  $k^w$ ” (p. 150) in order to account for violations of proposed phonological generalizations.

A consequence of all of the positions described above was the development of analyses that were “abstract,” a term often used but less often defined. In general, abstract analyses accounted for phonological alternations by means of formal analyses in which the crucial determinant factor was phonological, but not present on the surface. If one posits a  $k^w$  for English (p. 158, n. 116), and a morpheme /sek<sup>w</sup>/ and a rule convert  $k^w + At$  to  $kUt$ , then one can account for the relationship between the English words *consequence* and *consecutive* and its apparent phonological complexity. This encouraged the development of phonological analyses for linguistic material that had been treated as derivational and inflectional morphology in structuralist frameworks.

Of the four major tenets sketched above, and other more minor concerns of the *SPE* model, the most important was the view that the best form of explanation was algorithmic explanation. An algorithmic explanation is one which provides an account of the data which satisfies the conditions for being an algorithm: it is a fully explicit description of a process that can be carried out in a finite amount of time on a computational device such as a Turing machine or its equivalent.

With the rise of algorithmic analysis, it was now possible to accept a new kind of *mentalism* and still adhere tightly to a mechanistic scientific methodology, one which rejected the use of terms that were inextricably linked to the postulation of an inner psychological world. One could accept virtually all of the positivist’s criticism of 19<sup>th</sup> century psychologizing (criticisms that were accepted in their entirety by Bloomfield and his followers) and still develop a formal linguistics with room for at least some kinds of mental entities, though not the mental entities of a Sapirian, anthropologically based linguistics. This new kind of mentalism did not assume or make use of an internal world in the head of a speaker that refused to be bound by the principles of the Newtonian world; instead, it looked to understand and explain mental phenomena in terms of algorithms that modeled their essential character.

Algorithmic explanation became a new competitor with earlier notions of explanation in linguistics, such as historical, psychological, and sociological explanations. Accounts of complex linguistic data which appeared to require complexities typical of algorithms, such as sequences of crucially ordered rules, but atypical of psychological or sociological explanation, became highly valued in the new context of generative phonology.

In sum, the two most important fundamental ideas of generative phonology were these: first, the fundamental premise of generative grammar, that the goal of linguistic theory is to

develop a formal theory in which conciseness of formal expression correctly models phonological naturalness—rather, for example, than to develop an algorithm for finding the correct grammar, given the data, which was *de facto* the goal of most theorizing in American structuralism. Paraphrasing this, the generative goal is to develop an explicit function which can, given a set of observations from a language, determine which of a set of analyses is the best; the goal is not to develop a function which generates the grammars, given the data (except in the relatively trivial sense in which all possible grammars can be enumerated). The function is called an evaluation metric, and it can be employed in a way that permits grammar justification to be conceived of as an optimization process. Second, the phonological grammars themselves algorithmically (that is, fully explicitly, in a fashion compatible with a digital computer such as a Turing machine) generate surface forms on the basis of underlying forms composed by a lexicon or morphological component.

### **Issues of 'abstractness' and 'naturalness'**

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By the end of the 1960s, the vast majority of the work in phonology by younger linguists was being conducted and published in the framework of generative phonology, and if there were phonologists who disagreed with it, *SPE* was nonetheless *the* work by which one's position was to be defined.

#### **6.1 Natural phonology and natural generative phonology**

By the early 1970s—forty years after the Prague School had sharply distinguished the fields of phonetics and phonology, and twenty years after the strict differentiation of the *etic* and *emic* levels and the American structuralist affirmation of the bulwark separating the two—it might have seemed that the question of the role of phonetics had been settled once and for all. The decade of classical generative phonology and the utter domination of the kind of formal phonology that it promoted would only reinforce this impression. In *SPE*, a phonetics that was assumed to be universal played a secondary role, ultimately useful just to the extent that it could provide a vocabulary of features permitting the linguist to specify explicitly and overtly the abstract dimensions of the sound stream in a strictly binary fashion. The formal manipulation of these features by the phonology itself remained strictly binary (with marginal exceptions involving stress). With the suspension of phonetic realism and the abandonment of explanation based on concrete phonetic properties, the naturalist conception of phonology would seem to have run out of steam.

Nonetheless, *SPE* did *not* take a radically abstract position; Chomsky and Halle in fact held a position more closely resembling that of Jakobson (Jakobson and Waugh 1979), who saw phonology as a superstructure holding together the concrete sounds of language, than that of Trubetzkoy, who argued for a logical system of oppositions that was markedly more abstract, separate from the physical substance of the speaker-hearer, and hierarchically superior to the sound stream itself. The classical generative framework soon found itself criticized for its excessive phoneticism by phonologists (such as (Foley 1977)) holding to an even more abstract and formal view of the sort that echoed the glossematic form/substance dichotomy introduced in the 1930s by Hjelmslev (Hjelmslev 1939). In this approach, form alone played a structural role; substance was merely its physical support, its manner of being made manifest.

By refusing ultimately to adopt a totally abstract formalist logic, *SPE* itself opened the door to the naturalist critique that would develop during the 1970s. *SPE*'s final chapter ("Epilog and prolog: the intrinsic content of features") was perhaps the first symptom of this critique to come: the universalization of the theory of markedness proposed in Chapter 9 reintroduced

phonetic substance into the theory by examining the intrinsic content of features and the natural character of various classes of segments and the processes that apply to them. Chomsky and Halle drew what certainly appeared to be radical conclusions regarding “the fundamental theoretical inadequacy” of a model which had no internal evaluation metric capable of evaluating phonological naturalness and universality.

Even before the official publication of *SPE*, questions had arisen regarding the degree of abstractness of underlying representations, the formal complexity of derivational processes, and the phonological and morphophonological relevance of the abstract analyses that the *SPE* model permitted and encouraged. Constraints were proposed (Stanley 1967; Kiparsky 1968; Kiparsky 1968) that put strong limits on underspecification of lexical representations, constraints that minimized allomorphy and maximized the transparency of analyses. The synchronic and diachronic plausibility of excessively abstract analyses was challenged by a number of younger phonologists, many of whom were inspired by Kiparsky’s (Kiparsky 1968) question, virtually a call to arms: “How abstract is phonology?” Notably with Vennemann (Vennemann 1971; Vennemann 1974) and Stampe (Stampe 1972), a movement came into being that argued for concrete, naturalist, surface-oriented analyses up through the 1980s at least. Although it would be impossible to identify a homogeneous and stable core doctrine, naturalist approaches fell roughly into two camps: that of Natural Generative Phonology, or *NGP* (Hooper 1973; Vennemann 1974), and that of Natural Phonology (Stampe 1972), (Donegan 1978), (Donegan and Stampe 1979). In what follows, we shall refer to both movements together with the term “natural phonology,” without capital letters.

By choosing the term *natural*, the adherents of natural phonology inevitably invited the interpretation according to which *SPE* generative phonology was in some sense *artificial phonology*, and thus incapable of grasping or adequately modeling what is natural and universal in well studied processes such as apophony, found in both diachronic and synchronic phonological studies. In retrospect, it is notable that natural phonology seemed incapable of completely breaking with the generative phonological framework which was (or seemed to be) in full swing at this point: natural phonology continued, notably, to employ phonological derivations and ordered rules. Natural phonology was grounded in diachronic studies far more than was classical generative phonology, and nowhere was this more so than in reconsideration of neogrammarian analyses couched in terms of phonetic laws and diachronic rules, such as Grimm’s or Verner’s law, or those describing the passage from classical to vulgar Latin. If the impetus for derivational conceptions of phonological analysis can be found, in part, in ordered sound change, this may account in part for natural phonology’s continued adherence to a derivational perspective. In the end, natural phonology limited its positive statements to formulations of constraints and principles whose effect was to limit the generative power of the dominant model, and to put limits on the distance permitted between abstract underlying representations and surface representations (for example, by forbidding absolute neutralization, an underlying contrast that is never found on the surface in a given language, such as a vowel length contrast in a language where the length contrast has been lost on the surface), and, in the case of Natural Generative Phonology, to restrict the formal mechanisms available to the phonologist to those found within a two level model. In a sense, natural phonology was unable to rise to the challenge enunciated in Chapter 9 of *SPE* (which could indeed have been read as an admission of great vulnerability)—that is, it was unable to provide a strictly phonological evaluation metric capable of correctly discriminating between formalizations on the basis of their

naturalness in the broadest sense of the term (essentially, their commonness and expectedness in human languages).

Much of natural phonology was—or at least appeared to be—motivated by a particular conception of human cognition, one which was both empiricist and “sensualist,” in the sense that the “natural” in “natural phonology” included (and was perhaps dominated by) the character of human audition and articulation; naturalness and function would follow directly (if the theory were to hold) from the anatomy and physiology of the human species, and the grounding of a phonological explanation would ultimately emanate from a deeper understanding of anatomy and physiology of acoustic perception and articulatory action.

It is no accident that this typology, and the grammatical architectonic which flows from it (absence of rule ordering but ordering of mechanism types, etc.), echoes neogrammarian views on sound laws, rules, and their mechanisms. At the same time, we see ideas here which are very much of current moment: the equivalents of faithfulness constraints, output-output constraints, and so on. Present as well is the first articulation of a parametric theory which locates phonological universals in constraints which the physical character of the human biological endowment exerts on cognition, and thus on the form that it produces. Thus at the very moment of the apparent triumph of the most formal and abstract view of phonology—the classical generative conception—the naturalist tendency reintroduced phonetic motivation and brought back the importance of the phonic and articulatory substance in the definition and characterization of phonological systems.

## 6.2 Lexical phonology

Lexical phonology was a program of research developed during the 1980s jointly by a number of phonologists, including Paul Kiparsky (Kiparsky 1982; Kiparsky 1982), K. P. Mohanan (Mohanan 1982), Douglas Pulleyblank (Pulleyblank 1986), and Steven Strauss (Strauss 1982), drawing heavily on work by Dorothy Siegel, Mark Aronoff (Aronoff 1976), and David Pesetsky (Pesetsky 1979), among others. It was proposed as a refinement of classical generative phonology, but incorporated insights from a wide range of theories, notably pre-generative structuralist phonology and natural phonology. One of its strengths, and one of the aspects that made it attractive, was that it was an effort to synthesize elegantly solutions to a large number of problems, many of which had not hitherto been viewed as directly related.

Within the framework of lexical phonology, the phonology of a language was divided into two distinct components, the lexical phonology and the post-lexical phonology. In processual terms, the output of the lexical phonology was the input to the post-lexical phonology, which meant that no information computed in the post-lexical phonology could play a role in any rule or generalization in the lexical phonology. In addition, much of the information about the internal morphological structure of a word was “erased” (so to speak) from a representation when it passed to the post-lexical component, and thus such information could play no role in a generalization in the post-lexical phonology. In this regard, lexical phonology showed the distant influence of the structuralist distinction between morphophonology and phonemics, as well as distinction between rules and processes in natural phonology, as we have seen immediately above.

Post-lexical rules, in the original version of the theory, had many properties of Stampean processes and structuralist principles of allophony, and lexical rules bore many of the hallmarks of structuralist morphophonology. The central idea of all structuralist phonology is that a set of

phonemes can be identified in a language, and that these phonemes are used essentially by the language in order to allow the construction, so to speak, of lexical items which differ utterly from one another, even if they are as similar phonetically as *peak* and *pick*. If a language has more sounds than these—and every language does—these additional sounds, which are not used by the language to express any lexical contrasts, should be subject to distributional statements accounting for where they may or may not appear in the sound stream. These additional sounds are the allophones of the phonemes, in American structuralist terms, terms which had been discarded by generative phonology. Lexical phonology insisted on the importance of characterizing an inventory of sounds (and structures, too) which were permitted within the lexical phonology; rules within the lexical phonology could change one segment to another, but within the limits of the inventory of the lexicon.

Post-lexical rules had many of the properties of such rules of allophony. they were exceptionless, they could in principle apply in contexts that involve phonological material crossing from one word to another (e.g., voicing assimilation applying across word-boundary), they were not sensitive to morpheme identity, and they could describe the distribution of sounds that are not contrastive in the language. Phonological rules of the lexical phonology, by contrast, could be governed by morphemes or segregated in *layers* (also known as *strata* or *levels*) which were associated with certain aspects of the morphology. In addition, feature-changing operations of phonological rules could not create any segments which were not part of the underlying inventory of sounds in the language, and so (at least with respect to these segmental rules) the lexical rules mapped one sound-type permissible underlyingly to another sound-type that was also permissible underlyingly – what an earlier generation might have described as mapping one phoneme to another.

### **Syllables and non-linear phonology**

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The inadequacies of a purely linear model of phonological representations were discussed in detail in the two principal statements of late American structuralist phonology, *Structural Linguistics* (Harris 1951) and *A Manual of Phonology* (Hockett 1955). Harris discussed what he termed *long components* in connection with phenomena that today would be called prosodic or autosegmental, while Hockett placed hierarchical structure, especially syllable internal hierarchical structure, at the center of his account of phonological structure. While not all phonologists in the 1950s and 1960s agreed that phonological analysis should include syllable structure, *SPE* dismissed it. Indeed, one of the bones of contention between natural generative phonology and *SPE* was NGP's strong adherence to the syllable as a unit of analysis.

Thus from the perspective of the 21<sup>st</sup> century, we can perceive a continuity in the role played by the syllable in phonological theory which is less evident if we focus primarily on generative phonology. Pulgram (Pulgram 1970) offers a brief overview of the treatment of the syllable in pre-generative mid-century, ranging from views that dismiss the syllable entirely ((Kohler 1966): "...it can be demonstrated that the syllable is either an UNNECESSARY concept...or even a HARMFUL one..."), to the view that the syllable is important because it is the "smallest unit of recurrent phonemic sequences" (Haugen 1956)) and hence the "unit best suited for stating the phonotactics of a language" (Kučera 1961). The syllable's role in structuralist phonology was precarious, due to the fact that it is, in general, predictable and hence not distinctive. The inclusion of the syllable in generative accounts, in particular, was the direct

result of several lines of work, notably that of (Hooper [Bybee] 1979), Fudge (Fudge 1969), Selkirk (Selkirk 1982), and Kahn (Kahn 1976).

There were very mixed views among the American Bloomfieldians regarding the necessity or appropriateness of the syllable in phonology. Kenneth and E.V. Pike (Pike and Pike 1947) introduced the view of the syllable as an object analyzed with the tools of syntactic structure as opposed to the more traditional view of the syllable as a wave of sonority, the latter view being the one found in Whitney (Lepsius and Whitney 1865) and de Saussure (Saussure 1916). Pike and Pike (1947) applied Bloomfield's notion of immediate constituent to phonology (see (Gleason 1988) for discussion), a view that was developed in (Hockett 1955) and later in (Fudge 1969). This view was developed in the United States by (Selkirk 1982) and others. Kahn (1976) applied autosegmental notation, in part because he used the notion of ambisyllabicity to analyze the context in which the American flap occurs. He noted that flapping of *t* in American English is subject to very different conditions when it is word-internal (as in *Italy*; in this case, the following vowel must be unstressed) and when it is not (word-final *t* may always flap if followed by a vowel, and word-initial *t* never flaps unless it is part of the encliticizing morpheme *to*). Ambisyllabicity does not lend itself to an analysis within an immediate constituency approach, since a terminal element can be a member of only one superordinate constituent.

Several developments in American phonology in the mid 1970s which were related to the ideas sketched above were rapidly integrated into generative phonology, notably autosegmental phonology, metrical phonology, and work on syllable and foot structure.

Autosegmental phonology (Goldsmith 1974; Goldsmith 1976; Goldsmith 1976) explored the consequences for generative theory of phonological structures consisting of multiple, parallel tiers of segments, organized by association lines indicating registration in time. Figure 1 adapted from Goldsmith (1990, p.33) illustrates the shift of a tone from a stem-initial position to word-final position in *Digo* (Kisseberth 1984). The notion that sound representations are ineluctably linear in character is clearly stated in Saussure (Saussure 1916). While it was challenged notably in Bloch (Bloch 1948), Harris (Harris 1944), and Hockett (Hockett 1955), autosegmental phonology challenged the linear character of phonological representations within generative phonology, and did something more: it laid out as a research project for phonologists the discovery of a consistent geometry for phonological representations that would allow for considerable simplification of the conception of phonological rule and even of abstractness. Many productive phonological rules would be reinterpreted not as feature changing rules, but as rules that reorganize the representation through shifts in association lines. One of the most striking phenomena that could be well handled within this perspective was that of *stability*, in which part of a segment's phonological specification—for example, the tone of a vowel—would, so to speak, remain despite the deletion of the vowel due to the effect of a phonological rule; the tone would appear instead on a neighboring vowel. A typical example of this is seen in Figure N, which illustrates the sentences “The women hoe” and “The woman hoes” in Kirundi. In the singular form, the last vowel of the subject *umugoré* is deleted, and its tone surfaces on the first syllable of the verb.

--- Put Figure 1 around here ---

--- Put Figure 2 around here ---

Metrical phonology (Lieberman 1975; Lieberman and Prince 1977; Hayes 1980) used a system of labeled, binary branching trees to establish phonological structure above the level of the syllable, and a similar model, also adumbrated in (Lieberman 1975) was developed in Prince (Prince 1983). See Figure 3 for a hierarchical representation of the word *Athabaskan*.

-- Put figure 3 around here ---

Autosegmental and metrical phonology gave rise to a great deal of research during the late 1970s and 1980s into the structure of phonological representations. The study of tonal systems of Africa and Asia played a major role in this, as did the study of other prosodic systems, such as vowel harmony and nasal harmony, and the study of templatic morphology as found notably in Semitic and other Afro-Asiatic languages. An example of an Arabic verbal conjugation analyzed with vowels and consonants on separate tiers (reflecting their morphemic identity) is given in Figure 4 (McCarthy 1981). During the late 1980s and early 1990s, considerable work was devoted to the development of a formal analysis of a hierarchical relationship among distinctive features placed on distinct autosegmental tiers, allowing a predictive theory of possible assimilation rules. Influential work on such feature geometry models was proposed by (Mohan 1983), (Sagey 1986), (Clements 1985), (Clements and Hume 1995), and others.

-- Put figure 4 around here ---

### **Optimality theory**

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As we noted at the end of section 6.1, the freedom that derivational analyses—firmly established in phonological theory by *SPE*—permitted phonologists was viewed with considerable suspicion by more than a few phonologists within a brief period of time after the publication of *SPE*. One of the concerns was that rule ordering could be used to justify abstract segments, and both abstract segments and rule ordering could be used to hide (or gloss over) the distinction between phonological rules and morphologically conditioned sound alternations. By the late 1980s, it could not be said that a new orthodoxy existed on the subject, but it would be fair to say that alternatives to rule ordering were welcome in many quarters.<sup>3</sup>

It had long been noted that generalizations, both positive and negative, about “output” structures were conceptually in competition with explanations that depended on either processual rules or static and purely distribution statements. Zellig Harris (Harris 1951) noted this explicitly in the review of Sapir we referred to earlier; he noted there that *he* might say that in a given language, a “

VV sequence never occurs across morpheme junction, just as it doesn't occur within a morpheme. In contrast with this, Sapir would say that no two vowels *could* come together (within a morpheme), and that when a particular morpheme

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<sup>3</sup> The papers in Goldsmith, John A. (1993). The Last phonological rule: reflections on constraints and derivations.

conjunction *would* have the effect of bringing two vowels together a glottal stop comes in as a protective mechanism to keep them apart.” [emphasis added].

Sommerstein (Sommerstein 1974; Sommerstein 1977) made a case for the importance of output conditions, such as the one mentioned above by Harris, in an integrated formal theory of phonological rules. He argued that the formal *changes* described by generative phonological rules could, and should, be divorced from the character of the structural description. In a range of cases, it is not that there is a phonological structure that is found underlyingly that serves as the dynamic force causing a rule to apply, as it were, but rather the phonology of a language is a set of rules that serve to restructure the output of the morphology *in order to* satisfy a set of surface phonological restrictions, in precisely the manner that Harris attributed to Sapir: an active process like vowel-deletion occurs, eliminating a particular vowel, *because* of the constraint in the language against adjacent vowels. The idea was developed by Kisseberth (Kisseberth 1970) under the rubric of “conspiracies” in phonology—conspiracies being the term for phonological rules acting in concert in a fashion that phonological theory did not at the time countenance. (Singh 1987) and (Paradis 1988) developed these ideas as well, and following on this work Goldsmith (Goldsmith 1989; Goldsmith 1990; Goldsmith 1993) suggested a model of “harmonic phonology,” in which phonological representations were assigned a graded measure (rather than a categorical measure) of well-formedness, and rules served to increase the “harmonic” character of the representation, alluding to a model of stochastic Hopfield neural networks proposed by Smolensky (Smolensky 1985).

Prince and Smolensky (Prince and Smolensky 1991; Prince and Smolensky 1993), and McCarthy and Prince (McCarthy and Prince 1993) proposed and developed a model of phonology called optimality theory (OT), in which underlying and surface forms are related formally, but not by a sequence of explicit processes which described the change performed on a representation as in classical generative, but rather by an algorithm that selects a surface representation from a wide set of candidates on the basis of a method of determining which candidate best satisfies. The constraints themselves were taken to be universal, in the sense that while the developers of the theory must discover what the constraints are, the language learner who modeled by the theory was assumed to know *a priori* what the constraints were. Languages would differ, however, by the ranking of the constraints, and the determination of the ranking was one of the challenges that constitute the learning of the phonology of a language. For example, if the universal set of constraints includes a ban on adjacent vowels and a ban on deleting a vowel, then languages which have vowel-initial and vowel-final morphemes will have to *rank* the two constraints with respect to each other, thereby imposing a decision as to which constraint will be ignored if the underlying structure does indeed contain a sequence of two vowels. Will one of them be deleted? Will neither be deleted? Only a ranking of the constraints will decide.

Optimality theory thus jettisoned the notion of derivation in phonology, and separated the two parts of the phonological rule. A generic phonological rule of the form  $A \rightarrow B/C \_ \_ D$ —for example,  $[-\text{voice}, -\text{sonorant}] \rightarrow [+voice] / V \_ V$ —could be understood as being, in part, a conjunction of two statements: first, that the representation CAD (here,  $V[-\text{voice}, -\text{sonorant}]V$ ) is in some sense dispreferred, and second, that the string CBD (here,  $V[+\text{voice}, -\text{sonorant}]V$ ) is the option used in preference to CAD. Optimality theory transfers statements of the form “CAD is dispreferred” to a universal inventory of theory-specific markedness constraints, and eliminates the possibility of explicitly specifying how a dispreferred representation is modified; instead, a

universal inventory of faithfulness constraints demands a language-specific ranking in order to allow a computation of which modification of “A” in context C\_D violates the fewest highly ranked constraints.

Optimality theory, as we have just noted, assumed the existence of a universal inventory of constraints, rather than the *learning* of language-specific phonological rules as in generative phonology; in generative phonology, the granularity of what is language-particular is much finer than in OT: a phonological rule is built up out of brackets, variables, features and feature-values, and part of the challenge to the language-learner and to the linguist is to uncover how the rule should be formulated to best account for the data of the language. By contrast, the OT constraint simply *is*; its internal formulation is typically not of concern: one can define a constraint as, for example, “a syllable must have no segments in its coda.” In this respect, optimality theory follows in the intellectual tradition of natural phonology (see above) and atomic phonology (Dinnsen 1979), in which universal grammar is assumed to contain a large inventory of rules (so that the child learning German need not cast about to formulate a rule of word-final devoicing; he need merely figure out that one of the rules he was born with will have the effect that he needs to understand the varied forms morphemes take in his parents’ speech), and in a somewhat looser sense, it follows in the tradition of the “principles and parameters” view of universal grammar, as adumbrated in Chomsky (Chomsky 1981) and developed in subsequent work. All of these perspectives share the view that the postulation of an information-rich universal grammar is a desirable move from a methodological point of view, presumably based on the view that by limiting the challenge of language-learning to the selection of options from a finite list given by universal grammar, some headway will have been made in the ultimate challenge of explaining language learning.

### **Other approaches to phonology**

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The title of the present paper suggests a one-dimensional view of the development of phonological activity over the past 80 years, but the reality of phonologists’ work during this time extends well beyond such an image. In this section we will discuss briefly some of the issues that have continued to engage phonologists’ attention in the period following that of classical generative phonology.

The first concern—and it is one whose centrality we have not emphasized up to this point—is the continued and cumulative effort to better describe and explain the phonologies of the world’s roughly 6,000 languages. Most working phonologists continue to contribute to this effort, and we are aware of no language family which has not been the object of detailed study over the last several decades: not in order to improve phonological theory, but in order to better understand the synchronic and diachronic realities of the languages under discussion.

A second ongoing concern has been the continued development of methods of analysis of phonological structure that reflect the *syntax* of phonological representations—that is, the formal treatment of the syntagmatic relationship between units of the phonological representation. We have touched on this question in relation to syllable structure and autosegmental structure, but these topics by no means exhaust the areas of current research, and some phonologists have followed by Pike’s lead by actively looking to current theoretical views of syntax for new ways of treating phonological phenomena. Notable in this context have been models of government (Kaye, Lowenstamm and Vergnaud 1988) and of dependency in phonology (Anderson and Ewen 1987), van der (Hulst Van der and Ritter 1999), especially in the treatment of codas as syllables with empty nuclei in the context of government phonology.

A third very broad area of concern has been the relationship of phonetics and phonology, a subject that has engaged phonologists since the beginning of phonology; we discussed this briefly in section 2 above. We take the essential difference between phonetics and phonology to be in the character of the objects studied: phonetics studies objects in continuous three-dimensional space, frequency domain, and time, whereas phonology studies symbolic representations employing a largely discrete alphabet, whose global structure can be represented as a relatively simple graph. Until recently, there has been a strong bias towards interpreting phenomena that are influenced by grammatical or lexical factors as phonological and not phonetic, and a bias towards interpreting phenomena that are variable or non-categorical as phonetic and not phonological (Scobbie 2005).

Closely related to the efforts to link phonology and phonetics have been the efforts to more tightly link phonology and the methods of psychological experimentation; this tendency includes phonologists describing themselves as laboratory phonologists (see (Kingston and Beckman 1990) and the subsequent volumes in this series) and as articulatory phonologists (Browman and Goldstein 1989, 1990, 1992)), and, to be sure, others not applying any particular label to their work.

In addition, important work has continued throughout this period on variation in phonology (heavily influenced by the work of William Labov and his students) and formal learning theory.

## **Conclusion**

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The principal contribution of generative phonology has been the heightened awareness among phonologists of the importance of a highly explicit formal model, algorithmic in character, whose goal is to account for the varied possibilities of phonetic realization of such grammatical units as morphemes and phonemes. Rather than focusing on discussions in the professional literature of how phonological data could be organized and subjected to various analytic procedures, the focus of the phonologist's attention became, within the framework of generative phonology, the actual *form* of the grammar being proposed; the relationship of the observed data to the formal grammar which was under discussion became more indirect, and indeed, it seems to have been a noteworthy terminological innovation in generative phonology that the analyst could and would point, proudly, to the result that the data "simply fall out of" the analysis. In order to accomplish this, generative phonology drew the practitioner's attention to the theoretical cost that lay in "missing a linguistic generalization," or, what is the same thing, it emphasized the notion that there was a great deal of theoretical credit to be obtained by simplifying the exposition of a grammar by means of a small number of (possibly ordered) rules. In this respect, generative phonology disagreed sharply with the methodological perspectives of the American structuralists of a previous generation; these perspectives felt instead that while the austerity and conciseness of a neat analysis was a good in itself, the phonologist who gave in at every turn to the temptation to write an elegant analysis would no longer be doing scientific linguistics.

Issues involving variation in the data, whether the result of looking across the dimension of time or the boundaries of various social conditions, have been of relatively little import to generative analysis. At the same time, the belief has been strong and central in generative phonology that the formal models being developed were not "merely" formal restatements of data collected by linguists in the field, but are rather models of human cognition in a sense that has remained contested to this day.

There have been three major innovations in phonological theory since *SPE* that challenged specific notions within that work but which have seemed to the majority of working generative phonologists to be very much within the larger spirit of the enterprise, that of developing a formally simple, algorithmic account of data involving largely what would once have been called morphophonemic alternations and allophonic variation. These three are the shift to models of geometrical representation (autosegmental and metrical phonology), the inclusion of a qualitative difference between lexical and post-lexical processes (lexical phonology), and non-derivational selection of output by means of optimality theoretic tableaux.

With rare exceptions, work in generative phonology (as work in generative grammar more generally) has been framed within a totalizing philosophical perspective: the ultimate generative account, on such a view, will be a *complete* scientific model of language, with essentially no room left for anything else, or else it will have been proven to be wrong.<sup>4</sup> This perspective is, and will remain, appealing to many working phonologists.

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<sup>4</sup> The *locus classicus* of this point of view is Chomsky and Halle (1965)

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Figure 1

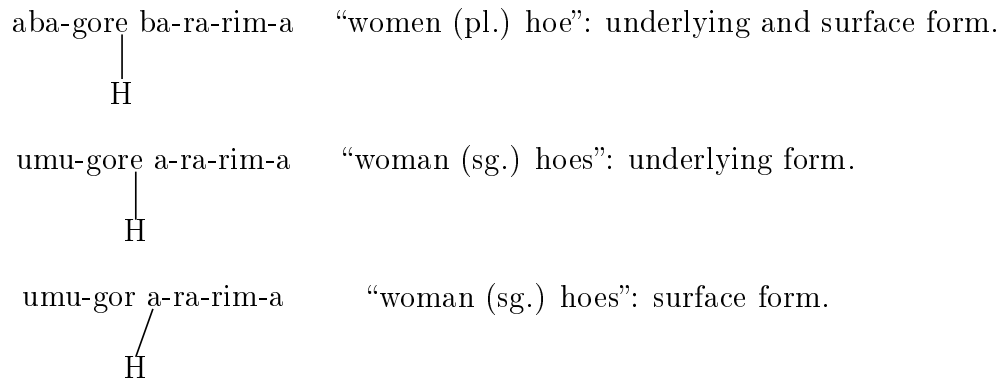


Figure 2

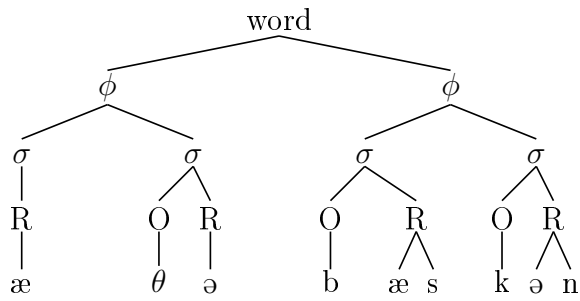


Figure 3

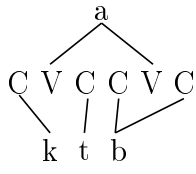


Figure 4