19 *The Sound Pattern of English* and Early Generative Phonology

Michael J. Kenstowicz

19.1 Introduction

Chomsky and Halle's (C&H) The Sound Pattern of English (SPE) is the first detailed exposition of the generative model of phonology and linguistics. With its reliance on ordered rewrite rules, it is no exaggeration to say that SPE revolutionized the field of phonology and together with Chomsky's Syntactic Structures (1957) raised the practice of linguistics to the level of a predictive science. SPE was the basis of courses taught at MIT in the 1960s and according to its authors is the product of years of reflection, discussion and elaboration in collaboration with many students, colleagues, and critics. The book is dedicated to Roman Jakobson, who was instrumental in advancing the careers of Noam Chomsky and Morris Halle and an inspiration to them for his farreaching ideas and speculations about phonology and linguistics in general. SPE is composed of nine chapters, grouped into four sections. The central chapters include detailed analyses of the word-level stress of English (Chapter 3) and its segmental phonology (Chapter 4). Here the authors take us into their kitchen to see how phonological analysis is conducted in the new generative approach. The final three chapters return to more general theory laying out the distinctive feature framework (Chapter 7), assumptions about the form of the rules and the representations to which they apply, and how they derive the surface phonetic output (Chapter 8). The final chapter (Chapter 9) sounds a note of caution on the overly formal approach of the analyses proposed throughout the book and acknowledges that substantive (phonetically

grounded) factors must be integrated into the model. A tentative proposal is sketched that gives explicit representation of the Prague School notion of markedness.

SPE is (and certainly was) not an easy book to read. It is presented as an interim progress report on an ambitious long-term research program. While analyses are presented in considerable detail, some questions are raised but never resolved and decisions taken at one point are later reconsidered or abandoned. In the end, it requires considerable study on the reader's part to understand how the stress contour and vocalic phonology of a particular English word is to be derived.

The rest of this chapter is organized as follows. First, it summarizes the general model of phonology proposed (section 19.2) followed by a discussion of *SPE*'s analysis of English word stress (section 19.3). Section 19.4 reviews C&H's treatment of the Vowel Shift alternations. Section 19.5 examines the feature system, and section 19.6 the final chapter on markedness. Section 19.7 reviews how *SPE* was received in the wider field, some of the factors that shaped the climate in which it developed, and the contributions of C&H's first generation of students. Section 19.8 is a brief conclusion.

19.2 SPE: The general framework and model

For C&H, phonology is viewed as one module of a generative grammar that represents the idealized native speaker's tacit knowledge of the rules and representations that relate sound and meaning in their language. The phonological component interfaces between the surface syntactic structure of an utterance and its phonetic representation. Readjustment rules with a variety of functions may modify the surface syntax to derive the first level of phonological representation. Ordered rules (some applying in a cycle that

reflects the constituent structure of the word or phrase) derive the surface phonetic representation through an often-times long series of small modifications. But when one steps back to look at the entire derivation, the input and output may diverge considerably (raising the issue of abstractness). The applicability of a rule is determined solely by the output of the immediately preceding step in the derivation and cannot look back to earlier stages (global rules) or look forward to the final output (surface structure constraints). There are no trans-derivational constraints that would allow the application of a rule to depend on a related word unless the latter is itself produced as a substring on an earlier cycle.

The phonological rules alter the structure of a segment by changing its feature coefficients. They also have the power to insert, delete, and transpose entire segments. The constituent structure of the word or phrase is encoded through a set of boundary symbols $\{+, \#, \#\#, =\}$ which themselves are represented as feature matrixes.¹ The phonological features have a classificatory function defining the inventory of distinctive elements ('phonemes') that encode the lexicon; the features also have a phonetic dimension when they are translated into instructions to the vocal apparatus to implement articulatory gestures and to the auditory system to define their acoustic and perceptual correlates. Most importantly, the features define the natural classes of sounds over which the phonological rules operate. *SPE* notes that if the features were purely abstract and arbitrary labels then a series of mapping rules would be needed to define their phonetic realization (given the goal of relating sound and meaning). Moreover, there would be no expectation that the phonological behavior of a given segment, say /p/, would tend to be

¹ See Scheer (this volume) for discussion of boundary symbols in phonology.

replicated in the behavior of /t/ and /k/ (Postal's 1968 Naturalness Condition). When the phonological features are cashed out at the level of phonetic representation, the binary plus and minus coefficients are mapped to phonetic scales that define the degree of aspiration, nasalization, etc. of a segment on a language-particular and presumably context-sensitive basis. But given the feed-forward architecture of the grammar, such fine-grained phonetic differences can have no direct impact on the way the phonological rules operate.

For SPE there is no linguistically significant level of representation between the underlying phonological and the surface phonetic representations. C&H explicitly reject the phonemic level of American Structuralism defined by the criteria of biuniqueness and invariance based on earlier arguments presented in Halle (1959) and Chomsky (1964); see Dresher & Hall (this volume) for discussion. With the rejection of the 'taxonomic' phonemic level and equipped with the tools of context-sensitive feature changing rules that apply in a language-particular order, SPE is well prepared to give an account of the inner recesses of English phonology. The goal is to develop a general framework of rules and representations that model the native speaker's tacit knowledge of their language. C&H's analysis of the many fine points of English structure is always approached with this larger and more ambitious objective in mind. In order to carry out this research program, an explicit statement of the rules and representations is essential to determine their well-formedness as well as how the analysis generalizes to novel data. SPE gives special attention to an evaluation procedure—a method for comparing alternative analyses that are compatible with the data in order to select the optimal one. The evaluation is presented as a kind of simplicity measure that economizes on the symbolic

statement of the rules as well as the input representations to which the rules apply. It is said to model the kinds of decisions a child might take in crafting a grammar in the light of data from the environment and general constraints on the form of rules and representations.

19.3 English word stress

SPE's analysis of English word-level stress begins with a discussion of the way two or more rules can interact. Phonological rules take the general form of rewrite operations A \rightarrow B / X___Y, where A and B are individual feature matrixes and X and Y are strings (possibly null) of segments also characterized by their feature specifications. Under disjunctive ordering, the rules are organized into a hierarchy of options; once a rule applies, the remaining rules in the hierarchy are skipped. Under conjunctive ordering, the derivation continues to check each rule in sequence. If a match to the rule's structural description (SD) is found, then the rule applies and the derivation proceeds to the next rule in the sequence and checks its SD. The authors observe that disjunctive ordering minimizes processing time and hence can be considered computationally desirable. These concepts are illustrated with the paradigm of nonderived verbs sampled in (1).

(1) a.	astónish	b.	maintáin	c.	collápse
	elícit		achiéve		lamént
	detérmine		surmíse		eléct
	imágine		cajóle		obsérve

The words in (1a) with penultimate stress are characterized by word-final syllables composed of a lax vowel (V) and a single consonant (C), while in (1b) the final syllable has a tense vowel (\overline{V}), and in (1c) it terminates in a consonant cluster. SPE observes that the stress in these data could be assigned by three separate rules that supply the feature [+stress] to vowels in the contexts $C_0 \check{V} C_0^{\dagger} \#$, $V C_0 \#$, and CC #, respectively. (C_0 denotes a string of zero or more consonants while C_0^1 denotes zero or one consonant; # denotes a word boundary.) Under this analysis, the rules can be applied in any order since the contexts are disjoint. But the computationally more optimal analysis is possible if the rules are viewed as a hierarchy of options. In particular, stress falls on the penult if the final syllable contains a 'weak cluster' ($\check{V}C_0^1$), and otherwise on the final syllable. Under this conception, the second and third contexts can be consolidated into a single and much simpler statement C₀. The formal relation among the rules making this consolidation possible is notated by enclosing in parentheses the information of the more specific rule whose exclusion will yield the more general rule. We thus obtain the rule in (2a), which abbreviates the two disjunctively ordered rules in (2b): the first derives the words of (1a) and the second the words of (1b) and (1c).

(2) a.
$$V \rightarrow \acute{V} / _ C_0 (\check{V}C_0^1) \#$$

b. $V \rightarrow \acute{V} / _ C_0 \check{V}C_0^1 \#$
 $V \rightarrow \acute{V} / _ C_0 \#$

The question then arises as to when the disjunctive vs. conjunctive mode of rule application is to be imposed. *SPE* hypothesizes that disjunctive order will obtain when the second rule can be obtained from the first by cancelling information in the latter, in

effect broadening the context and thereby increasing the set of structures that are subject to the simpler and more general later rule, as illustrated by the rules of (2b) where the more general rule is obtained by blocking out the weak cluster specification. A second requirement is that no distinct rule intervenes between the disjunctively ordered rules.

SPE then proceeds to the stress of nouns. The data in (3) illustrate the location of main stress in nonderived nouns whose final syllable contains a lax vowel.

(3) a.	América	b.	aróma	c.	agénda
	ásterisk		balaláika		synópsis
	ársenal		horízon		asbéstos
	lábyrinth		aréna		appéndix

The descriptive generalization is that stress may recede from the end of the word to the antepenultimate syllable so long as the penultimate syllable contains a weak cluster (3a). Otherwise, stress appears on the penult (3b,c). Once again disjunctive order is called upon to express this relationship. The stress rule already at hand in (2) will suffice so long as it ignores the final syllable when the latter contains a lax vowel and the word is a noun. The formal statement in (4) then becomes possible; it employs angled brackets—a subtype of the parentheses notation that expresses discontinuous dependences. In this statement, the word-boundary symbol # is replaced by the equivalent constituent boundary symbol]; the rule states that the $\langle VC_0 \rangle$ expression is considered if and only if the word is a noun.

 $(4) \quad V \to \acute{V} / \underline{\qquad} C_0 (\check{V}C_0^1) < \check{V}C_0 >]_{<N>}$

The expression in (4) constitutes the Main Stress Rule (MSR) of English and abbreviates the hierarchy of options in (5) obtained by eliminating innermost parentheses first.



SPE then considers the stress of nouns whose final syllable contains a tense vowel (6). C&H transcribe the tense vowel in the final syllable of the words in (6b) and (6c) with a secondary stress on the assumption that there is a one-to-one relation between stress and non-reduced, full vowels (a point challenged by later researchers such as Vanderslice & Ladefoged 1972).

(6)	a.	machíne	b.	húrricàne	c.	cávalcàde
		canóe		pédigrèe		mártingàle
		bazáar		cándidàte		ánecdòte
		políce		mátadòr		Árkansàs

Two observations are made concerning these data. There is a stress on the final syllable; but when the word is trisyllabic (or longer), another stress appears on the antepenult. Furthermore, as seen in the words of (6c), the antepenult stress assignment skips over a medial closed syllable. For *SPE* this implies a separate stress rule since the MSR can only assign a single stress, given disjunctive order. As stated, the MSR will assign final stress to the words of (6) by the default case (5d). To obtain the nonfinal stresses in the data of (6b,c), the Alternating Stress Rule (ASR) of (7) is proposed.

(7)
$$V \rightarrow \acute{V} / _ C_0 V C_0 \acute{V} C_0 \#$$

The ASR stresses the antepenult provided the final syllable is stressed; the nature of the intervening syllable does not matter. In order to derive the secondary stress on the final syllable of the words in (6b,c), SPE adopts the general stress lowering convention from Chomsky, Halle, & Lukoff (1956) that demotes the stress level of all other syllables in the word or phrase by one degree whenever a new primary stress is introduced (see Dresher & Hall, this volume). Thus, the [1stress] specification on the final syllable of *húrricàne* is demoted to secondary after the insertion of [1stress] by the ASR in (7): /hurricane/ \rightarrow /hurricane/ \rightarrow /hurricane/. As stated, the ASR must obviously be in a conjunctive (feeding) order with the MSR (4). SPE does not comment on (or even notice) that the ASR could be obtained from the first case of the MSR (5a) by broadening the character of the penultimate syllable and dropping the [-tense] specification on the final vowel. But this move would incorrectly impose disjunctive order. This observation calls into question just how much faith can be placed in the strategy of collapsing separate rules into a single statement based solely on their formal properties. SPE mentions the argument of Kiparsky (1965) that the shortening of long vowels in the contexts CCC and CCVCVC# in Old English was simplified to CC and CVCVC, respectively, at a later stage of the language. C&H take this finding as independent justification for combining two rules into a single shorter statement with the brace

notation.² This was essentially the only external justification offered for the general abbreviatory policy and Kiparsky's analysis itself was later challenged by Anderson (1969), who claimed that the simplifications happened at different points in the evolution of English with other rules intervening.

The Auxiliary Reduction Rule (ARR) is the final major rule in the *SPE* analysis of English word stress. It inserts a secondary stress at the left edge of longer words like *Winnepesáukee, Oklahóma,* and *Monòngahéla*. The secondary stress falls on the first vs. second syllable of such words as a function of their syllabic structure: light-light (*Winnepesáukee*), heavy-light (*Oklahóma*), light-heavy (*Monòngahéla*).

(8)	Winnepesaukee	Oklahoma	Monongahela	underlying
	Winnepesáukee	Oklahóma	Monongahéla	MSR
	Winnepesáukee	Òklahóma	Monòngahéla	ARR

The Auxiliary Reduction Rule is anomalous when compared to the Main Stress Rule in that it inserts a secondary stress directly rather than a primary stress and reliance on the general stress lowering convention. C&H note that the trisyllabic LLL (L = light syllable) initial string of *Winnepesáukee* vis a vis the LHL (H = heavy syllable) of *Monòngahéla* bear a strong resemblance to the structures delineated by the MSR that works from the 2 Thus, C&H (334) propose that the two older shortening (or laxing) rules could be combined as in (i); this rule then underwent a single simplification to (ii):

(i)
$$V \rightarrow [-\text{tense}] / __CC \begin{cases} C \\ VC_0 V \end{cases}$$

(ii) $V \rightarrow [-\text{tense}] / __C \begin{cases} C \\ VC_0 V \end{cases}$

right edge of a word in *cínema* and *agénda* and acknowledge as a 'defect' of the analysis that they are not subsumed under the same formal statement.

The MSR, ASR, and ARR constitute the core of the *SPE* analysis of the stress of nonderived words in English. The stress contours of more complex words are derived through cyclic application of these rules and the judicious use of internal boundaries as well as a set of destressing rules to eliminate clashing stresses.

When viewed from a more contemporary perspective, the SPE analysis has a number of quirks. Foremost among them is the absence of any formal representation of prosodic structure and the treatment of stress as a feature on a par with [nasal]—an assumption directly challenged in the next decade by the metrical theory of stress (see Kisseberth, this volume). The $\check{V}C_0^1$ expression of the MSR defines a light syllable. The SPE analysis never states directly that a heavy syllable attracts stress. Rather, stress assignment recedes from the end of a word so long as it does not encounter a heavy syllable. It is no accident that the disjunctive ordering mechanism that blocks the application of a later rule is motivated by the phenomenon of stress. Later research in the metrical framework diagnoses stress as a relative prominence relation between a given syllable and its neighbors as represented by a metrical tree or grid, rather than as a feature with fixed phonetic correlates; and the distribution of stress itself is regulated by rhythmic principles that avoid stress clashes on adjacent syllables and lapses of successive unstressed syllables. Finally, the distinction between various levels of the metrical grid allow the attraction of stress to a heavy syllable and the avoidance of a lapse to fall under the same rule iterating through the word or applying from the edges inward (Halle & Kenstowicz 1991). The rightward orientation of the major stress of the word (Winnepesáukee,

Àpalàchicóla) or phrase (*rèd shírt*) is defined at a higher grid level (Liberman & Prince 1977; Prince 1983; Selkirk 1984; Halle & Vergnaud 1987).

Following its publication, the SPE analysis of English stress continued to be explored and refined at MIT and elsewhere. Significant adjustments were made in an important paper by Ross (1972) based on class lectures at MIT with input from Paul Kiparsky, Joseph Emonds, James Fidelholtz, and others. A major area of refinement was the treatment of word-final syllables for both primary and secondary stress with particular attention paid to the segmental structure-what, from a later perspective, would be the properties distinguishing a light vs. heavy syllable. Ross notes first that the ASR of (7) must be broadened to include disyllables (sátire, árchive, prótèin) and that there is significant lexical variation as to whether or not this rule applies for both disyllables and trisyllables: compare boutíque, crùsáde, domáin and bùccanéer, guàrantée, İllinóis with the words in (6) above like machine and húrricàne, respectively. Certain suffix-like final syllables such as *-ese, -oon, and -ique* block retraction of main stress via the ASR and the stress lowering convention in both disyllables and trisyllables (*Chinése, Jàpanése;* pontóon, macaróon) while -off and -ine systematically allow it (Lákoff, Jáckendoff; *pórcupine, cánine*). Ross also notes that nouns and adjectives with a lax vowel in the final syllable can be subclassified in terms of their feature structure. Most nouns ending in a cluster stress their final syllable: ánthràx, Cýclòps, ásterisk, ávalànche, cátaràct, *Pódùnk*. Weak syllables are composed of a cluster of coronals and even here there is variation: sýcophànt, Péntecòst, and ácòrn stress the ultima while élephant, cátalyst, and lántern do not. Words ending in a single consonant also subdivide: nondental obstruents

strongly favor a stressed ultima (9a), while dentals (9b) and sonorants (9c) can go either way.

(9)	a.	hándicàp	Bólshevìk
		shíshkabòb	démagòg
	b.	Connécticut	ócelòt
		périod	Íchabòd
	c.	strátagem	Ábrahàm
		cínnamon	márathòn
		vínegar	métaphòr
		cápitol	álchohòl

SPE extended the well-motivated cyclic analysis of phrasal stress in Chomsky, Halle, & Lukoff (1956) to the internal structure of words. This move is supported by cases where words of the same surface syllabic structure differ in their stress contours. A wellknown example is the *órigin, oríginal, orìginálity* paradigm where each level of affixation pulls the main stress to the right—analysed by *SPE* as a reapplication of the antepenult branch of the MSR (5a). On the surface, the second syllable stress of *orìginálity* is anomalous when compared to monomorphemic *Wìnnepesáukee*. Both words have a string of three initial light syllables. But the contrast follows directly if the stress is assigned cyclically with *orìginálity* inheriting the stress of *oríginal*. Another striking minimal pair is the contrast between the medial [0stress] pretonic syllable of *còmpensátion* (with stress pattern 2010) vs. the [3stress] of *còndènsátion* (2310). At the phonetic surface, the words differ solely in the point of articulation of the first NC

cluster—hardly a relevant factor. In the *SPE* analysis the former derives from *cómpensàte* (103) and the latter from *condénse* (01). The *SPE* cyclic analysis entails an intricate set of stress reduction rules alleviating clashes and lapses that take account of both the preceding and following contexts as illustrated in the derivations of (10) for the *órigin, oríginálity* and *Japán, Jàpanése* paradigms.

		Jàpanése	Auxiliary Reduction Rule
	orìginálity	Japanése	clash removal
	[òrìginál]ity		third cycle
	[òrígin]al	[Japàn]ése	second cycle
	órigin	Japán	first cycle
(10)	origin	Japan	underlying

In the *SPE* framework the rules are central. C&H state that as a matter of policy when analytic choices have to be made, the simplicity and generality of the rules are decisive (as dictated by the evaluation measure). In the absence of any countervailing theory of morphology, this sensible strategy leads to some questionable structures, such as a morpheme boundary in [hágg-ard] (cf. *lag*, *laggard*) to avoid final stress due to the cluster, and an internal stem [lel] for the prefix in [pára[lèl]] (McCawley 1974). An immediate consequence of the *SPE* program was to raise the question of abstractness—how far and in what ways the underlying representation of a lexical item could diverge from its various surface phonetic realizations. At one extreme, Lightner (1971: 543) showed that looking for systematic sound correspondences in words with similar meaning puts the phonologist on a slippery slope leading to reconstructing parts of

Grimm's Law into the structure of English (cf. *brother-fraternal, mother-maternal, father-paternal,* for example). Kiparsky (1968) raised the question directly in the famous paper 'How Abstract is Phonology?'(see Kenstowicz & Kisseberth, this volume). The abstractness question continues to be debated in the contemporary literature and no definitive answer seems possible until related questions like what counts as evidence and the relation between phonology and morphology are clarified.

19.4 English Vowel Shift

Chapter 4 presents *SPE*'s analysis of the segmental phonology of English. The discussion concentrates on the deeper morphophonemic interior of the language with a focus on vocalic alternations and distributions. The more superficial allophonic phonology was well described in the American Structuralist period (see Ladd, this volume) while morphophonemics was largely uncharted territory open for exploration with the ordered rule methodology. Central to the *SPE* analysis are the alternations in (11) between a stressed tense diphthongal element and its short lax counterpart known as the Vowel Shift (VS), the synchronic reflex of sound changes occurring towards the end of the Middle English period. In view of space limitations, our discussion is restricted to the better-attested front vowel alternations.

(11)	div <u>í</u> ne	[aj]	div <u>í</u> nity	[1]
	ser <u>é</u> ne	[ij]	ser <u>é</u> nity	[٤]
	prof <u>á</u> ne	[ej]	prof <u>á</u> nity	[æ]

While these alternations are found primarily in the derivational morphology, a subset also occur in the past tense of strong verbs: *bite* [aj] \approx *bit* [1]; *keep* [ij] \approx *kept* [ε]. The tense/diphthongal vowels are normally found in stressed syllables—both primary as well as secondary. Contrasts such as the stable [1] of *acid-acidity* in the face of the alternating vowels of *divine-divinity* indicate that the tense vowel must underlie the alternation. A frequent shortening context is the antepenultimate syllable, which is normally followed by a weak cluster in the penult, given the *SPE* analysis of stress. Another shortening context is the consonant cluster found in the past tense of strong verbs: *keep* \approx *kep-t*.

SPE also points to alternations that run from lax to tense (12). They arise when a derivational suffix creates an underlying vowel sequence that triggers a tensing of the stem vowel.

(12)	vár <u>y</u>	[i] < [I]	var <u>í</u> ety	[aj]
	mánag <u>e</u> r	[3] > [¢]	manag <u>é</u> rial	[ij]
	Ir <u>á</u> n	[æ]	Ir <u>á</u> nian	[ej]

The upshot is that a significant descriptive generalization would be missed if the same alternations arose in two different contexts necessitating a change from a diphthong to a lax vowel in one environment (11) and a change in the opposite direction in the other environment (12). A simpler and more insightful analysis postulates an underlying vowel that takes its quality from the lax member of the alternation [I], [ϵ], [ϵ] and its quantity from the diphthongal tense vowel [aj], [ij], [ej]: ergo underlying /ī/, /ē/, /æ/. Rules altering the height features of the tense vowels then distort the underlying long-short pairing. In the *SPE* analysis, the VS rule is broken down into two conjunctively ordered subrules.

Capitalizing on the Greek letter variables implicit in the binary distinctive feature notation, the first subrule (13ai) alters the feature specifications for [high] so that [+high] $/\overline{i}$ / and [-high] $/\overline{e}$ j/ exchange places in the vowel space. The second branch of the VS rule (13aii) then interchanges the tense low vowels with the mid vowels (just derived from the underlying high) by altering the specifications for [low] in parallel fashion. Later rules (some dialect dependent) adjust the nucleus of the low diphthong to a central vowel. (13a) shows the basic VS rules and (13b) some derivations.

SPE argues that the Velar Softening processes realizing /k/ and /g/ as [s] and [dʒ] before the front nonlow vowels and glide provide independent evidence for their analysis: *electric* (with final *c* pronounced [k]), *electric-ity* ([s]); *neglec-t* ([k]), *neglig-ence* ([dʒ]), *neglig-ible* ([dʒ]). In *criticize* ([s]) and *analogize* ([dʒ]) (cf. *critical* ([k]) and *analogous* ([g])) the process appears to apply before a low back vowel [aj] while in *locate* ([k]) and *interrogate* ([g]) the velars are followed by a mid front vowel [ej] that would be expected to trigger the softening rule. Both puzzles are solved if the Velar Softening rule applies before Vowel Shift, as seen in the derivations of (14).

(14)	critik-al	critik-īz	lok-al	lok-æt	underlying
		critis-īz			Velar Softening
		critis-āzjz		lok-ējt	Vowel Shift
		critis-ajz			later rules

An important detail of the analysis is that the long low vowel \bar{a} must be exempted from the Vowel Shift rule—at least as it applies in the dialect of John Hart (*SPE*: 263). In the *SPE* feature system there is no provision for distinguishing central from peripheral vowels; [\bar{a}] stands out as having opposing values for [back] and [round] and so on this basis can be excluded from the rule. The essential final form of the VS rule appears as in (15).

(15)
$$[\gamma back, \gamma round, +tense, +stress] \rightarrow \begin{cases} [-\alpha high] / [\alpha high, -low] \\ [-\beta low] / [\overline{\beta low, -high}] \end{cases}$$
 ii

The exchange rule derivation of (13b) where two sounds systematically replace one another in a context-free manner immediately raised eyebrows. Reiterating some of the points of Dobson (1957), Stockwell (1966,1972) believed that this aspect of the SPE analysis was highly implausible as a historical sound change and suggested an alternative in which the high vowel nucleus of the /īj/ diphthong first centralized to /ij/. Then the two-step lowering via the Greek letter variables could lower the high vowel along the central track of the vowel space without having to leap over the front mid vowel. *SPE* points to some alternations in the weak verbs as reason to reject this suggestion; and Halle & Keyser (1967) defend the *SPE* analysis against this criticism on substantive as well as theoretical grounds, the latter turning on the question of whether sound change is the superficial reflex of the underlying grammar as opposed to a more gradual evolution of elements in phonetic space. Later analysts such as McCawley (1974) found C&H's appeal to the weak verbs unpersuasive and suggested reinterpreting the VS as two separate phonological processes: lowering of the high vowels via centralization and a separate chain-shift filling in the vacant high vowel slot by raising the peripheral vowels by one degree—essentially a synchronic restatement of Jespersen (1909) which was adopted by many later researchers such as Labov (1994). In a review of the exchange rule alternations that had been attested at the time, Anderson & Browne (1973) found the most plausible examples such as the verbal ablaut alternations in Semitic (*SPE* 356–7) to be ones that preserve a contrast between different slots in a morphological paradigm as opposed to the wholesale interchange of two phonemes.

As with many nonautomatic alternations, questions arose about the productivity and psychological reality of the various alternations comprising the English Vowel Shift and Velar Softening. A number of experiments were run to test these cases. We mention two here. Cena (1978) had naïve English subjects learn pairs of nonce words in which each of the five diphthongal tense vowels /aj, ij, ej, aw, ow/ were matched with each of six lax vowels /I, ε , a, Λ , $\mathfrak{0}$, $\mathfrak{0}'$. His subjects recalled the pairings that conformed to the Vowel Shift significantly better for all except the [aw] \approx [$\mathfrak{0}$] alternation of *profound-profundity* and concluded that naïve English speakers have cognizance of the VS alternations. McCawley (1986) questioned the prevalent generative assumption that just because two words share a similar meaning, it does not automatically follow that they derive from the same underlying form and so he endorsed the need for psycholinguistic experiments to bolster analyses based on corpus-internal data. McCawley reports an experiment in

which his subjects rated 150 word pairs for their degree of morphological and semantic relatedness. The words contained vowel pairings that either conformed to the VS (*vile-villain*), were identical (*see-scenic*), or did not conform to the VS (*mind, mental*). For 75% of his subjects, the morphological relatedness judgments of VS compatible words was comparable to or exceeded the control pairs where the vowels were identical; and for the remaining 25% the VS was only a 'slight obstacle'. While providing some support for the *SPE* analysis, the experiment suggested to McCawley that different speakers might arrive at alternative analyses of the same alternation and hence raised the general question of grammatical uncertainty, a problem that C&H abstract away from with their focus on the idealized native speaker. In the contemporary linguistics scene, lexical and phonetic gradience is being taken more at face value and modeled with various kinds of stochastic grammars (see Pierrehumbert, this volume).

Another relevant point is that abstract analyses like the *SPE* Vowel Shift are more easily motivated when the alternations are found within an inflectional paradigm where the productivity of the alternation is less of an issue. A much cited example was Kuroda's (1968) analysis of Yawelmani, which posits long high vowels /i:/ and /u:/ that surface regularly as either short [i] and [u] or as nonhigh [e:] and [o:] comparable to *SPE*'s derivation of [aj] \approx [I] from /ī/ (see Kenstowicz & Kisseberth, this volume). And in highly agglutinative languages such as Bantu where the number of verb forms in a paradigm runs into the thousands, native speakers can readily construct novel words and phrases with complex tonal patterns that imply a generative procedure: e.g. [alojechéésyeene] 'they just bewitched each other' in Yao (Odden 1998: 280) or [ci-thu ca bá-nó-tí-bz-il-á bú-síìkú] 'the thing that they belch for us at night' in Ikalanga (Hyman & Mathangwane

1998: 220). Cassimjee & Kisseberth (2018) make the same point with the tonal patterns of Shingazidja where the successive underlying high tones of words like /kapúká/ 'tin can' are realized or simplified as a function of their odd vs. even position in the phonological phrase: [kapúka] citation but [tsi-hulu kápuká] 'I bought a tin can' from underlying /tsihulú kapúká/ with rightward tone shift. French loanwords such as [sigaréti] 'cigarette' from /sigarétí/ but [nde e sigáretí] 'the cigarette' from /nde é sigarétí/ attest to the productivity of the phenomenon.

The subsequent generative literature on these questions split along two general lines. The Lexical Phonology model of Kiparsky (1982) and its OT descendants follow *SPE* in allowing different surface variants like the English $[aj] \approx [I]$ VS alternation to be derived from more abstract underlying forms such as /i:/ with the differences in productivity treated as a function of various levels (root, stem, word, post-lexical) of the morphology. An opposing approach developed by Vennemann (1974) and Hooper (1976) links the surface alternants directly to one another as well as to particular morphological and grammatical constructions, apparently content with the repetition of the 'same' sound change across multiple affixations (see Kenstowicz & Kisseberth, this volume).

19.5 Feature system

SPE begins the discussion of the features with the observation that the Phonetic Representation constituting the output of the phonological component represents the grammatically determined properties of an expression and hence is only one aspect of its physical realization. This view departs from the more traditional notion of phonetic transcription as a representation of the 'facts of speech' (p. 293). *SPE*'s more abstract

conception is based on the assumption that speech perception is an active process in which the listener attempts to match the physical signal with what would be a possible output of their grammar; even a crude match may be sufficient to confirm the internally generated hypothesis. Given this view, it is possible to abstract away from factors of coarticulation and represent the output of the phonology as a linear sequence of feature matrixes inherited from the input level, which was less controversially assumed to consist of a linear sequence of segments. This abstract view also makes it possible to equate the same sound cross-linguistically even though it may differ in the details of its phonetic realization from one language to another. The total set of features is thus identical with the phonetic properties that can in principle be grammatically controlled in speech; they represent the 'phonetic capabilities of man' (p. 295) and are therefore the same for all languages. It is knowledge of the features and their organization into segments that the child brings to language acquisition to impose structure on the continuous and highly variable data of speech. Subsequent research showed that C&H were overly optimistic on how clean a break could be fashioned between the categorical features of phonology and the gradience of phonetics. On the one hand different articulatory gestures can join forces to realize a phonological contrast on a language-particular basis, as in English where the voicing distinction in obstruents is cued by voice onset time and duration of the preceding vowel as well as vocal fold vibration. And on the other hand a given contrast may itself be realized in a lexically or contextually gradient manner (Beckman et al. 2014).

In the *SPE* system, the features fulfill three distinct functions: they define an inventory of minimally contrasting segments to encode the lexicon; they define the natural classes for the phonological rules; and they specify the grammatically determined

properties of an expression in speech. Evidence for the features may derive from any one of these three aspects. *SPE*'s underlying assumption was that the evidence would converge on the same system. But subsequent research has shown that factors such as syllabification or whether or not a stop consonant is released can have a major impact on the phonological rules and the phonetic realization of segments even though these factors are normally predictable and hence do not by themselves distinguish lexical items.

The SPE feature system outlined in Chapter 7 continues many of the assumptions of the Jakobsonian system of Preliminaries to Speech Analysis (PSA; Jakobson, Fant, & Halle 1952).³ Foremost among them is the thesis of binarity as the simplest formalization of minimal contrast: either two sounds are members of the same phonological category or they are not. But SPE also modifies the PSA system substantially. We mention several changes here. First, the features are redefined primarily in articulatory rather than acoustic-auditory terms. A neutral position for the major articulators prior to the onset of speech is specified: the velum is raised shutting off the nasal cavity; the vocal folds are drawn together loosely to a posture that permits spontaneous voicing; and the tongue body assumes a position that approximates the vowel of English *bed*. Second, the tonguebody features of [high], [low], and [back] are utilized to distinguish place contrasts among the palatal, velar, uvular, and pharyngeal consonants. This innovation allows some common assimilatory effects between consonants and vowels to be expressed in a natural way, such as the palatalization of velars before front [-back] vocoids and the lowering of high vowels to mid before [-high] uvulars. The remaining major place features for consonants are defined by [coronal] (articulated with the tip or blade of the

³ See Battistella and Dresher & Hall (both this volume).

tongue) and [anterior] (a point at the roof of the oral cavity where [s] abruptly changes to [ʃ], Stevens 1972). But other common relations between consonants and vowels remain unexpressed. Given that labials are [+anterior, –coronal], there is no way to naturally express the rounding (and backing) effect of labial consonants on vowels, as in Korean where /i/ is turned to [u] in the context of labials, or the dissimilatory (Obligatory Contour Principle; see Kisseberth, this volume) phonotactic constraint of English that bars a labial stop plus [w] in the face of the dental [tw] of *twin* and the velar [kw] in *quit*.

The publication of Ladefoged's (1964) fieldwork on the phonetics of various West African languages prompted SPE to modify and expand the feature system. Contrasts among dental, alveolar, and retroflex places of articulation with laminal vs. apical tongue blade postures are expressed with a feature [distributed] whose phonetic realization is 'constriction that is extended along the direction of airflow' (p. 312). SPE continues the *PSA* assumption that there is no internal ordering among the features within a segment even though features like [±delayed release] to distinguish stops from affricates clearly refer to just the right edge of a stop. Hoard (1970) called for a revision to the model in order to allow affricates to be represented with two successive segment-internal specifications for [continuant] on the basis of Puget Salish, where underlying /t+s/ is realized as an affricate [t^s]. The bi-positional representation of affricates was later extended to all stops in Steriade's (1993) proposal to distinguish a closure and release phase—the latter constituting the site where the laryngeal features of aspiration and glottalization are represented. Anderson's (1976) discussion of prenasalized stops and postoralized nasals in Maxakalí also demonstrated the need for segment-internal sequencing of features, coinciding with similar conclusions concerning the representation

of tone and setting the stage for autosegmental phonology (see Kisseberth and Scheer, both this volume). Finally, *SPE* takes into account the influential cross-linguistic survey of voicing contrasts by Lisker & Abramson (1964) and Kim's (1965) x-ray study of Korean stops to give a more nuanced view of the laryngeal features. The former study distinguished four categories of word-initial stops in terms of the onset of voicing in a following vowel (voice onset time, VOT): voicing precedes stop release [b], voicing coincides with stop release [p], voicing lags moderately after release [p^h], and voicing lags considerably after release [p^{hh}]. Given the *SPE* premise banning a precedence relation among the features internal to the segment, VOT must be treated as a reflex of different segment-internal feature specifications rather than taken at face value. *SPE* has four features to play with ([tense], [voice], [subglottal pressure], and [constricted glottis]) and tentatively suggests the matrix in (16) to distinguish among the categories uncovered in Lisker & Abramson's survey. In particular, aspiration is treated as the superficial reflex of a segment-internal feature of heightened subglottal pressure.⁴

	b	р	p^h	$p^{\rm hh}$	p*	b^h
tense	_	_	_	+	+	_
voice	+	±	_	_	_	+
subglottal pressure	-	—	+	+	_	+
constricted glottis	_	±	_	_	+	_

(16) VOT categories in SPE (328)

⁴ p^{hh} and p^* in (16) denote respectively the heavily aspirated and tense stops of Korean; lax p is subject to variable voicing and tensing.

In a rejoinder to C&H's analysis of the VOT typology, Lisker & Abramson (1971) argue for inclusion of the timing factor directly into the phonological system. They are not convinced that the [tense] and [constricted glottis] features play the role C&H assign them and reiterate their position that the timing of the contraction of the laryngeal muscles with respect to stop closure provides the best analysis of the cross-linguistic differences. They acknowledge the possibility that an aspirated stop and sequence of voiceless stop followed by segment /h/ might have the same phonetic realization and thus constitute a case of phonological-phonetic ambiguity, as in languages like Korean, where /Vp#hV/ and /V#p^hV/ are virtually indistinguishable.

This discussion underscores the tension between two different points of view: that phonological categories are manifested only obliquely in speech where a variety of other 'performance' factors enter in to shape the physical realization of a sound; or alternatively that phonological categories arise from abstractions over the continuous data of speech with languages seeming to converge on the same categories cross-linguistically because of regularities in the physical data itself (as a function of the presumed uniformity of the vocal apparatus across populations). The investigation of the phonological and phonetic properties of the laryngeal features has remained a focus of intensive research over the fifty intervening years since *SPE* and points up more general questions such as whether the various articulatory maneuvers to maintain voicing are of equal status with languages choosing which and how many to deploy (Kingston & Diehl 1994), whether some properties have a privileged status and others play a supporting role (Stevens & Keyser's 1989 'enhancement'), and whether the same phonological contrast of [±voice] and attendant rules of assimilation and dissimilation that recur in the

Germanic and Slavic languages should be analyzed with one cover feature even though the contrast may be realized at the phonetic level as primarily one of voicing, of aspiration, or some more complex mixture of the two (Keating 1984, Beckman et al. 2013).

SPE drops, or at least is silent on the viability of, acoustic auditory features like [flat] whose phonetic correlate of lower second formant can be achieved by several different articulations (labialization, pharyngealization, retroflexion) that were assumed in PSA to never contrast. The articulatory basis of the features is also revealed in SPE's discussion of tenseness in stops, which is often accompanied by aspiration. Instead of admitting a global 'cover' feature of [tense], C&H (326) remark 'Since, however, the tenseness of the supraglottal muscles is evidently controlled by a different mechanism than is tenseness in the subglottal cavities, these two properties cannot be combined into a single phonetic feature' as 'it conflicts with our conception of phonetic features as directly related to particular articulatory mechanisms' and so requires a separate feature of heightened subglottal pressure. As justification they point to the voiced aspirates of Hindi where aspiration occurs with closure voicing—the latter inimical to tenseness. As Keating (1984) observes, with the requirement that each feature be tied to a designated articulation, the system will seriously over-generate the number of categories available for lexical contrast. It is ironic to see that in a work that was criticized for excessive abstractness on so many other grounds, SPE's insistence on phonetic 'realism' at the phonology-phonetics interface is called into question.

19.6 Chapter 9 and markedness

The concluding chapter of SPE begins with the statement 'The entire discussion in this book suffers from a fundamental theoretical inadequacy' (p. 400). This would be an odd statement indeed to end a treatise on phonology. But SPE presents itself as an interim report on a long-term research program and so it is appropriate to highlight problems that lie beyond the grasp of the current model. C&H diagnose the problem as one in which the grammatical statements have been 'overly formal' and do not take account of the 'intrinsic content of the features'. They observe that with the number of features being the sole criterion for evaluation, the theory fails to distinguish a rule palatalizing velars before front vowels from one palatalizing velars before back vowels, or a statement that obstruent clusters are voiced rather than voiceless. Such over-generation problems arise in the characterization of phonological inventories, in the statement of rules, and even in the types of ordering relations among rules. SPE proposes to distinguish the natural from the unnatural by adapting the Prague School notion of markedness (see Battistella, this volume). According to this idea, minimal phonemic oppositions are not typically equipollent (of equal status); rather the 'unmarked' member is more expected (optimal) compared to the 'marked' one. Thus, [+voice] in obstruents is marked compared to [-voice], nasal vowels are marked compared to oral vowels, and mid vowels are marked compared to high or low vowels. Jakobson (1941) speculated that these biases not only shape phonemic inventories, but also determine the development of the child's mastery of a language's sound system, and the relative order of the loss of contrasts in aphasia. SPE proposes that a non-equipollent feature's plus and minus coefficients be replaced by marked (m) and unmarked (u) along with a set of universal interpretive rules that replace

the u and m coefficients with pluses or minuses. Being universal, the markedness conventions do not contribute to the complexity of the grammar. There then follows a statement of 39 markedness conventions spread over three and a half pages (pp. 404-407).

I comment on several of them here. The first few characterize the Jakobsonian CV hierarchy by specifying the values for [consonantal] and [vocalic] based on the segmental context (later instantiated in Prince and Smolensky's 2004 Onset and No-Coda constraints). The *SPE* marking statements are ordered; the first one optimizes the initial segment of a morpheme as a consonant. Subsequent marking rules eschew consonant and vowel sequences. These conventions predict the following complexity hierarchies, where '<' means 'is less complex than': C < V; CV < VC < CC < VV. Since *SPE* has no formal conception of the syllable, it predicts incorrectly that the optimal one and two-segment words prefer consonants over vowels.

For the definition of various vowel inventories, the *SPE* markedness conventions assign the values in (17).

	a	i	u	æ	э	e	0	ü	i	Œ	ö	Λ
low	u	u	u	m	m	u	u	u	u	m	u	u
high	u	u	u	u	u	m	m	u	u	u	m	m
back	u	_	+	m	u	_	+	_	+	m	_	+
round	u	u	u	u	m	u	u	m	m	m	m	m
complexity	0	1	1	2	2	2	2	2	2	3	3	3

(17) Markedness and complexity values for vowels (SPE: 409)

The optimal one-vowel system is /a/ and the unmarked three-vowel system comprises /a, i, u/. C&H note that their conventions cannot converge on the optimal five-vowel system /a, i, u, e, o/ and so they add more conditions. One requires that [round] can only be marked (i.e. plus) if some segment is marked for [high]. This effectively says that the grammar cannot choose the marked /ü/ or /i/ unless it already has /e/ and /o/, for example. Another problem is that phonemic inventories do not freely choose among the vowels of complexity 2 in the table of (17). So a symmetry condition in imposed that favors inventories which combine /ü/ with /ö/ (German) or /i/ with / Λ / (Korean) rather than, for example, /ü/ and / Λ /.

Given that some of the markedness conventions are context sensitive, they can be used to define the complexity of segment sequences; as a consequence, some common lexical redundancy rules can be reinterpreted in more universal terms. We already observed that the marking conventions for [consonantal] and [vocalic] favor CV sequences. The preference for obstruent clusters to be voiceless (German) can be treated as simple iteration of the preference for a single obstruent to be [–voice]. C&H observe that their markedness conventions define [+coronal, +anterior] as the least marked place of articulation for obstruents and choose [+continuant] for the initial obstruent in a cluster. From these two markedness preferences it follows that the /s/ in initial /sC/ clusters is not an idiosyncratic feature of English but reflects more general considerations.

The final section of Chapter 9 returns to the problem of distinguishing natural from unnatural feature changes. *SPE* proposes that if a rule changes a particular feature value of a segment then accompanying feature changes that would be unmarked by the marking

conventions can be treated as expected and hence do not contribute to the complexity of the grammar. Phonological rules that bear this relation are said to be 'linked' to the corresponding markedness convention. The concept is illustrated with the palatalization processes in the Slavic languages. For example, the First Palatalization replaces /k, g, x/ with /č, j, š/ (IPA /tʃ, dʒ, ʃ/). The basic change is assimilation of the feature [–back] from a following front vowel or glide so that underlying /k, g, x/ become /k', g', x'/ (= IPA /k^j, g^j, x^j/). The subsidiary changes of /k', g', x'/ into the corresponding palatal affricates and fricative involve the specifications of [+coronal], [+delayed release], and [+strident]. But these feature specifications are the unmarked values according to the marking conventions that make the affricate /č/ a better choice than the stop /k'/, and that make the optimal coronal affricate strident. Hence, these subsidiary changes come for free and do not contribute to the complexity of the rule.

Critics were quick to point out the limitations of the *SPE* approach to naturalness. Most of the marking statements are context free and their linkage to context-sensitive rules is restricted to supplying expected features that accompany the basic change. But it is unclear how to state the basic change itself as a natural one so that, for example, devoicing of obstruents in word-final position is distinguished from final voicing. Also there is no mechanism to reflect the naturalness of the contexts triggering a rule so that palatalization of velars before front vowels is distinguished from palatalization before back vowels. Another problem is that the same segment is natural in one context but not in another; so for example while voiced obstruents are marked at the end of a word, they are arguably favored after a nasal. Also, *SPE* does not address the question of how to express the unmarkedness of a segment at a later point in the derivation once an earlier

markedness constraint has interpreted it as plus or minus. Some of these limitations could be overcome by favoring assimilation rules (reconceptualized as feature spreading in the later autosegmental framework, see Kisseberth, this volume). Finally, as pointed out by Kisseberth (1970), there can be multiple ways of achieving the same basic output (conspiracies), anticipating a variety of 'constraint and repair' approaches (see Calabrese. this volume).

Chapter 9's most severe critic was David Stampe (1973), who founded an alternative approach to markedness known as Natural Phonology. Like SPE, Stampe also drew inspiration from the Prague School, in particular Jakobson (1941). But instead of viewing markedness as a property of representations, Stampe interprets the concept as a phonological process. He draws a sharp distinction between rules like Velar Softening in English (which are conventionalized products of history) and natural processes like Obstruent Devoicing or Tense Vowel Diphthongization, which 'substitute, for a class of sounds or sound sequences presenting a specific common difficulty to the speech capacity of an individual, an alternative class identical but lacking the difficult property' (Stampe 1973:1). Natural processes fall into two broad categories: lenitions make a sound or sound sequence easier to articulate and fortitions that make a sound or sound sequence easier to perceive. Thus, a nasal vowel is marked in comparison to an oral one because there is a natural process of denasalization (and no natural process of context-free vowel nasalization). A voiced obstruent is marked in comparison to a voiceless one because there is a natural process of obstruent devoicing (and no natural process of context-free voicing). Another important thesis of Natural Phonology is that the mature grammar of a speaker evolves gradually from an original post-babbling state when the child starts to

acquire a lexicon; at this stage of development the natural processes freely apply to severely restrict the phonetic output. Acquisition of the phonology of a language involves harnessing the natural processes so that the adult pronunciation can emerge. Three mechanisms are distinguished: suppressing the natural process entirely, limiting its scope, or imposing an order on the processes. So for example, in the acquisition of French, the child must suppress the vowel denasalization process to express the contrast between *beau* [bo] 'beautiful' and *bon* [bõ] 'good'. For the English speaker, who has difficulty making the oral-nasal vowel contrast freely but nevertheless easily and unconsciously nasalizes a vowel before a nasal consonant, the vowel denasalization process $\tilde{V} > V$ must be ordered before the process that nasalizes the vowel before a tautosyllabic nasal: VN > $\tilde{V}N$.

The Natural Phonology framework was initially viewed as an attractive alternative to the overly formal *SPE* approach. But as its implications were explored doubts arose as to how much of the mature grammar really can be viewed as the residue of childhood processes, which often seem to have their own etiology (Drachman 1976). And if much of the deeper morphophonology of a language like English is not natural, it still must be the output of grammatical computations, about which Stampe's approach has little to say (Anderson 1981). The question of whether and how to distinguish between phonetically motivated vs. more arbitrary sound substitutions remains an unresolved question that has divided the field into distinct camps: substance-free phonology, phonetically-driven phonology, evolutionary phonology.

19.7 SPE: Reception, climate, and culture; refinements and extensions

SPE grew out of earlier work by Halle and Chomsky critiquing the strictures of American Structuralism (Halle 1959, Chomsky 1964). There were pointed exchanges with structuralists such as Householder (1965) and C&H's (1965) response published in the same issue of Journal of Linguistics. The discussion turned on general questions of methodology and goals and ultimately, the nature of language itself as a biologically determined faculty of the mind-brain with its own inherent properties vs. a more arbitrary and contingent product of history and culture that could be analyzed from different but equally valid perspectives. These contrasting views had been labeled somewhat jocularly as 'God's Truth' vs. 'hocus pocus' in the literature of the period-terminology originally introduced by Householder (1953) and commented on by Joos (1957: 80). Similar issues were debated by the Stratificationalist Sydney Lamb (1966) and Paul Postal (1968) in a vigorous response. SPE was reviewed in most of the major linguistics journals of the time: Glossa (Hoard 1971), Lingua (Kohler 1970), Linguistics (Hill & Nessly 1973), and IJAL (McCawley 1974), but curiously not in Language or Word. Further afield, a sympathetic review by John MacDonald (1969) appeared in the Harvard Educational Review and a highly critical one by John Fought (1973) in the Annual Review of Anthropology. Finally, Goyvaerts & Pullum (1975) anthologize the reviews from Hoard, Kohler, Hill & Nessly, and McCawley along with a lengthy introduction summarizing the developments in the SPE model in the immediate aftermath of its publication.

SPE was very much the product of a highly collaborative research effort in which graduate students and visitors to the MIT program played a major role. Several independent factors conspired to shape this joint effort. A lab-based culture was the norm at MIT. The program was housed in the infamous Building 20—a 'temporary' structure

erected during World War Two with minimal amenities but having sufficient office space to equip each graduate student with a desk that created an atmosphere encouraging discussion and collaboration. As the program grew in stature, it was generously supported by the Institute, and afforded students the time for and fostered the expectation of sustained, high-level work. Given its sharp break with American Structuralism, the generative program enjoyed the cachet of 'the next big thing' where originality and critical thinking were prized over erudition. And with its emphasis on formalism, a young scholar with minimal language background but facility in assessing the consequences of abstract symbolic expressions could immediately begin contributing to the research effort. Most of the early entrants to the Ph.D. program had math backgrounds. Seven of the thirteen dissertations in the first class of graduates (1965) were focused on phonology and nine of the next 22 (1966-1970) were as well. During this period only two Ph.D.'s were women (Barbara Hall Partee and Nancy Woo) and three were international (Paul Kiparsky from Finland, Yuki Kuroda from Japan, and François Dell from France). Graduate linguistic programs with a generative emphasis or generative sympathizers were quickly established at various mostly state universities including Illinois, Texas, Ohio State, UCLA, Washington, Massachusetts, and Chicago, and raised the research effort to a higher level. New publication outlets (*Linguistic Inquiry*, Foundations of Language, Papers in Linguistics) and annual conferences, such as the Chicago Linguistic Society (CLS) and the North East Linguistics Society (NELS), were inaugurated for generative linguists to showcase their research. Their articles began appearing in the more venerable Language and International Journal of American Linguistics; and generative linguists became an active presence at the LSA annual meetings. Several of the LSA Summer

Institutes (1968, 1969, 1970) featured well-attended classes offered by some of MIT's early Ph.D.'s. It is fair to say that by the mid 1970s the generative approach had replaced structuralism as the dominant paradigm for phonology and linguistics more generally in North America and was beginning to make inroads in the Netherlands, Britain, and Japan, and later more widely in Europe with the establishment of GLOW (Generative Linguistics in the Old World).

In closing, the dissertations of some of the earliest MIT graduates are worthy of brief mention as exemplifications of the generative approach to phonology articulated in SPE.

Paul Kiparsky (1965) explored the implications of the generative model for the theory of linguistic change and showed how diachronic evidence could shed light on the inner workings of the synchronic grammar. Proceeding from the premise that each child constructs their grammar anew based on the language of the environment, comparison of successive stages of a language can reveal how a rule is simplified and often eliminated entirely when the alternations motivating it are obscured by later rules. With its novel perspective, Kiparsky's dissertation research and subsequent papers reinvigorated the field of historical linguistics.

Theodore Lightner (1965) built on Jakobson's (1948) long-stem analysis of the Russian verb to develop a cyclic description of the language's complex vowel truncations and consonant palatalizations. The thesis also distinguished a stratified lexicon with three levels of Native Russian, Slavic, and Foreign, each with their own rules or rule variants. Finally, Russian's *e*, $o \approx 0$ (fleeting) vowel alternations were analyzed with abstract underlying jers /I, σ / that never surface phonetically. The problem of the Slavic jers has continued to occupy generative phonologists as each new theoretical development

(autosegmental representations, lexical phonology, Optimality Theory, experimental phonology) is applied to this alternation that is emblematic of the deeper morphophonology explored in the *SPE* framework. See for example recent papers by Becker & Gouskova (2014) and Scheer (2018).

James McCawley (1965) applied the *SPE* concept of cyclic stress to an analysis of the pitch accents in Japanese words and phrases. He discovered that the accent found in western loanwords mimicked the Latin Stress Rule (and thus the Main Stress rule of English), a finding that was later extended to the statistical distribution of accents in the native lexicon by Kubozono (2006). McCawley's dissertation research became the starting point for all subsequent work on Japanese phonology. He also wrote an important paper on the feature system (1967) and the incisive review of *SPE* referenced above (1974).

Sanford Schane (1965) used the variable feature notation to combine into a single statement the elision and liaison rules of French, alternations which came to be viewed as reflexes of the optimal CV syllable structure. Arnold Zwicky (1965) applied the *SPE* system of cyclically ordered rules over distinctive feature representations to the major sandhi rules of classical Sanskrit: vowel sequences, retroflexion, ruki, aspiration, and voicing.

19.8 Conclusion

In the fifty or so years since its publication no single work has come close to *SPE*'s combination of theoretical originality and descriptive insight. Anyone studying some aspect of the stress or segmental morphophonology of English today first looks to see

what *SPE* might have said about the matter. Most of the major issues facing the field today were addressed by *SPE* with specific proposals and clearly articulated positions. Questions about data vs. theory, gradience vs. abstraction, competence vs. performance, etc. that were thought settled (at least within the field of generative linguistics) are now being raised anew as researchers adopt experimental probes of linguistic competence and computational modeling of grammar and its acquisition inspired by machine learning techniques over large corpora of speech and text. Time will tell whether these approaches yield insights comparable to those achieved by the *SPE* program initiated by Chomsky and Halle in the middle of the last century.

Acknowledgements

The author is grateful to the editors Elan Dresher and Harry van der Hulst as well as to two anonymous reviewers and to Jay Keyser and François Dell for helpful comments on the substance and form of this chapter.

References

- Anderson, Stephen. 1969. West Scandinavian vowel systems and the ordering of phonological rules. Cambridge, MA: MIT Ph.D. dissertation.
- Anderson, Stephen. 1976. Nasal consonants and the internal structure of segments. Language 52: 326–44.
- Anderson, Stephen. 1981. Why phonology isn't 'Natural'. *Linguistic Inquiry* 12: 493–539.
- Anderson, Stephen and Wayles Browne. 1973. On keeping exchange rules in Czech. *Papers in Linguistics* 6: 445–82.
- Beckman, Jill, Michael Jessen, and Catherine Ringen. 2013. Empirical evidence for laryngeal features: Aspirating vs. true voice languages. *Journal of Linguistics* 49: 259–84.
- Beckman, Mary, Fangfang Li, Eun Jong Kong, and Jan Edwards. 2014. Aligning the timelines of phonological acquisition and change. *Laboratory Phonology* 5: 151–94.
- Blevins, Juliette. 2004. A reconsideration of Yokuts vowels. *International Journal of American Linguistics* 70: 33–51.
- Cassimjee, Farida and Charles Kisseberth. 2018. Abstractness and Shingazidja tonology: Evidence from French loanwords. In Eugene Buckley, Thera Crane, and Jeff Good (eds), *Revealing structure*, 37–56. Stanford, CA: CSLI Publications.
- Cena, Richard. 1978. When is a phonological generalization psychologically real? Bloomington, IN: Indiana University Linguistics Club.

Chomsky, Noam. 1964. Current issues in linguistic theory. The Hague: Mouton.

- Chomsky, Noam and Morris Halle. 1968. *The sound pattern of English*. New York: Harper & Row.
- Chomsky, Noam and Morris Halle. 1965. Some controversial claims in phonological theory. *Journal of Linguistics* 2: 95–138.
- Chomsky, Noam, Morris Halle, and Fred Lukoff. 1956. On accent and juncture in English. In Morris Halle, Horace Lunt, Hugh McClean, and C.H. van Schooneveld (eds), For Roman Jakobson: Essays on the occasion of his sixtieth birthday, 11 October 1956. 65–80. The Hague: Mouton.
- Danielsson, Bror (ed). 1955. John Hart's works on English orthography and pronunciation, 1551, 1569, 1570: Part II, phonology. Uppsala: Almqvist and Wiksell.
- Dobson, Eric. 1957. English pronunciation, 1500–1700. Oxford: Clarendon Press.
- Drachman, Gaberell. 1976. Child language and language change: A conjecture and some refutations. In J. Fisiak (ed) *Recent Developments in Historical Phonology*, 123–44.The Hague: Mouton.
- Fought, John. 1973. On the adequacy of recent phonological theories and practices. *Annual Review of Anthropology* 2: 153–64.
- Gouskova, Maria and Michael Becker. 2016. Source-oriented generalizations as grammar inference in Russian vowel deletion. *Linguistic Inquiry* 47: 391–425.
- Goyvearts, Didier and Geoffrey Pullum. 1975. *Essays on* The sound pattern of English. Ghent: E. Story-Scientia P.V.A.
- Halle, Morris. 1959. The sound pattern of Russian. The Hague: Mouton.

- Halle, Morris and Michael Kenstowicz. 1991. The free element condition and cyclic vs. noncyclic stress. *Linguistic Inquiry* 22: 457–501.
- Halle, Morris and Samuel Jay Keyser. 1967. Review of Danielson (1963). *Language* 43: 773–87.
- Halle, Morris and Jean-Roger Vergnaud. 1987. An essay on stress. Cambridge MA: MIT Press.
- Harris, Zellig. 1951. *Methods in structural linguistics*. Chicago: University of Chicago Press.
- Hill, Kenneth and Larry Nessly. 1973. Review of the Sound Pattern of English. Linguistics 106: 57–121.
- Hoard, James. 1971. The new phonological paradigm. Glossa 5: 222-68.
- Hooper, Joan. 1976. *An introduction to natural generative phonology*. New York: Academic Press.
- Householder, Fred. 1952. Review of Harris (1951). International Journal of American Linguistics 18: 260–8.
- Householder, Fred. 1965. Some recent claims in phonological theory. *Journal of Linguistics* 1: 13–34.
- Hyman, Larry and Joyce Mathangwane. 1998. Tonal domains and depressor consonants in Ikalanga. In Larry Hyman and Charles Kisseberth (eds), *Theoretical aspects of Bantu tone*, 195–230. Stanford, CA: CSLI Publications.
- Jesperson, Otto. 1909. A modern English grammar on historical principles, part 1: Sounds and symbols. Heidelberg: Carl Winter.

Jakobson, Roman. 1941. *Kindersprache, Aphasie, und allgemeine Lautgesetze*. In Roman Jakobson (1962) *Selected Writings*, vol. 1, 328–401. The Hague: Mouton.

Jakobson, Roman. 1948. Russian conjugation. Word 4: 155-67.

Jakobson, Roman, Gunar Fant, and Morris Halle. 1952. *Preliminaries to Speech Analysis*. Cambridge, MA: MIT Press.

Joos, Martin. 1957. Readings in linguistics I. Chicago: University of Chicago Press.

- Keating, Patricia. 1984. Phonetic and phonological representation of stop consonant voicing. *Language* 60: 286–319.
- Kim, Chin-Wu. 1965. On the autonomy of the tensity feature in stop classification. *Word* 21: 339–59.
- Kingston, John and Randy Diehl. 1994. Phonetic knowledge. Language 70: 419–54.
- Kiparsky, Paul. 1965. Phonological change. Ph.D. dissertation, MIT, Cambridge, MA.
- Kiparsky, Paul. 1968. How abstract is phonology? Bloomington, IN: Indiana University
 Linguistic Club. Reprinted in Paul Kiparsky, *Explanation in phonology*, 119–63.
 Dordrecht: Foris Publications, 1982.
- Kiparsky, Paul. 1982. Lexical phonology and morphology. In I. Yang (ed), *Linguistics in the morning calm*, 3–91. Seoul: Hanshin.
- Kisseberth, Charles. 1970. On the functional unity of phonological rules. *Linguistic Inquiry* 1: 291–306.
- Kuroda, S.-Y. Yawelmani phonology. Cambridge, MA: MIT Press.
- Kohler, Klaus. 1970. Review of *The sound pattern of English*. Lingua 26: 73–95.
- Kubozono, Haruo. 2006. Where does Japanese loanword accent come from? A case study of Japanese loanword accent. *Lingua* 116: 1140–70.

Labov, William. 1994. Principles of linguistic change. Cambridge, MA: Blackwell.
Ladefoged, Peter. 1964. A Phonetic study of West African languages. Cambridge:
Cambridge University Press.

Lamb, Sidney. 1966. Prolegomena to a theory of phonology. Language 42: 536-73.

Liberman, Mark and Alan Prince. 1977. On stress and linguistic rhythm. *Linguistic Inquiry* 8: 249–336.

- Lightner, Theodore. 1965. Segmental phonology of Modern Standard Russian. Cambridge, MA: MIT Ph.D. dissertation.
- Lightner, Theodore. 1971. Generative phonology. In William Dingwall (ed), *A survey of linguistic science*, 498–556. Maryland: Linguistics Program, University of Maryland.
- Lisker, Leigh and Arthur Abramson. 1964. A cross-language study of voicing in initial stops: acoustical measurement. *Word* 20: 384–422.
- Lisker, Leigh and Arthur Abramson. 1971. Distinctive features and laryngeal control. Language 47: 767–85.
- MacDonald, John. 1969. Review of *The sound pattern of English*. *The Harvard Educational Review* 39: 180–5.
- McCarthy, John. 2002. *A thematic guide to Optimality Theory*. Cambridge: Cambridge University Press.
- McCawley, James. 1965. The accentual system of Standard Japanese. Ph.D. dissertation, MIT, Cambridge, MA. Published as *The phonological component of a grammar of Japanese*. The Hague: Mouton, 1968.

- McCawley, James. 1972. The role of a phonological feature system in a theory of language. In Valerie Becker Makkai, (ed.), *Phonological theory: Evolution and current practice*, 522–8. New York: Holt, Rinehart and Winston, Inc.
- McCawley, James. 1974. Review of *The sound pattern of English*. International Journal of American Linguistics 40: 50–88.
- McCawley, James. 1986. Today the world, tomorrow phonology. *Phonology Yearbook* 3: 27–43.
- Odden, David. 1998. Principles of tone assignment in Tanzanian Yao. In Larry Hyman and Charles Kisseberth (eds), *Theoretical aspects of Bantu tone*, 265–314. Stanford, CA: CSLI Publications.

Postal, Paul. 1968. Aspects of phonological theory. New York: Harper & Row.

Prince, Alan. 1983. Relating to the grid. *Linguistic Inquiry* 14: 19–100.

- Prince, Alan and Paul Smolensky. 2004. *Optimality Theory: Constraint interaction in generative grammar*. Cambridge, MA: MIT Press.
- Ross, John. 1972. A reanalysis of English word stress, part 1. In Michael Brame (ed). *Contributions to generative phonology*, 229–323. Austin: University of Texas Press.
- Schane, Sanford. 1965. The phonological and morphological structure of French. Ph.D. dissertation, MIT, Cambridge, MA.
- Scheer, Tobias. 2017. On the difference between the lexicon and computation (regarding Slavic yers). To appear in *Linguistic Inquiry*.
- Selkirk, Elizabeth. 1984. *Phonology and syntax: The relation between sound and structure*. Cambridge, MA: MIT Press.

- Stampe, David. 1973. A dissertation on Natural Phonology. Ph.D. dissertation, University of Chicago. Reprinted as *Outstanding Dissertations in Linguistics* 22, New York: Garland Press.
- Steriade, Donca. 1993. Closure, release and nasal contours. In Marie Huffman and Rina Krakow (eds), 401–70. Nasals, nasalization and the velum. San Diego: Academic Press.
- Stevens, Kenneth. 1972. The quantal nature of speech: Evidence from articulatoryacoustic data. In Patrick Denes and E. David (eds), *Human communication: A unified view*, 51–66. New York: McGraw-Hill.
- Stevens, Kenneth and S. Jay Keyser. 1989. Primary features and their enhancement in consonants. *Language* 65: 81–106.
- Stockwell, Robert. 1972. Problems in the interpretation of the Great English Vowel Shift.
 In M.E. Smith (ed), *Studies in linguistics in honor of George L. Trager*, 344–62. The Hague: Mouton. Also in Didier Goyvearts and Geoffrey Pullum (eds), *Essays on* The sound pattern of English, 331–53. Ghent: E. Story-Scientia P.V.A., 1975.
- Vanderslice, Ralph & Peter Ladefoged. 1972. Binary suprasegmental features and transformation word-accentuation rules. *Language* 48: 819–38.
- Vennemann, Theo. 1974. Phonological concreteness in natural generative grammar. In Roger Shuy and Charles J. Bailey (eds.), *Toward tomorrow's linguistics*, 202–19.
 Washington, D.C.: Georgetown University Press.
- Zwicky, Arnold. 1965. Topics in Sanskrit phonology. Ph.D. dissertation, MIT, Cambridge, MA.