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THE PHONOLOGY OF SYLLABIC NUCLEI IN SLOVAK

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The complex phonology of Slovak syllabic nuclei is studied from the twin perspectives of three-dimensional representation theory and Lexical Phonology. A variety of evidence is adduced to show the necessity of recognizing a distinct nucleus node in the internal structure of the syllable. It is also argued that Slovak syllabic nuclei are right-headed metrical structures. The well-known Slovak Rhythmic Law, shortening the first of two successive long syllables, is demonstrated to be a cyclic rule. It is argued that its cyclicity follows necessarily from the Lexical Phonology model.*

Over the past decade, two major lines of research in generative phonology have extended—and, in very significant respects, modified—many of the key assumptions of the early generative model articulated in Chomsky & Halle's *SPE* (1968). One line of research has developed a much richer conception of phonological representation than the spartan *SPE* view, which regarded phonological structure as essentially a linear string of feature matrixes, punctuated by boundary symbols. Intensive study of the prosodic features of tone, accent, and quantity has led to a three-dimensional model of representation comprising a string of empty positions (the skeletal tier), onto which are projected largely autonomous systems to represent tone, accent, and the segmental phonemes. Particularly important for our present purposes is the idea that the skeletal tier is organized into syllables with an internal structure that minimally distinguishes nuclear from non-nuclear positions. Part of the evidence for distinguishing the syllable and segmental tiers is that contrasts between, e.g., syllabic and non-syllabic nasals can be characterized explicitly in terms of the location of a segment in the syllable; this permits us to dispense with the problematic *SPE* feature [±syllabic].

Another major line of research has been the development of L[exical] P[honology]. Developing an idea that goes back to essentially the beginning of the scientific study of phonology, LP argues that the phonological component of the grammar is organized into two autonomous subsystems, the rules and principles of which display quite different properties: the LEXICAL SYSTEM places the phonological rules inside the lexicon, where they interact with the word-formation component, while the POSTLEXICAL SYSTEM applies to phonological words as they are situated in the surface syntax. Given these two different locations, the contrasting properties of lexical and postlexical rules begin to make sense. Lexical rules apply to the output of each word-formation process, and hence are inherently cyclic; they may be sensitive to idiosyncratic lexical properties (e.g. exceptions). Postlexical rules are largely blind to internal

* The names of the authors appear in alphabetical order; each has contributed equally to the research and writing of this paper. Jerzy Rubach would like to thank the University of Illinois, especially its George A. Miller Committee, for appointing him Visiting Professor at the Urbana-Champaign campus in 1985–86. The appointment as George A. Miller Professor enabled Rubach to work with Kenstowicz and to carry out the research reported in this study.

morphological and idiosyncratic lexical structure, applying across the board. In addition, the application of lexical rules is restricted to so-called derived environments, while postlexical rules may find their scope of application entirely within a morpheme. Thus LP has a richer, more articulated conception of the internal structure of the grammar than the *SPE* model, and leads to a more constrained and explanatory characterization of phonological structure.

It is a commonplace of theory-driven linguistic research that we return to the same data again and again as new theoretical ideas are explored. (Hence the frequency of titles of the form 'X revisited'.) Data that were problematic for an earlier version of the theory may become tractable when viewed from a fresh perspective; and when one returns to old data from a new perspective, one can get a sense of how much progress has been made in the field. In this paper we want to re-examine the syllabic nuclei of Slovak, a West Slavic language, from this viewpoint.[1] We shall argue that the Slovak data have an important bearing on a number of issues in the two lines of research mentioned above.

Slovak played a rather prominent role in the early development of generative phonology. It was the first Slavic language besides Russian to be addressed from the generative perspective, in the important paper of Isačenko 1964. Its well-known Rhythmic Law was introduced into the generative literature by Browne 1970, and came to occupy an important position in the discussion of the multiple application problem (Anderson 1974, Kenstowicz & Kisseberth 1977). Its vocalic phonemes were subjected to a textbook analysis, illustrating some of the most important analytic and descriptive techniques of the early generative model, in Kenstowicz & Kisseberth 1979 (based on Kenstowicz 1972). Finally, its intricate system of syllabic phonemes was the subject of a classic paper by Jakobson 1931, in which some of the most important concepts and motivations of the emerging theory of the phoneme were given early expression.

In this paper we shall argue that, although these earlier studies uncover many important insights into the structure of Slovak, they are nevertheless seriously deficient on both empirical and theoretical grounds. Significantly, these deficiencies can in large measure be traced directly to the one-dimensional, linear nature of *SPE* and earlier models of phonological representation. Many of these problems disappear when the data are approached from the twin perspectives of three-dimensional phonology and LP. More importantly, in addition to improving the descriptive record, we find theoretical motivation for 'revisiting' this language. We shall argue that the Slovak material has a direct bearing on some important questions and issues at the leading edge of these two research programs.

[1] The data upon which this study is based have been drawn from the standard grammars of Slovak such as Dvonč et al. 1966, Peciar et al. 1963, Pauliny 1979, and Bartoš & Gagnaire 1972, as well as from the standard dictionaries. Some of the data were also corroborated by our language consultant Marek Miňo, to whom we extend our gratitude. We also thank L'ubomir D'urovič, who has helped to clarify for us some of the points on which our sources did not give unambiguous information. Finally, we wish to thank Donna Farina for stimulating discussion of §4.

Our exposition will take the following course. In §1, we introduce the *SPE*-based analysis of the major phonological alternations in which Slovak syllabic nuclei participate. We then note that this analysis works only if we exclude etymologically borrowed words. We argue that this exclusion of historical loanwords is illegitimate. In §2, we show that the problem posed by the loanwords is solved from the perspective of LP. In the course of this discussion, we present a striking example of a phonological rule whose application must be restricted to a derived environment.

In §3, we show that our analysis works only if a three-dimensional approach to the representation of syllabic nuclei is adopted. This representation is needed in any case, it turns out, to explain some interesting features of the syllabic structure of Slovak first noted by Jakobson. One of the most notable results is that Slovak has a three-way phonological contrast on segmental strings of the form [ie], depending on whether or not the two segments are tautosyllabic and whether or not they appear in the nucleus of the syllable. In §4, on the 'jers'—Slavic vowels which alternate with zero—we show how the three-dimensional model allows for a fresh approach to the treatment of these problematic segments that have plagued all earlier, linearly-based studies. We show that this approach is independently motivated by some of the LP assumptions underlying our analysis. In §5, we discuss special problems of the diphthong *iu*. Finally, in §6, we explore the idea that the property of cyclicity has a significant connection with sensitivity to morphological and lexical structure. We do this by examining the properties of other rules ordered before those known to be cyclic on independent grounds. We see that the well-known Rhythmic Law must be lexical and hence cyclic, contradicting its earlier interpretation as an across-the-board rule of simultaneous application.

1. THE *SPE* ANALYSIS. If attention is restricted to the etymologically native vocabulary, then the surface inventory of vocalic syllabic nuclei in Slovak presents some striking disparities:[2]

(1)

i u	*í ú*	*ie uo* = [ô]
e o		*ia*
ä a	*á*	
short vowels	long vowels	rising diphthongs

Here a balanced system of six short vowels is paired off, front and back, at each of the three heights. But the long vowels number only three: two high, and one low back.[3] However, the language has three rising diphthongs: two consist of a high onglide *i u* followed by a homorganic mid vowel, while the third is *ia*. In view of the well-known tendency towards symmetry in the un-

[2] We cite Slovak words in their orthographic form. For the most part, the graphs have the expected phonetic correlates, but note the following: The acute accent denotes a long syllabic segment; it does not denote accent, which is always on the initial syllable of the word. The vowel *ä* is low front; *ô* is the diphthong [uo]; *y* is high front [i]; *ch* is the velar fricative [x]. The consonants *t d n* are palatalized before *i* and *e*; in addition, *t' d' l'* are palatalized.

[3] Long [e:] occurs only in the word *dcéra* 'daughter' and in the adjectival formant appearing in *dobr-ého* 'good' (gen.sg.) We will return to these marginal cases later.

derlying inventory of vocalic phonemes (cf. Trubetzkoy 1939), one might hypothesize that *ie ô* derive from underlying long *e: o:* by a natural diphthongization process. Given this move, we have succeeded in pairing up five of the six short vowels with a long counterpart. The low front vowel *ä* and the diphthong *ia* are the only obstacle to a perfect matching of long and short elements, and the desire to identify these elements as members of an underlying short–long opposition is almost irresistible. Slightly problematic, however, is the fact that the low vowel component of *ia* is a back vowel, akin to *a* rather than to the front vowel *ä*; nevertheless, the pairing of *ia* with *ä* rather than with *a* makes perfect sense in the Slovak system. Low front *ä* has a very restricted surface distribution; it occurs only after the labials *p b m v*, where it contrasts with *a*. Furthermore, the vowel of the suffix for animal young, *-ä(t')*, surfaces unchanged only after labials; elsewhere it appears with a back *a*, supporting the existence of a rule which changes *ä* to *a* after [−labial] segments:

(2)

NOM.SG.	GEN.SG.	
holúb-ä	*holúb-ät'-a*	'young pigeon'
žrieb-ä	*žrieb-ät'-a*	'colt'
pras-a	*pras-at'-a*	'pig'
mač-a	*mač-at'-a*	'kitten'

Given this rule, nothing stands in the way of deriving *ia* from underlying long [ä:]. All we need assume is that a process of diphthongization adds a homorganic onglide *i u* to the first portion of the long vowels [e: o: ä:]. Then [ä:] will turn to [iä], and the independently needed rule which backs *ä* after a non-labial will apply to derive *ia*.

Thus, from simple inspection of the surface vowel inventory, we find reason to hypothesize a deep-seated symmetry which balances short and long elements. Abundant evidence internal to the grammar of Slovak also supports this interpretation of the short–long pairings. The language has numerous alternations affecting the length of vocalic nuclei. In each case where *i u a* lengthen to *í ú á*, we find that *e o ä* appear as *ie ô ia*. For example, in the gen.pl. of feminine and neuter nouns, the final vowel of the root is lengthened, giving rise to precisely this pattern of alternation:

(3)

	NOM.SG.	GEN.PL.	
a.	*kopyt-o*	*kopýt*	'hoof'
	bruch-o	*brúch*	'belly'
	blat-o	*blát*	'mud'
	koles-o	*kolies*	'wheel'
	lon-o	*lôn*	'lap'
	hoväd-o	*hoviad*	'beast'
b.	*lip-a*	*líp*	'linden tree'
	much-a	*múch*	'fly'
	lopat-a	*lopát*	'shovel'
	žen-a	*žien*	'woman'
	os-a	*ôs*	'wasp'
	päť-a	*piat*	'heel'

Similarly, the diminutive suffix *-ok* has the property of lengthening the preceding vowel: *hrad, hrád-ok* 'castle'; *list, líst-ok* 'leaf'. But if the vowel of the root is drawn from the set *e o ä*, then we find the corresponding diphthong: *kvet*, dim. *kviet-ok* 'flower'; *hoväd-o*, dim. *hoviad-ok* 'beast' (gen.pl.); *batoh*, dim. *batôž-ok* 'bundle'.[4] To cite another example, numerals show a lengthening of their root vowel in oblique forms: *päť, piat-i* 'five'; *šesť, šiest-i* 'six'; *osem, ôsm-i* 'eight'. The hypothesis that *ie ô ia* derive from long [e: o: ä:] by a diphthongization process explains the fact that short *e* appears as *ie* in precisely the contexts where *i* appears as long *í*. We need merely assume that the various vowel-lengthening rules apply before the diphthongization rule.

Slovak also has numerous shortening rules which appear to support the analysis of the rising diphthongs as surface manifestations of underlying long vowels. In each situation where underlying *í ú á* shorten to *i u a*, the diphthongs *ie ô ia* appear as *e o ä*. If *ie ô ia* derive from [e: o: ä:], then the two sets of alternations can be brought under a single generalization: shorten long vowels.

The Slovak shortening rules fall into two classes. First, vowel length is removed from the stem before an apparently arbitrary class of derivational suffixes, such as imperfectivizing *-ova* or agentive *-ár*:

(4)

	PERFECTIVE	IMPERFECTIVE	
a.	*kúp-iť*	*kup-ova-ť*	'buy'
	ohlás-iť	*ohlas-ova-ť*	'announce'
	obliet-ať	*oblet-ova-ť*	'fly around'
	uviaz-ať	*uväz-ova-ť*	'bind'

b.	*pís-ať*	'write'	*pis-ár*	'writer'
	hviezd-a	'star'	*hvezd-ár*	'astronomer'
	drôt	'wire'	*drot-ár*	'tinsmith'

The second class of shortening rules is constituted by the well-known Rhythmic Law, which shortens a long vowel when immediately preceded by a syllable containing a long vowel. This rule produces short-vowel alternants for many basically long-vowel inflectional suffixes, such as nom.pl. neuter *-á* and loc.pl. *-ách*:

(5)

NOM.SG.	GEN.SG.	NOM.PL.	LOC.PL.	
mest-o	*mest-a*	*mest-á*	*mest-ách*	'town'
hoväd-o	*hoväd-a*	*hoväd-á*	*hoväd-ách*	'beast'
písmen-o	*písmen-a*	*písmen-á*	*písmen-ách*	'letter'
dlát-o	*dlát-a*	*dlát-a*	*dlát-ach*	'chisel'
vín-o	*vín-a*	*vín-a*	*vín-ach*	'wine'
hniezd-o	*hniezd-a*	*hniezd-a*	*hniezd-ach*	'nest'

The rule also applies in the inflection of adjectives and verbs:

(6)

	MASC.	FEM.	MASC.GEN.SG.	
a.	*dobr-ý*	*dobr-á*	*dobr-ého*	'good'
	krasn-ý	*krasn-á*	*krasn-ého*	'beautiful'

[4] As we shall see later, there is good reason to believe that the gen.pl. is marked by a vocalic suffix that is essentially the same as the vowel appearing in the diminutive *-ok*; so the vocalic lengthenings observed here are arguably the product of the same rule.

	múdr-y	*múdr-a*	*múdr-eho*	'wise'
	biel-y	*biel-a*	*biel-eho*	'white'
	zaviat-y	*zaviat-a*	*zaviat-eho*	'blown'
b.	1sg.	3sg.	3pl.	
	nes-iem	*nes-ie*	*nes-ú*	'carry'
	rast-iem	*rast-ie*	*rast-ú*	'grow'
	strež-iem	*strež-ie*	*strež-ú*	'guard'
	môž-em	*môž-e*	*môž-u*	'be able'

The Rhythmic Law also applies to derivational suffixes like agentive *-ník* and diminutive *-ík*:

(7)	*rol-ník*	'farmer'	*voz-ík*	'cart'
	stráž-nik	'guard'	*kút-ik*	'corner'
	papier-nik	'stationer'	*človieč-ik*	'person'

We see here that diphthongs parallel the behavior of long vowels in two ways. First, they trigger the Rhythmic Law (e.g. *biel-y*); second, they lose their onglide after a long syllable (*môž-em*). We can account for this parallel by deriving the diphthongs from underlying long vowels. Indeed, in the *SPE* system this is essentially the only possible analysis, because of the way phonological quantity is treated. In *SPE*, phonological distinctness is a function either of distinct feature matrices or of a difference in string length. Thus there are just two ways that a short and long vowel can be distinguished: either in terms of a feature [±long], or as a single vs. double string of identical segments (e.g. [a] vs. [aa]). Kenstowicz 1972 adopts the former choice for Slovak and expresses the long/short vocalic alternations as changes in the binary feature [±long]. The diphthongization process is then ordered after all rules which affect vocalic length. It is slightly awkward to state, since the conversion of a single segment like [e:] into the sequence *ie* requires a transformational operation which inserts the onglide and simultaneously changes the original vowel to [−long]. However, by delaying diphthongization until a late point in the derivation, all length alternations can be expressed in terms of the binary feature [±long]. What formal complexity exists in the analysis is localized in the diphthongization rule itself. Given the *SPE* system of representation for length, this is the only possible analysis. An early application of diphthongization, preceding a quantity-changing rule, would have the disastrous consequence of requiring two quite formally different statements for what is patently the same alternation. Lengthening or shortening of *i u a* would have to be expressed by a rule changing the feature [±long]; but alternations between *e o ä* and *ie uo ia* would have to be treated by a formally quite different (transformational) mechanism that inserts or deletes the onglide. As we have seen, there is every reason to believe that the alternations between *i* and *í* and between *e* and *ie* are manifestations of the same underlying process. The only way to avoid duplication in the *SPE* system is to delay diphthongization until all length alternations have been implemented.

Representing long vowels as a sequence of identical segments is not really a viable alternative within the *SPE* framework. It would permit statement of the diphthongization process which turns [ee] to [ie] to be expressed as a simple feature change in the first of two identical vowels; however, this approach runs afoul of the lengthening and shortening rules. Lengthening has to be expresed as the insertion of an identical vocalic segment—converting underlying *lopat-* 'shovel', e.g., into gen.pl. [lopaat]. But the insertion of an extra vowel must somehow be blocked in underlying long-vowel roots like *dlát-o* 'chisel'—since, in the gen.pl., the root vowel does not change in this class of forms: *dlát*. With the feature representation for length, this restriction is easy to state. Like all other features, [±long] has just two values. Lengthening in the gen.pl. is vacuous for a root that already has its vowel specified [+long]. But with the sequence representation for length, we are forced to look at the surrounding context in order to distinguish between a single and a double occurrence of a vowel—so that lengthening will convert gen.pl. *lopat* to [lopaat], but fail to insert another vocalic segment in gen.pl. [dlaat] to give the incorrect [dlaaat]. Thus a lengthening process is particularly clumsy to state with the geminate mode of representation for quantity.

To briefly review the results of this section, the *SPE*-based analysis posits a symmetrical system of six underlying vowels, each having a long and short value. The manifold length alternations are expressed in terms of the binary feature [±long], and a late rule of diphthongization converts [e: o: ä:] into the diphthongs *ie uo ia*. The few morphemes in the native vocabulary with surface [e:], such as *dcéra* and *-ého*, are simply marked as lexical exceptions to the diphthongization rule. In this way, most of the vocalic alternations are accounted for in a simple and descriptively insightful manner.

2. LEXICAL PHONOLOGY. One of the most important modifications in the theory of generative phonology of the post-*SPE* period of the early 1970's was Kiparsky's (1973) discovery of a class of phonological rules whose scope of application must be restricted to what he referred to as 'derived' environments. A derived environment is one in which the structural description of the rule is satisfied either by material that comes from separate morphemes (thus usually occasioning an alternation), or one where the structural description is satisfied by material contained solely within the scope of a single morpheme—but where part of this material has resulted from the application of a previous rule. In this case, we say that the rule is triggered by 'derived' as opposed to 'underlying' information. Determining exactly how the class of derived-environment rules is circumscribed has proven to be a difficult question, and much of the work leading up to LP has been concerned with trying to provide a satisfactory answer. Following Mascaró 1976, who shows that the notion 'derived context' is essentially equivalent to Chomsky's (1973) concept of strict cyclicity, most phonologists have assumed that limitation to derived contexts is a property of cyclic rules. However, not all cyclic rules are subject to the derived-context limitation. Rules which build prosodic structures (such as metrical accent trees, syllable structures, or tonal patterns) may apply cyclically in non-derived contexts. According to Kiparsky 1982, it is only the class of cyclic structure-changing rules that are limited to derived contexts.

The issue of strict cyclicity becomes relevant to the analysis of Slovak vowels when we realize that diphthongization applies in a non-derived environment in forms like *hniezd-a* 'nest', *kôr-a* 'bread crust', and *rias-a* 'cassock'. As we have seen, the *SPE* analysis must derive these roots from [hne:zd], [ko:r], and [rä:s] in order to avoid duplication in the analysis of long vowels and diphthongs. In this section we provide strong reasons to believe that the Slovak diphthongization rule is restricted to derived contexts, and hence is a lexical cyclic rule. But if this is so, then the rule may not apply in the derivation of forms such as *hniezd-a*, *kôr-a*, and *rias-a* and their diphthongs must be considered to form part of the underlying representation of these morphemes. The consequences of underlying diphthongs with respect to the duplication problem will be explored in the subsequent section.

The problem with the analysis developed in §1 is that it is limited to the etymologically native vocabulary. When the data base is expanded to include etymological loanwords, the analysis encounters a serious problem. Contemporary Slovak has literally hundreds of lexical items like those in 8, with long mid vowels. There is no tendency whatsoever to diphthongize these vowels:

(8) *aféra* 'affair', *metóda* 'method', *drén* 'drain', *premiéra* 'premiere', *majonéza* 'mayonnaise', *anténa* 'antenna', *téma* 'theme', *bazén* 'pool', *chlór* 'chlorine'.

A proponent of the *SPE* analysis might claim that these items have not been integrated into the Slovak grammatical system, and thus are exempt from the native rules. This response is untenable, however, for two reasons. First, from a purely synchronic viewpoint, there is no way independent of the presence of [e: o:] to identify these words as being of foreign origin: they are otherwise composed entirely of segments that appear in the phonological inventory of Slovak, and many conform to the canonical root shapes of the native vocabulary. Second, by any legitimate test, these lexical items have been thoroughly integrated into the morphological and phonological systems of the language. For instance, they take the same inflections as native items (9a), and appear with many of the more productive native derivational suffixes (9b–c):

(9) a.	*magnet*, pl. *magnet-y*	Cf. *dom* 'house', pl. *dom-y*
b.	*magnet-ov-ý* 'magnetic'	*dom-ov-ý* 'domestic'
c.	*Švéd* 'a Swede'	*Čech* 'a Czech'
	švéd-sk-y 'Swedish'	*česk-ý* 'Czech'
	švéd-č-in-a 'Swedish language'	*češ-t-in-a* 'Czech language'

More significant still is the fact that these items regularly induce rhythmic shortening in suffixes such as *-ách*, *-ý*, and *-ého*; also, they may lose their length before such derivational suffixes as the agentive *-ár*:

(10) a.	*majonéz-a*	*antén-a*	*epizód-a*	Cf.	*par-a*	(nom.sg.)
	majonéz	*antén*	*epizód*		*pár*	(gen.pl.)
	majonéz-ach	*antén-ach*	*epizód-ach*		*par-ách*	(loc.pl.)
	'mayonnaise'	'antenna'	'episode'		'pair'	

b.	*šofér*	*makarón-y*			
	šofér-sk-y	*makarón-sk-y*	Cf.	*dobr-ý*	(adj., nom.sg.)
	šofér-sk-eho	*makarón-sk-eho*		*dobr-ého*	(gen.sg.)
	'chauffeur'	'macaroni'		'good'	
c.	*biblioték-a*	*betón*			
	bibliotek-ár	*beton-ár*			
	'library'	'cement'			

There is thus every reason to believe that many of these etymological borrowings have been thoroughly integrated into the Slovak lexicon. But if so, why do the items in 8 not diphthongize? Failure to diphthongize is understandable if the rule is cyclic, and hence subject to the derived-context requirement. Particularly significant in this regard is the fact that etymological loanwords do systematically undergo diphthongization in certain contexts. Like all the other rules we developed in §1, gen.pl. lengthening applies quite regularly to many etymological loanwords. When the vowel is mid, it systematically appears as the corresponding diphthong:

(11)	NOM.SG.	GEN.PL.	
	gitar-a	*gitár*	'guitar'
	fabrik-a	*fabrík*	'factory'
	legend-a	*legiend*	'legend'
	omelet-a	*omeliet*	'omelette'
	bomb-a	*bômb*	'bomb'
	kompozít-um	*kompozít*	'compound'

It is thus not possible to claim that diphthongization is blocked in words of foreign origin. On the contrary, it applies quite systematically to such items, provided that the long vowel is derived by the application of a preceding lengthening rule. But this discrimination between application in 11 and blockage of the rule in 8 is exactly what we expect if diphthongization is a cyclic lexical rule. The vowel length in *afér-a* 'affair' is part of the underlying representation, and hence is not visible to the diphthongization rule. But the rule can see the length in, e.g., gen.pl. [omele:t] (from *omelet*), since this length is assigned by a prior rule operating on the same cycle.

If diphthongization is a cyclic rule and hence limited to derived contexts, then the diphthong of the roots in *hviezd-a*, *rias-a*, and *kôr-a* must be present in their underlying representations. On the one hand, positing an underlying diphthong in these items might be considered a positive step: the representations become less abstract than the *hve:zd*, *rä:s*, *ko:r* of the *SPE* analysis, where the long vowel is not justified by alternations. But on the other hand, there are two drawbacks to this move. First, if diphthongs are underlying, then we encounter the duplication problem mentioned in the last section. The shortening in *hvezd-ár* 'astronomer' would have to be implemented by a deletion rule, while that in *bibliotek-ár* 'librarian' (cf. *biblioték-a*) would have to be treated by a feature-changing operation. Second, the introduction of diphthongs into the underlying inventory of segments disrupts the symmetry of the system.

3. REPRESENTATIONS. In this section we show that the problems just noted can be solved in a natural way by appeal to the three-dimensional model of phonological representation—in particular its distinction between segmental, skeletal, and syllable tiers. We show how the grammar of Slovak may contain underlying diphthongs, and yet be able to state the parallel with long vowels without duplication. We also show that, even with underlying diphthongs, we can still maintain a completely balanced inventory of underlying vocalic segments. Our account relies crucially at a number of points on the three-way distinction of tiers.

As articulated by Clements & Keyser 1983, Levin 1985, and others, the skeletal tier consists of a sequence of empty slots (marked by C and V, or X) to which elements of the segmental tier are autosegmentally associated. In this model, the contrast between short and long *a* can be represented as identical structure on the segmental tier, with a difference of one vs. two positions of phonological timing on the skeletal tier:

(12) segmental tier *a* *a*

skeletal tier X X X

With this representation, the *SPE* feature [±long] can be eliminated. Phonological quantity thus becomes a geometric relation between elements of the segmental and skeletal tiers (Leben 1980). Like other autosegmental tiers, the syllable is projected on the skeletal tier. Following Kaye & Lowenstamm 1984 and Levin 1985, we assume that the syllable is to be characterized as an X-bar projection of the primitive category 'N[ucleus]'. (The terms 'onset' and 'coda' are then nothing but names for the complement of the first and second projections of N.) A Slovak word like *rád* 'order' will have the representation of Figure 1.

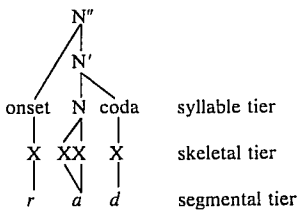


FIGURE 1.

One motivation for introducing the syllable into phonological representation is the possibility of dispensing with the problematic feature [± syllabic]. Contrast between syllabic and non-syllabic liquids and nasals, for example, can be treated not as a feature distinction, but simply as a function of whether or not the liquid appears under N in the representation of the syllable (Selkirk 1984). Slovak is interesting in this respect, in that it has a fully developed system of syllabic liquids which precisely parallel vocalic segments with respect to the various length alternations discussed earlier. In particular, syllabic liquids

lengthen in the gen.pl. (13a) and before the diminutive suffix (13b). They trigger the Rhythmic Law (13c), and they lose their length before the same class of derivational suffixes (13d):

(13) a.	*srn-a*	'deer'	*sŕn*	gen.pl.
	jablk-o	'apple'	*jabĺk*	gen.pl.
b.	*chlp*	'hair'	*chĺp-ok*	dimin.
	vrš-a	'hill'	*vŕš-ok*	dimin.
c.	*krv-n-ý*	'bloody'	*kŕm-n-y*	'food'(adj.)
	dlh	'debt'	*dlž-ník*	'debtor'
	klb	'joint'	*klb-ik*	dimin.
d.	*predlž-i-t'*	'extend'	*predlž-ova-t'*	imperf.

We assume that the underlying representations of [srn] of 13a and of [kŕm] of 13c are as in Figure 2. The liquid [r] is associated with a skeletal slot of the nucleus, and thus will be phonetically implemented as a syllabic liquid. With this representation for the syllable, the various lengthening and shortening rules operative in 13 and earlier can now be defined as operations to insert or delete a nuclear skeletal slot. These rules need refer only to the relation between the syllabic and skeletal tiers. The particular segmental material with which the nuclear slots are associated is of no relevance to the operation of these prosodic rules. In this way the parallel behavior of long/short vowels and of long/short liquids—phonemes which share few features on the segmental level—is captured in a very natural way.[5]

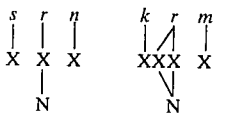
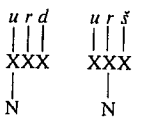


FIGURE 2.

As we have just seen, elimination of the feature [±syllabic] entails that the distinction between syllabic [l̩] and non-syllabic [l] is a function of the representation—whether or not the segment is dominated by the nucleus. Phono-

[5] As in other languages with syllabic sonorants, the distribution of the Slovak syllabic liquids is largely predictable. These segments are only found between consonants. Curiously, they are barred word-initially before a consonant (perhaps because this is an 'extrametrical' position): *lkat'* 'to moan' and *rmut* 'sediment' are monosyllabic. Also, liquids are assigned to the syllabic nucleus only when an adjacent non-high vowel is not available. We know of no cases where a syllabic liquid appears adjacent to *a e o*. On the other hand, for the less sonorous [u] there are at least a few minimal pairs such as *urd-a* 'sweet whey', *úrd* (gen.pl.) vs. *vrš-a* 'hill' (cf. *vŕš-ok* dimin.) We argue in the text immediately below that [v] derives from [w], which is segmentally identical with [u]; the contrast between [u] and [w] is a function of nuclear vs. non-nuclear position. If this is correct, then these morphemes have the same segmental structure *urC*; the contrast is in the relation of the *ur* substring to the nuclear skeletal slot:



logical alternations between high vowels and the corresponding glides are often distributed similarly (e.g. in Indo-European); and so a natural step in the evolution of the three-dimensional model has been to construe the contrast of [i] vs. [j] and [u] vs. [w] in geometric terms as well: specifically, as [+high, −cons] segments dominated by nuclear or non-nuclear positions. Slovak is particularly relevant to this geometric issue because it has a three-way distinction in the treatment of sequences of certain vocalic segments. Consider this minimal triple:

(14) *klient* 'customer', *tried-a* 'class', *jednak* 'yet'.

In the word *klient*, the *i* and the *e* constitute the nuclei of two separate syllables, while in *tried-a* and *jednak* they are tautosyllabic. (Among other things, this contrast is crucial to locating the initial syllable stress of Slovak). In our model, this contrast can be represented straightforwardly as in Figure 3.

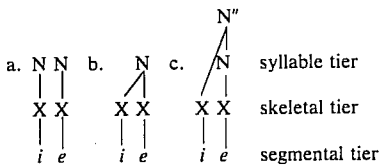


FIGURE 3.

These representations are identical at the segmental level, and differ solely in the ways the skeletal slots are organized into syllables. In (a), the two slots are assigned to the nuclei of two separate syllables; in (b), both X slots are members of the same nucleus; in (c), the *i* is part of the syllable onset, and thus is interpreted phonetically as the glide [j]. A similar contrast also exists underlyingly for sequences of [uo] in Slovak. This is masked slightly by the fact that Slovak realizes [w] as the fricative [v] when in onset position: cf. *dvor* 'court' vs. *dôraz* [duoras] 'emphasis'. Derivation of [v] from the semivowel [w] is motivated by, e.g., the fact that the regular Slovak rule which regressively assimilates voicing in obstruent clusters does not apply before [v]: cf. *dvor* 'court' vs. *tvor* 'creature'.[6]

[6] There has been some controversy in the Slovak literature on the existence of a phonetic contrast between the diphthongs *ie* and *ia* vs. the glide–vowel sequences *je* and *ja*. Hála 1929 denied the contrast, and claimed that the distinction was merely orthographic. This contention was vigorously disputed by Jakobson 1931. We hear a difference in the speech of our consultant.

We should point out, however, that distributional gaps make the citation of minimal pairs difficult. First, *ie* and *ia* do not occur word-initially in Slovak. This gap is explicable on diachronic grounds: the diphthongs *ie ia* are the lengthened reflexes of oral **e* and nasal **ę*, respectively, but these phonemes were barred from initial position in Common Slavic. Furthermore, since the long vowels of loanwords fail to diphthongize, the word-initial gap has not been filled through subsequent lexical borrowing. Postconsonantal position also manifests distributional gaps: dental or velar plus jod sequences have merged to palatals, and so the contrast of diphthong vs. glide+vowel is only possible after labials (Isačenko 1968 cites *obiehat'* 'to circulate' vs. *objektív* 'objective') or after a prefixal consonant (as in other Slavic languages, most phonological rules are suspended at the prefix–root boundary; cf. *ziabnut'* 'to freeze' vs. *zjavit'* 'to appear' from underlying *z[javit']*).

The rich phonology of the Slovak syllabic nuclei permits us to bring a number of factors to bear on the validity of this interpretation of the opposition between *i u* and *j w*. (Many of the following observations were made by Jakobson 1931). First, if the [+high, −cons] segment is part of the onset, then we expect (other things being equal) that it should be able to combine with any vocalic nucleus—since, in general, syllable onsets and rimes collocate freely. However, as we have seen, the inventory of Slovak rising diphthongs is limited to *ie ô ia*. The data confirm this expectation:

(15)	*jasný*	'bright'	*var*	'boiling'
	jednak	'still'	*vek*	'century'
	jota	'jot'	*voda*	'water'
	junák	'youth'	*vulkán*	'volcano'

Second, if the various Slovak length-sensitive rules are defined on syllabic nuclei, as we have proposed, then we predict that while *ie ô ia* count as long, sequences like [ja je wo ...] will count as short—since the glide is, by hypothesis, part of the syllable onset. The data in 16 confirm this prediction as well. The diphthongal roots trigger application of Rhythmic Law shortening to the suffixes *-ý* and *-ách*, while roots with a glide plus short vowel do not:

(16)	a.	*jasn-ý*	'bright'	*piat-y*	'fifth'
	b.	*jedl-o*	'meal'	*tried-a*	'class'
		jedl-ách	loc.pl.	*tried-ach*	loc.pl.
	c.	*svork-a*	'pack'	*kôrk-a*	'bread crust'
		svork-ách	loc.pl.	*kôrk-ach*	loc.pl.

Finally, if the [+high, −cons] segment is part of the onset, then it should be able to combine freely with a long syllabic nucleus—either underlying (16a) or derived (16b). But since *ie ô ia* themselves only occur in long nuclei, their existence is not compatible with an additional lengthening. Hence, roots with an underlying diphthong remain unmodified in lengthening contexts such as the gen.pl. (16b–c). Finally, we predict that a heterosyllabic sequence of vocalic segments will permit the second element to lengthen (16d):

(17)	a.	*Ján*	'John'			
		júl	'July'			
		kvóta	'sum'			
		vôl	'ox'			
	b.	*jam-a*	'hole'	Cf.	*rias-a*	'cassock'
		jám	gen.pl.		*rias*	gen.pl.
	c.	*vod-a*	'water'		*kôr-a*	'bread crust'
		vôd	gen.pl.		*kôr*	gen.pl.
	d.	*pian-o*	'piano'			
		pián	gen.pl.			

Our analysis assigns the underlying representations of Figure 4 (overleaf) to the gen.pl. forms *jám, rias*, and *pián*. Since lengthening adds an extra X-slot under the nucleus, increasing the degree of the N node from one to two, the rule may apply in *jám* and *pián*. But the rule must be blocked from applying in *rias* since the nucleus is already long in this representation.

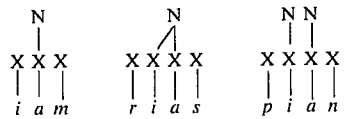


FIGURE 4.

We can achieve the desired effect by simply stipulating that a nuclear node may dominate at most two skeletal slots. If we also assume that it must dominate at least one slot, merely in order to exist, then we achieve the effect of the binary opposition mentioned earlier as the major advantage of the feature representation for length. The failure of another vocalic segment to be added in the representation of *rias* is now explained in a natural fashion as a restriction on the size of a prosodic unit. In a purely linear framework like that of *SPE*, such a restriction amounts to no more than an arbitrary limit on string length.[7] The two-mora restriction on syllabic nuclei implies there will be no true triphthongs—a prediction which, as far as we know, is not contradicted empirically.

To summarize, we see that the length-sensitive rules in Slovak simply look at the syllable and skeletal tiers to determine if the nucleus dominates one or two slots. Which phonemic segments are linked to these slots has no bearing on the operation of the prosodic rules. Before formulating these rules, however, we must consider more closely how the Slovak diphthongs are to be represented.

Other than by simple concatenation, diphthongs seem to arise from two forces: (a) a centripetal force, attracting elements together (often to the same skeletal point, to create the monophonematic diphthongs of Trubetzkoy 1939 or the light diphthongs of Kaye 1981); and (b) a centrifugal force, projecting a feature from a core to create a glide element. The glide is characteristically oriented in the same direction with respect to the core throughout the entire system of diphthongs, as either onglide (Slovak) or offglide (English, Canadian French). It is natural to construe this left–right orientation as fixing a parameter of the representational system. As noted, the inventory of Slovak diphthongs is composed of *ie uo ia*. We have also seen that the rule which backs *ä* to *a* after non-labials (cf. 2) motivates deriving *ia* from [iä]. Thus the inventory is really [ie uo iä]. It is now apparent that the onglide of the diphthong is predictable from the core—as front *i* with a front vowel core, and back *u* with a back vowel core. This principle is incomplete, however, since only three of the six vocalic phonemes are matched by diphthongs. While the absence of [i̯i] and [u̯u] might be seen as an effect of the Obligatory Contour Principle (McCarthy 1986), it is unclear why *a* has no onglide. The same restriction is found in other languages and is perhaps characteristic of centrifugal diphthongs in general, suggesting that a deeper principle is at work. Another problem is

[7] The limitation to two is probably the reflection of a more general principle. When a limitation is imposed on some linguistic structure, the limitation generally involves the number two—e.g., the number of tones per tone-bearing unit; the number of segments per skeletal slot, the number of syllables in a bounded metrical foot, the number of thematic roles assigned by a predicate. At least some of these cases might be subsumed under an adjacency requirement. (See Berwick & Weinberg 1984 for discussion of the general point.)

that the combination of *e o ä* to the exclusion of *a* is difficult to state in distinctive features, and requires recourse to a complex Boolean expression.

This asymmetry finds a natural interpretation in the theory of vocalic systems sketched by Kaye, Lowenstamm & Vergnaud 1985 (hereafter KLV). The idea behind this theory is that vocalic systems are the outgrowth of the algebraic combination of the primitive elements *a i u*. More complex systems are built by licensing certain combinations. For our purposes we need only know that $e = a^*i$, $o = a^*u$, and $ä = i^*a$, where the asterisk denotes the basic algebraic operation of the KLV theory. From this viewpoint, we see that *e o ä* each have a high vowel component that the primitive *a* lacks. It is a natural step to trace the onglide of the Slovak diphthongs from the high vowel element of *e o ä*.

Developing this idea further, let us suppose that Slovak syllabic nuclei are organized as metrical structures, with a head position on the right that governs its satellite sister slot (if it exists) to the left. Just as tones tend to associate to a metrically prominent position, we assume that vocalic phonemes do as well. The onglide of the diphthong can be produced by simply linking the governed skeletal slot to the high vowel element of the vocalic segment associated with the head, as indicated in Figure 5.

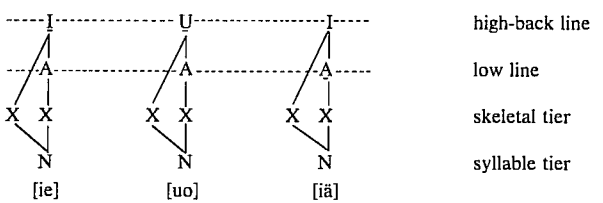


FIGURE 5.

The KLV theory assumes that the elements are displayed on lines; certain elements, such as [I] and [U], are permitted to occupy the same line, blocking their fusion to produce [ü]. The underlining of an element designates the element appearing on the right in the binary * operation. Thus both [e] and [ä] are composed of [I] and [A], but in different 'orders' (* is not a symmetric operation.) Given this system, the Slovak diphthongs will emerge if we simply permit the satellite slot of the syllable nucleus to link to the element located on the high-back line of Fig. 5.

When the head of the nucleus is associated with a high vowel [i u], linkage of the satellite to the high element produces a representation equivalent to a geminate [ii] or [uu]. Thus the absence of [i̯i u̯u] diphthongs is predicted; see Figure 6.

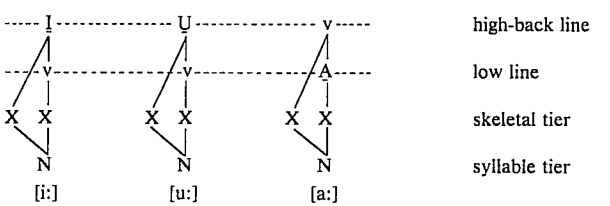


FIGURE 6.

Finally, since [a] has no high vowel element, the nuclear satellite position cannot be filled by association to such an element.[8] We assume that it then associates to the [A] element itself, perhaps 'by default'. Although KLV do not say so explicitly, it is natural to suppose that the elements form a hierarchy in which [A] is deeper than [I] and [U]. We might then propose that linkage to a deeper element implies linkage to all of the other elements above it in the hierarchy. (See Archangeli 1985 for a similar idea in the treatment of Yokuts vowel harmony). If so, then we can derive [e: o:] simply by linking the satellite to the [A] element, as in Figure 7.

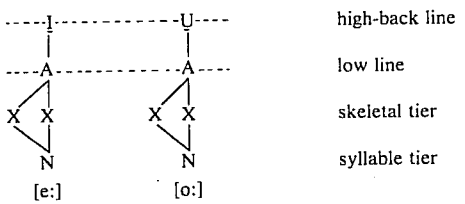


FIGURE 7.

Our discussion in §2 leads to the conclusion that the Slovak [ie uo iä] diphthongs are 'marked' elements. We know that they arose historically from long [e: o: ä:], creating a hole in the inventory of long vocalic segments that has been filled through the incorporation of recent loanwords into the system. We have interpreted this development as an indication that diphthongization is a lexical rule, limited to derived contexts; as a consequence, diphthongs are present in underlying representations. The marked status of [ie uo iä] finds a possible explanation if we assume that the low vowel [A] is in some sense a stronger, more prominent element than the high vowel [I] and [U] elements.[9] Given a complex mid vowel segment combining the low element [A] with the high element [I] or the back element [U], we postulate that a free nuclear slot will link to the more prominent [A] element in the unmarked case, yielding a long vowel. Linkage to the high vowel element, in preference to the [A], is then a more complex state of affairs and requires stipulation. Descriptively, the satellite X slot in diphthongs like [ie uo iä] must be prelinked in the underlying representation. For the long mid vowels *e:* and *o:*, linkage to the more prominent [A] element will arise when the default option operates postlexically. The underlying representations of the syllabic nuclei in such forms as *Grék* 'Greek' and *riek-a* 'river' are thus as in Figure 8, (a) and (b) respectively, under this analysis.

[8] Actually, the high-back line is occupied by the 'cold' vowel [v] in the KLV theory. However, the cold vowel may never dominate a branching structure (Lowenstamm 1986); thus linkage of the satellite slot to the high-back line in *a* is excluded in principle.

[9] In the KLV theory, [A] has positive 'charm' in comparison to the negatively charmed [I] and [U], and thus has a special status in the system.

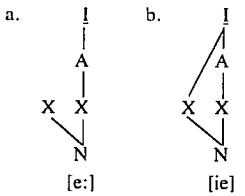


FIGURE 8.

Since [ie uo iä] also arise from the lengthening of underlying short vowels *e o ä*, we must stipulate the linkage of the free nuclear X slot as a lexical rule:

(18) Link a free nuclear X slot to the high back line of the head.

This diphthongization process is a lexical rule and hence is limited to derived contexts, as discussed in §2. It will apply to the derived long vowel arising in such gen.pl. forms as *žien* 'woman', but will be blocked on the free X slot of *Grék* in Fig. 8(a). The latter will follow the default option of linkage to the most prominent [A] element. This analysis restricts the [ie uo iä] diphthongs to the lexicon; it thus predicts that, if long vowels were to arise postlexically in Slovak, then a lengthened *e* should appear as [e:] and not as [ie]. To the best of our knowledge all Slovak lengthening rules are lexical processes; so, unfortunately, this prediction cannot be tested.

Let us briefly summarize our analysis of the Slovak diphthongs. The key proposal is that syllabic nuclei are metrical constituents, in which an obligatory head governs an optional satellite slot. This assumption permits us to construe the two-mora limitation on syllabic nuclei as another example of a government-adjacency requirement, familiar from other aspects of linguistic structure. More importantly, recognition of a head position is essential to understanding the coherent structure which the Slovak diphthongs display at various points in the grammar. First, assuming that the more sonorous core is associated with the nuclear head, we understand why the glide consistently appears on the left in the underlying inventory [ie uo iä]. Second, shortening of [ie uo iä] to *e o ä* can be interpreted as simply the elimination of the governed nuclear slot. Finally, the diphthongization process by which *e o ä* are converted to [ie uo iä] in lengthening contexts can be interpreted as simple augmentation of the syllable nucleus. Since Slovak heads govern to the left, the added slot predictably appears as an onglide rather than an offglide.

The claim that syllabic nuclei are headed constituents raises a number of general questions. Is the location of the less sonorous glide a reliable indicator of which nuclear slot is the head, and which is the governed position? When a nucleus shortens, is it in general the less sonorous glide that is eliminated? Can other phenomena, such as tone, be used to detect the head position? If the left–right orientation of the governing head is a parameter, is there an unmarked setting? Can diachronic alternations between, e.g., [ei] and [ie] be viewed as differences in the parameter setting, permitting us to dispense with at least some cases of metathesis as an independent category of phonological

change? These are some of the interesting questions for future research that are raised by viewing syllabic nuclei as headed constituents.

One more point remains to be made with respect to the Slovak diphthongs. Crucial to our metrical account has been the assumption that the centrifugal diphthongs arise from designating the second nuclear position as head. It therefore comes as a surprise that Slovak also has diphthongs like [ei ou ai]. Given our assumptions, these must be 'fake diphthongs', arising from the simple concatenation of a short nucleus with a coda position associated to a [+high, −cons] segment—essentially the inverses of the onset diphthongs [ja] and [vo] (=[uo]) described above. We can easily verify the validity of this interpretation by seeing whether these fake diphthongs display the properties of [je] vs. [ie] mentioned earlier. First, as the following data show, this class of diphthongs comprises the essentially free combination of any vowel plus glide:

(19) a.	*pravda*	[prau̯da]	'truth'
	slovko	[slou̯ko]	'word'
	obuv	[obuu̯]	'footware'
	krv	[kru̯]	'blood'
	krivda	[kriu̯da]	'injury'
	eunuch	[eu̯nux]	'eunuch'
b.	*tajga*	[taj̯ga]	'taiga'
	kujný	[kuj̯ni:]	'forgeable'
	judejský	[judej̯ski:]	'Judean'

Second, unlike true diphthongs, those in (19) do not trigger rhythmic shortening. Compare the fake diphthongs on the left in (20) below with the true diphthongs (or long vowels) on the right:

(20) a.	*tajg-a*	'taiga'	*miazg-a*	'sap'
	tajg-ách	(loc.pl.)	*miazg-ach*	(loc.pl.)
b.	*judej-sk-ý*	'Judean'	*soviet-sk-y*	'Soviet'
c.	*slovk-o*	'word'	*kôr*	'bread crust'
	slovk-ách	loc.pl.	*kôr-ach*	(loc.pl.)
	[slou̯ka:x]		[kuorax]	
d.	*obuv-ník* [obuu̯n'i:k]	'cobbler'	*kút-ik* [ku:t'ik]	'corner' (dim.)

Thus the contrast between the [ou] of *slovk-ách* and the [uo] of *kôr-ach* follows if they are assigned the representations in Figure 9. In *kôr-ach*, the [uo] sequence appears entirely under the nucleus node; but the [ou] sequence in *slovk-ách* spans the boundary between the nucleus and the coda of the syllable. Since the Rhythmic Law operates on successive long syllabic nuclei, no shortening occurs in *slovkách*.

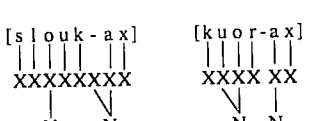


FIGURE 9.

If fake diphthongs do not trigger the Rhythmic Law—because they are not integral components of the syllabic nucleus—then we also predict that they will not undergo rhythmic shortening, since this rule is defined solely on the nuclei of adjacent syllables. Jakobson 1931 cites phrase 21 to illustrate this point. Note that the instrumental case suffix [ou] remains unchanged after a long syllable:

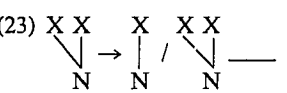
(21) *za nízk-ou hriadk-ou* 'behind a low garden-wall'

Finally, as we would also expect if the glide in these fake diphthongs is in the coda, the preceding nuclear vowel may appear as long—either underlyingly so (22a), or by virtue of lengthening in the gen.pl. (22b):

(22) a.	*dávka*	'portion'		
b.	*pravda*	'truth'	*tajga*	'taiga'
	právd [pra:u̯t]	(gen.pl.)	*tájg* [ta:j̯k]	(gen.pl.)

To summarize: we have proposed an analysis of the segmentally complex syllabic nuclei of Slovak. These include not only long and short vowels, but also liquids and diphthongs, all of which participate in an intricate system of quantitative alternations. In accordance with the non-linear methodology, we have reduced the complexity by factoring the representations into three levels: the segmental, skeletal, and syllabic. We propose that the syllabic nucleus consists of a right-headed binary structure. The quantitative alternations consist in the addition or elimination of a sister slot to this head. In this way we unite the simplification of diphthongs with the shortening of long vowels and liquids, and solve the duplication problem noted at the outset of this section. These are equivalent operations at the prosodic level. We also retain a simple segmental inventory of six vocalic phonemes *i u e o ä a*, each of which can be long or short. The diphthongs [ie uo iä] arise from representations in which the satellite nuclear slot is linked to the high-back line, bypassing the default option which links this slot to the low line. This analysis claims, correctly we believe, that [ie uo iä] are more complex than the corresponding long vowels [e: o: ä:].

It is possible to formulate the Rhythmic Law as a rule to eliminate the satellite of a long nucleus when preceded by a long nucleus, as in 23.[10] We postpone formulation of the vocalic lengthening rule until the next section.[11]

(23) 

[10] Alternatively, and more in keeping with its name, we might view the Rhythmic Law in metrical terms. If we follow Prunet & Tellier 1985 and permit the quantitative structure of the syllable to be altered as a result of the imposition of a metrical structure, then the Slovak rhythmic shortening could be interpreted as a side effect of the construction of left-headed binary feet. Since the recessive position in a foot may not branch, the second of two long syllables will shorten. Discussion of this alternative would take us too far afield, and we shall not pursue it here.

[11] One of our referees has called our attention to an important paper by Birnbaum 1981 which anticipates some of our results in this section. Birnbaum criticizes the *SPE*-based analysis of Ken-

4. JERS. Like all other Slavic languages, Slovak has a set of vowels that display different properties from those we have considered so far. In particular, they alternate with zero in specific contexts. In the generative literature these vowels have been referred to as 'jers', following the name of their historical reflexes in Common Slavic. Consider the masculine nouns below:

(24) a.

NOM.SG.	GEN.SG.	
pes	*ps-a*	'dog'
semester	*semestr-a*	'semester'
ovos	*ovs-a*	'oats'
bahor	*bahr-a*	'wheel rim'

b.

les	*les-a*	'forest'
jeseter	*jeseter-a*	'sturgeon'
povoz	*povoz-u*	'carriage'
bachor	*bachor-a*	'belly'

Although both groups exhibit phonetically identical vowels in the final syllable of the stem in the nom.sg., the root vowel is missing in the gen.sg. (and all other inflected forms) of the first group, but retained in the minimally different stems of the second. Feminine and neuter nouns show a similar alternation, this time with the jer appearing in the gen.pl., where it is lengthened (25a). Derivational suffixes such as diminutive *-ok* and agentive *-ec* also exhibit the alternation (25b):

(25) a.

NOM.SG.	GEN.PL.	
okn-o	*okien*	'window'
ihl-a	*ihiel*	'needle'
sosn-a	*sosien*	'pine'

stowicz 1972, and argues for the existence of an underlying diphthong *iu*. Since this diphthong sometimes appears as *u* under Rhythmic Law shortening, Birnbaum proposes a prosodic formulation of the rule that is essentially equivalent to our 23. We agree with Birnbaum's conclusion that the Rhythmic Law is formulated to delete the first mora of a long syllabic nucleus, but we disagree with his analysis of [iu]. However, we postpone this discussion to §5.

Birnbaum also reports that his two consultants showed no effective phonetic distinction between the rising diphthongs [ie uo ia] and a sequence of *j* plus short vowel. We have already commented on this issue in fn. 6. We hear a difference in the speech of our consultant; a dialect difference may be in operation. All this is relevant to the following interesting result reported by Birnbaum. He mentions a language game based on the insertion of the consonant [p] plus a copy of an adjacent vowel. For short vowel words such as *bud'* (disguised as *bupud'*), it is unclear whether the game inserts [pV] after the syllable nucleus or *Vp* before the nucleus. Birnbaum argues for the latter analysis on the basis of long vowels: *chorá* is disguised as *choporapá*, not *choporápá* or *choporápa*. If we assume that the position of the long vowel remains constant, then the disguise must be interpreted as inserting *Vp* before the nucleus. We might therefore expect that a word with a rising diphthong such as *biely* would be disguised as *bipielypy*, with *Vp* inserted before the nucleus. In fact this is wrong. Birnbaum's consultant consistently placed a *pV* sequence after the rising diphthong: *biepelypy*. This is a surprising contrast in a system which otherwise treats long vowels and rising diphthongs equivalently. Birnbaum's explanation is to invoke a rule which resyllabifies the onglide of a rising diphthong into the syllable onset. At the point where the speech disguise operates, the onset–nucleus structure of the initial syllable of *biely* is *bi+e*. Insertion of *Vp* between the onset and nucleus will then correctly yield *biepelypy*. The rule which resyllabifies the onglide thus not only explains the otherwise aberrant behavior of the diphthongs in the speech disguise, but also accounts for the phonetic impression of the diphthongs as equivalent to jod plus short vowel. It remains to be seen how widespread this resyllabification of the onglide is.

b.

líst-ok	*líst-k-a* (gen.sg.)	'leaf'
hoviad-k-o	*hoviad-ok* (gen.pl.)	'beast'
bor-ec	*bor-c-a* (gen.sg.)	'fighter'
jazd-ec	*jazd-c-a* (gen.sg.)	'rider'

Following traditional parlance, we shall refer to the phonetic realization of the alternating *e–Ø*, *o–Ø* segments as 'vocalization' of the jers. So far we have seen examples where the jer is vocalized in word-final syllables and deleted elsewhere (i.e. before a case suffix). However, jers are also vocalized before some, but not all, derivational suffixes:

(26) a.

ihl-a, gen.pl. *ihiel*	'needle'	*ihl-an*	'pyramid'
ihiel-k-a, gen.pl. *ihiel-ok*	diminutive	*ihl-ov-ý*	adjective
ihel-ník	'pincushion'	*ihl-ár*	'needle maker'

b.

palec, gen.sg. *palc-a*	'thumb, finger'	*palc-ov-ý*	'finger' (adj.)
paleč-n-ý	'thumb' (adj.)		

c.

okn-o, gen.pl. *okien*	'window'	*okn-ár*	'glazier'
okien-k-o, gen.pl. *okien-ok*	diminutive	*okien-c-e*	dimin.
oken-n-ý	adjective		

The stems *ihel, palec*, and *oken* have jers in their final syllables. In addition to being vocalized when no overt case suffix follows, the jers also surface before diminutive *-ok*, adjectival *-en*, and nominal *-ec*. Jers are systematically deleted before such suffixes as *-an, -ár*, and *-ov*. A deep-seated generalization distinguishes the class of suffixes which trigger vocalization of a preceding jer: these elements themselves contain a jer. Suffixes not containing a jer trigger the deletion of a preceding jer. A natural conclusion to draw is that the contexts where a jer appears to be vocalized in word-final position (i.e. nom.sg. of masculine nouns and gen.pl. of the feminines) also contain a jer as the case suffix. Then there is just a single generalization: jers are vocalized before another jer, and are deleted elsewhere. A further consequence is that there are no zero suffixes: all cases of the nominal inflection are marked by a suffix in the underlying representation. This analysis is also supported by the lengthening rule. Recall that certain suffixes, such as diminutive *-ok*, often trigger the appearance of length on the preceding syllable. Most of these suffixes contain jers. If the zero case suffixes are really marked by jers, then there is just one lengthening context: lengthen the syllable preceding a jer. This rule has many morphological and lexical restrictions. As we see below, the adjectival jer suffixes *-esk* and *-en* do not condition lengthening. Similarly, while the jer suffix of the gen.pl. regularly triggers lengthening, the nom.sg. masc. suffix does so in only a handful of stems, such as *nôž* and *mráz* (27b):

(27) a.

Boh	'God'	*mäs-o*	'meat'
bož-sk-ý	'divine'	*mäs-n-ý*	'meaty'

b.

nôž	'knife'	*mráz*	'frost'	*Boh*	'God'
nož-a	gen.sg.	*mraz-u*	gen.sg.	*Boh-u*	gen.sg.

The conclusion is that, like other Slavic languages such as Russian and Polish, Slovak has jers which are vocalized as *e o* before another jer, and are deleted otherwise. The obvious analytic problem which the jers pose is the assignment of a proper underlying representation. Since the patterns of vocalization and

deletion are so systematic, it is unreasonable to interpret the jer/zero alternation as simply a case of lexical allomorphy. The distinctive behavior of the jers must be attributed to a difference in their underlying phonological representation. In the *SPE* framework, where all phonological distinctions must be registered as distinct feature matrices in underlying representation, the jers must be distinguished from the other vowels by a feature difference. Most generative phonologists have adopted the solution to the problem first proposed by Lightner 1965 in his doctoral dissertation on Russian. Lightner distinguished the jers from the other vowels of Russian by introducing an underlying tense/lax (long/short) contrast, deriving the 'fleeting' (jers) [e o] from underlying lax (short) high vowels *i u* by rules which vocalize these elements as *e o* before another jer, and deleting them elsewhere. Although the appeal to the feature [±tense] (or [±long]) to distinguish the jers may seem arbitrary, Lightner's intuition was that lax, short, high vowels are especially likely to be deleted; in the absence of any other motivation, appeal to a feature like [±tense] is appropriate. Whatever the validity of positing an underlying tense/lax contrast that never appears on the surface for Russian, this sort of solution is particularly inappropriate for Slovak, which already has a long/short contrast. The jers are distinct from all other short and long vowels; consequently, some feature other than length must be sought to distinguish the jers in Slovak. However, there is a germ of truth in Lightner's proposal. An important clue to the jer behavior, we believe, lies in the fact that it is never necessary to posit long jers in the underlying representations of Slovak. Jers only appear as long in Slovak when they happen to be vocalized in a context where vowels are regularly assigned length by some independent rule (as in gen.pl. *okien*).

Given the three-dimensional model of phonological representation—in particular, its distinction between the segmental and the skeletal tiers—another approach to the problem posed by the jers is possible. Instead of seeing the contrast as a distinctive feature difference, we can profitably construe it as a difference in the geometry of the representational system. Two possibilities immediately suggest themselves. One is that jers differ from other vowels by constituting a skeletal slot without any associated vocalic phoneme on the segmental tier. A solution of exactly this form is proposed by Anderson 1982 for French shwa—which, although phonetically identical with [œ], patterns differently by alternating with zero in specific contexts. We might then pursue an analysis in which jers are bare syllabic nuclei which acquire a segmental realization by a default mechanism. Such a solution might work for Russian, where the choice of whether the jer takes the guise of [e] or [o] might be predictable from the palatalization of surrounding consonants. Analyses along such lines have been proposed by Farina 1985 for Russian and by Spencer 1986 for Polish. But this approach is not feasible for Slovak: palatalization has been lost in most contexts, and thus is unavailable to determine whether the bare skeletal slot is to be clothed as [e] or as [o].

There is of course a second possibility offered by the three-dimensional model, one which we suggest is correct—namely, that jers differ from other vowels in not being associated with an X-slot of their own in underlying representation. They acquire a skeletal realization only through the vocalization

rule, which will be formulated to provide them with an X-slot when the following syllable contains a jer. Letting the circled V stand for a vocalic segment which is unassociated with the skeletal tier, the vocalization rule can be expressed as follows:

(28) Ⓥ → V / ___ C Ⓥ
        |
        X

This solution has a number of advantages. First, an [e] that alternates with ∅ is identical with a non-alternating [e] in segmental content. Thus they will identically trigger such segmental rules as palatalization. We do not need to posit an abstract and essentially arbitrary feature difference to distinguish jers from otherwise identical vocalic segments. Our description now automatically explains why there are no long jers. Recall that, in the three-dimensional model, length is represented as the association of a single segment to two successive skeletal slots. If what is special about a jer is that it is not associated with any skeletal slot, then there is no way it can participate in a long-short opposition. Another argument is that, in principle, there is no reason why jers should be limited to the vocalic segments *e o*. Other things being equal, any other vocalic segment might be eligible to appear without a skeletal slot in the underlying representation. In fact Slovak shows some examples where the vowel *a* appears to participate in the jer syndrome: e.g. *dosk-a* 'board' has the alternate gen.pl. forms *dosiek* and *dosák*.

Our final argument for our solution is theory-internal, and follows from the LP assumptions which underlie the analysis. As we shall show in §6, there are good reasons to believe that the Rhythmic Law is a cyclic rule. Granting this assumption, consider the following data:

(29) a.	*riek-a*	'river'	*brigád-a*	'brigade'
	rieč-n-y	adjective	*brigád-n-y*	adjective
b.	*písm-o*	'letter'		
	písem	gen.pl.		
	písm-ach	loc.pl.		

We know from 26 that the adjectival suffix *-en* has an underlying jer, and so does the stem [písem]. What the data in 29 show is that the Rhythmic Law applies over a jer, as in underlying [písem-ách]. If we adopt an analysis in which the jers are associated with a skeletal slot, then the rule of jer deletion will have to be postcyclic, since it applies entirely within the scope of a single morpheme. But if the Rhythmic Law is cyclic, then, at the point of its application in [písem-áx], the two long vowels will not belong to adjacent syllables. Hence we expect the Rhythmic Law to be blocked; but it is not. The surface form of [písem-áx] is *písm-ach*. Note that any other non-jer vowel that intervenes between two long syllables suffices to block the application of the rule: e.g. *záhrad-ách*, loc.pl. of *záhrad-a* 'garden'. Only jers are skipped over. Skipping of the jers is not only unproblematic for our analysis, but in fact is just what we predict. Recall that one conclusion of the previous section is that the Rhythmic Law is a prosodic rule whose application is defined on the syllable/skeletal interface. The segmental tier plays no role in the application of the

rule. But if jers are not associated to the skeletal tier (as we have proposed), then, in the representation of [písem-áx], the *pís* and *ách* syllables will be adjacent and hence participate in rhythmic shortening; see Figure 10.

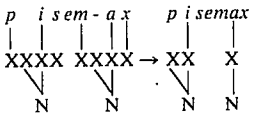


FIGURE 10.

However, if a jer does vocalize and hence acquire an X-slot, then it can inhibit application of the Rhythmic Law. This is exactly what we find in the adjectival form of *kríd-o* 'wing':

(30) *kríd-o* nom.sg.
kríde gen.pl.
kríde-n-ý adj. Cf. *rieč-n-y* 'river' (adj.)

Assuming that jer-vocalization is cyclic, we have the partial derivation in Figure 11. By the time the inflectional suffix *-ý* is added, the jer of the root will have been vocalized, and hence will inhibit application of rhythmic shortening.

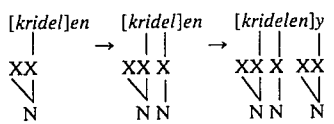
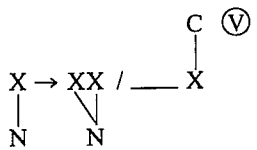


FIGURE 11.

Certain postlexical rules, such as voicing assimilation, apply to the output of jer deletion. It is in fact unclear whether jer deletion needs to be stipulated as a rule at all. Phonologists such as Steriade 1982 have proposed a convention called Stray Erasure: this deletes segments not attached to the skeleton at specific points in the derivation, such as the output of the lexical phonology. Under our analysis, unvocalized jers may be deleted by this convention. Finally, given this analysis of the jers, the rule lengthening a syllable before a jer may be expressed as in 31. When a syllabic nucleus is followed by a vocalic segment not linked to the skeletal tier, this rule augments it with another skeletal slot:

(31)



5. THE *iu* DIPHTHONG. This section has two goals. First, we provide an analysis for a final member of the set of Slovak diphthongs. This is *iu*; it stands outside the system of [ie uo iä] in terms of both structure and distribution. We show that *iu* arises from a rule of contraction, and thus has a different etiology

from [ie uo iä]. Our second goal is to begin building up some of the ordering relations among the rules that set the stage for §6, where we show that the set of lexical phonological rules in the grammar of Slovak constitutes a significant body of generalizations with a coherent formal structure.

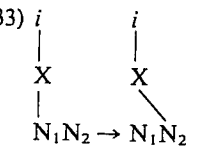
The *iu* diphthong appears at only two isolated points in the grammar of Slovak—as the inflectional affix in the dat.sg. of a certain class of neuter nouns, and as the suffix in the acc.sg. of a certain class of adjectives. In 32a, we cite a paradigm for neuter nouns. In 32b, we see the neuter paradigm for so-called 'soft' stems—ones that end in a palatalized or formerly palatalized consonant, such as the affricate [c]. Such stems trigger the fronting of the suffixal vowel in a number of cases by a special rule:

	(32) a.	b.	c.	
	mest-o	*srdc-e*	*písan-ie*	nom./acc.sg.
	mest-a	*srdc-a*	*písan-ia*	gen.
	mest-u	*srdc-u*	*písan-iu*	dat.
	mest-om	*srdc-om*	*písan-ím*	instr.
	mest-e	*srdc-i*	*písan-í*	loc.
	mest-á	*srdc-ia*	*písan-ia*	nom./acc.pl.
	miest	*sŕdc*	*písan-í*	gen.
	mest-ám	*srdc-iam*	*písan-iam*	dat.
	mest-ami	*srdc-ami*	*písan-iami*	instr.
	mest-ách	*srdc-iach*	*písan-iach*	loc.
	'town'	'heart'	'writing'	

The diphthong of interest to us in this section appears in the dat.sg. of a certain class of stems such as *písan-ie* 'writing', a resultative nominal built on the passive participle *písa-n-ý* 'written' nom.sg. (32c). The morphology of these forms comprises an *-i* suffix plus the fronted variants of the neuter case suffixes. We must stress that the sequences *ie ia iu* etc. in 32c are phonetic diphthongs which contrast sharply with such heterosyllabic sequences as the *ia* of *dialekt* 'dialect'.

It is fairly clear that the *iu* diphthong in 32c arises from a contraction of the suffix *-i* with the dat.sg. ending. The contraction rule is stated informally below. It assigns a skeletal slot associated with an *i* to an immediately following syllabic nucleus:

(33)



We are not interested here in trying to determine the precise details by which the merger of the two syllabic nuclei takes place. Note, however, that a contracted long vowel shortens, presumably through the occupation of its satellite position by the contracted *i*—a reflection of the fact that a syllabic nucleus contains at most two skeletal slots. We wish simply to establish that the *iu* diphthong arises by contraction and is thus not properly to be included with [ie uo iä] as constituting an organic diphthong of Slovak.

The other situation in which *iu* arises is quite parallel. Below we cite a few cases drawn from the adjectival inflection, where the suffixal vowels are long (34a):

(34)	M.NOM.SG.	F.NOM.SG.	F.ACC.SG.	
a.	*pekn-ý*	*pekn-á*	*pekn-ú*	'pretty'
	biel-y	*biel-a*	*biel-u*	'white'
b.	*holub-í*	*holub-ia*	*holub-iu*	'columbine'
	orl-í	*orl-ia*	*orl-iu*	'aquiline'

In 34b are examples of denominal adjectives formed on the bases *holub* 'pigeon' and *orol* (gen.sg. *orl-a*) 'eagle' by another word formation rule that suffixes *-i*. This suffix palatalizes a preceding dental (reflected in the spelling as *i* vs. *y*—cf. [orl'-i:] vs. [biel-i]). The acc.sg. fem. suffix is an underlying [-u:] which shortens when it contracts with the preceding *i*, producing the diphthong *iu*. We assume the derivation of Figure 12.

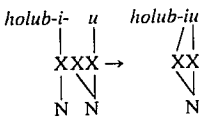


FIGURE 12.

Thus it is quite clear that *iu* has a special status in Slovak as compared to [ie uo iä]. The latter arise from the projection of a glide from the high vowel element of the core, while *iu* is the result of contracting two separately concatenated segments into a single syllabic nucleus.

Consider now these denominal adjectives:

(35)	M.NOM.SG.	F.NOM.SG.				
	páv-í	*páv-ia*	'pavonine'	Cf.	*páv*	'peacock'
	krokodíl-í	*krokodíl-ia*	'crocodilian'		*krokodíl*	'crocodile'
	kohút-í	*kohút-ia*	'rooster's'		*kohút*	'rooster'

All Slovak grammars cite these forms as exceptions to the Rhythmic Law. However, they are systematic exceptions. All denominal adjectives formed with the suffix *-i* fail to show rhythmic shortening. This rule interaction can be explained if contraction (33) is ordered after the Rhythmic Law. On this analysis, *kohút-ia* has the representation of Figure 13 at the point where the Rhythmic Law is applicable. There are no successive long syllables in Fig. 13, and so the rule does not apply. Subsequent contraction produces only superficial exceptions to the rule.

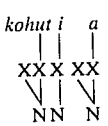


FIGURE 13.

As far as we have been able to determine, all forms arising from contraction fail to manifest Rhythmic Law shortening and thus receive a parallel explanation. To cite one more case, collectives are also formed by a suffix *-i*, which induces neuter inflection:

(36)						
	prút	'twig'		*tŕn*	'thorn'	
	prút-ie	'twigs'	nom.sg.	*tŕn-ie*	'thorns'	nom.sg.
	prút-ia		gen.sg.	*tŕn-ia*		gen.sg.
	prút-iu		dat.sg.	*tŕn-iu*		dat.sg.

Although his analysis is not spelled out in detail, Birnbaum (1981:10) apparently considers the diphthongs in 35–36 to arise via contraction. He also argues that there is an additional *iu* diphthong—one that must be treated as underlying. Since this diphthong, unlike those in 35–36, undergoes the Rhythmic Law, Birnbaum concludes that the latter must be formulated prosodically. As explained earlier, we agree with his conclusion, but do not agree that this diphthong is underlying. It appears in the neuter acc.sg. of soft-stem adjectives such as *cudz-iu* 'foreign' (cf. rhythmically shortened *svieže-u* 'fresh'). Here we appeal to a quasi-synchronic reflex of the historical origin of this *iu* diphthong. As mentioned earlier, the 'soft' stems terminate in palatalized or formerly palatalized consonants that trigger the fronting of certain case suffixes. Recall that, on our analysis, Slovak syllabic nuclei are right-headed structures. The initial mora of a long-vowel syllabic nucleus is a bare skeletal slot, postlexically linked to the vocalic element associated with the second mora. We therefore assume a rule which spells out this empty slot as *i* in the soft stems—either through autosegmental linking to the palatal element in the soft consonant itself, or by a special rule triggered by these consonants. In either case, it is clear that the *iu* diphthong is a derivative element, and thus has a status completely different from [ie uo iä].

6. LEXICAL PHONOLOGY AND THE RHYTHMIC LAW. As mentioned above, the leading idea of LP is that phonological rules are integrated with the W[ord] F[ormation] R[ule]s of the grammar, and thus apply in the lexicon (Kiparsky 1982). Each WFR creates a representation that is submitted to the ordered set of lexical phonological rules; their application gives as output a lexical item which may be resubmitted to the pool of WFR's to produce another lexical item. To take a simple example, consider the structure of *kohútia* 'rooster' (adj.) The base is the nominal *kohút*. The WFR which builds adjectives suffixes *-i* to give [kohút]*i*. This representation is submitted to the lexical phonological rules, among which is the palatalization rule mentioned earlier. Its application produces [kohút']*i*. This lexical item forms the base for the addition of such inflectional suffixes as the feminine sg. *-á*, producing [[kohút']*i*]*á*. This representation is then input to the same set of lexical phonological rules, which yield as output the contracted diphthong in *kohútia*. From this integration of the phonology with the morphology, it follows that the lexical phonological rules are inherently cyclic, with one cycle per level of affixation. Thus, from the LP perspective, the language learner is faced with learning the rules of the system and also with the task of determining the lexical/postlexical status of any given

rule. Several properties are diagnostic of lexical rules, and can be assumed to aid the learner in this task. The most important of these are:

(37) a. Cyclic application.
b. Limitation to derived contexts.
c. Sensitivity to lexical information.

Let us briefly discuss each of these from the perspective of the LP model, and as cues for determining rule status. As we have just seen, cyclicity follows from the decision to integrate the phonological rules with the WFR's. As far as diagnostic properties are concerned, the difference between cyclic and non-cyclic application in many phonological rules is not detectable by simple examination of the surface string. However, in certain cases cyclic application can have a material effect. Consider the structural change induced by the Rhythmic Law. Given a chain of long vowel affixes V:]V:]V:], cyclic application will shorten the first pair to yield V:]V]V:]. Shortening of the final vowel is now prevented, since it is no longer preceded by a long vowel. Thus a V:]V]V] sequence may not be derived from V:]V:]V:] if the shortening rule is applied cyclically.

Our major goal in this section is to show that the Rhythmic Law does in fact, and indeed must in principle, apply in just this fashion. We lay the groundwork for achieving this by first reviewing the other two features of 37, and then placing the Rhythmic Law in the context of the other Slovak rules.

Returning to 37b, we simply assume that the derived context limitation must be stipulated as a feature of lexical rules. (See Kiparsky 1982 for an attempt to derive this constraint from the Elsewhere Condition.) The cue for this factor would be the observation of rule blockage or application inside a morpheme on a non-derived string. Finally, with respect to 37c, it is reasonable to suppose that the non-phonological features of a lexical item are available for inspection by the phonological rules only under very restricted circumstances. Postlexical rules are characteristically insensitive to such structure, and apply in across-the-board fashion. We can severely limit access to this information by assuming that it is erased by an expanded version of the bracket erasure convention (cf. Pesetsky 1979), which deletes internal brackets at the end of each cycle. This effectively limits access to lexical information to a two-cycle window, formed by the cycle on which a given morpheme first enters the representation plus the immediately following cycle. As a diagnostic, any phonological rule whose application must be restricted to particular morphological or lexical contexts is necessarily a lexical rule.[12]

Thus various features detect the lexical status of a rule. Furthermore, because of the architecture of the LP model, the status of a rule can also be established by its ordering with other rules. If the application of any rule *r* displays one or more of the features in 37, then any rule applied before *r* must

[12] Booij & Rubach 1987 show that it is necessary to permit the lexical component to be partitioned with a postcyclic block of rules that do not respect the derived environment limitation. However, being lexical, these rules still have access to lexical information. As far as we can determine, the distinction between cyclic and postcyclic lexical rules is not relevant for any of the Slovak rules which we discuss in this paper.

be a lexical rule. This is a very strong claim. It places significant restrictions on the kinds of properties which a phonological rule may display, simply on the basis of that rule's position in the ordering network; it thus has obvious learnability advantages (cf. Booij & Rubach 1987).

In this section we test the implications of the LP model with respect to our Slovak rules. We show that these rules form a coherent system consistent with LP, and thus provide significant support for this model. Consider first rule 33, which contracts an *i* with a following syllabic nucleus. This must be a lexical rule, since it is restricted to derived contexts. Slovak has numerous morphemes with internal sequences of *i* + vowel which remain heterosyllabic (e.g. *dialekt* 'dialect', *diéta* 'diet', *patriot* 'patriot'). Since contraction is ordered after the Rhythmic Law, the latter must be lexical as well. We are not aware of any lexical exceptions to contraction, and simple inspection of its output gives no indication of its cyclicity.

Slovak has a lexically restricted rule which is of interest to us only in virtue of its position in the rule-ordering network. This rule was formulated by Isačenko 1964 to lengthen the vowel *e* when followed by the infinitive suffix *-t'*. We can see the role this rule plays from the following paradigm:

(38) *rozum* 'mind'
rozum-ie-t' 'to understand'
rozum-e-l 'understood' (past part.)
rozum-e-n-ý 'understood' (passive part.)

The verb 'understand' is derived from the noun base *rozum* with the verbalizing suffix *-e*. This suffix is lengthened (and subsequently diphthongized) before the infinitive morpheme *-t'*. It appears as short before the *-l* and *-n* participial affixes. Since the rule is restricted to apply before just the infinitival suffix, it is necessarily a lexical rule. This result is consistent with its ordering with respect to diphthongization. Recall that diphthongization is lexical in virtue of its derived context limitation; so any rule ordered before diphthongization will have to be lexical. We thus begin to appreciate the point that adoption of the LP model makes non-trivial predictions about the properties of phonological rules. If these predictions are confirmed, then LP represents a significant limitation on the power of the grammar.

Traditional Slovak grammars cite the long vowel [ie] standing before the infinitival suffix as an exception to the Rhythmic Law on the basis of paradigms like these:

(39)

múdr-y	'wise'	*vážn-y*	'important'
z-múdr-ie-t'	'to be wise'	*z-vážn-ie-t'*	'to be important'
z-múdr-e-l	past part.	*z-vážn-e-l*	

Since these 'exceptions' are systematic, we can explain them by ordering the infinitival lengthening rule after the Rhythmic Law. This rule ordering provides us with an additional reason to consider the Rhythmic Law to be a lexical, and hence cyclic, rule.

Another rule whose lexical status we need to determine before turning to the Rhythmic Law is 31, which lengthens a vowel preceding a jer. This rule

bears many lexical restrictions; only certain affixes containing jers trigger the rule, such as the gen.pl. and the diminutive (see 40a.) Even in these contexts, some stems fail to lengthen—e.g. *get-o, get* 'ghetto'; *kimon-o, kimon* 'kimono'. The jer lengthening rule must be ordered before the Rhythmic Law, since a syllable preceding the gen.pl. or diminutive suffix is never pronounced long if it in turn is preceded by a long syllable, as in 40b:

(40)	NOM.SG.	GEN.PL.	DIMIN.	
a.	*koles-o*	*kolies*	*kolies-k-o*	'wheel'
	baran		*barán-ok*	'sheep'
b.	*písmen-o*	*písmen*	*písmen-k-o*	'letter'
	kúpač		*kúpač-k-a*	'bather'
	nížin-a	*nížin*		'lowland'

We account for this systematic lack of lengthening by assuming that the Rhythmic Law shortens any vowel that might be lengthened by the jer-lengthening rule. In the case of a stem such as [nížín], from underlying *nížin*, the application of the Rhythmic Law does not span a cyclic boundary; nevertheless, the rule is applying in a derived context, since the long vowel of the second syllable of the stem arises from prior application of jer-lengthening.

The final rule we have to consider is jer vocalization (28). This rule provides a nuclear skeletal slot to an unlinked vocalic segment when followed by an unlinked vocalic segment. Jers may be lengthened when they precede the gen.pl. or diminutive suffixes. Jer-lengthening augments the syllabic nucleus with an additional skeletal slot; hence we assume that the vocalization rule, which provides a jer with a syllabic nucleus, applies before lengthening. Examples illustrating this point are:

(41)	NOM.SG.	GEN.PL.	DIMIN.	
	ihl-a	*ihiel*	*ihiel-k-a*	'needle'
	mzd-a	*miezd*		'salary'
	kvapk-a	*kvapôk*		'drop'

The stem in *ihiel-k-a* receives the partial derivation of Figure 14.

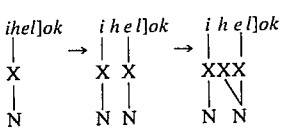


FIGURE 14.

In the first step, the jer of the root is vocalized by the addition of a skeletal slot. An additional slot is added in the second step by the lengthening rule. Subsequent diphthongization and suppression of the unvocalized jer of *-ok* yield *ihielka*.

To summarize, we have established the order of the rules as in Table 1. This also indicates where we have positive evidence for the lexical status of the rules by criteria 37b–c.

	DERIVED ENV.	LEXICAL INFOR.
jer vocalization	–	–
jer lengthening	–	yes
Rhythmic Law		
contraction	yes	–
infinitive length	–	yes
diphthongization	yes	–

TABLE 1.

By virtue of their position in this ordering, the Rhythmic Law and jer vocalization must be lexical rules. And since lexical rules are cyclic, we predict that the Rhythmic Law and jer vocalization will apply cyclically. The crucial point is that, in contrast to the other rules, cyclic application is independently detectable for the Rhythmic Law and jer vocalization. This fact allows us to perform a significant test of the validity of the LP model. Before introducing the data to show that these rules are indeed cyclic, it is worth observing that they differ on a couple of counts. In jer vocalization, the focus precedes the contextual trigger; in the Rhythmic Law, the focus follows the triggering long syllable. Any procedure which attempts to predict the direction of iteration on the basis of the location of the focus with respect to the context will predict a difference in direction of iteration. The LP model, however, requires that both rules apply in left–right mode on a chain of suffixes, since these rules are cyclic rules. Note also that cyclic application produces an alternating multiple application pattern for the Rhythmic Law, but a non-alternating pattern of vocalization on a chain of jers. Again, this result will be inconsistent with any attempt to predict the mode of application on the basis of the maximization or minimization of an alternating pattern (cf. the proposals to predict multiple application patterns in Anderson 1974 and Kenstowicz & Kisseberth 1977).

The following paradigm shows that jer vocalization is a cyclic process:

(42) a. *spol-u* 'together'
b. *spol-ok, spol-k-a* 'community'
c. *spol-oč-n-á* 'common' f.nom.sg.
d. *spol-oč-en-sk-á* 'social' f.nom.sg.

Here 42d contains a chain of three jer affixes built up from the base [spol] appearing in 42a. The first link is the nominalizing affix *-ok*. In 42b, we see that this affix has a jer. The second affix in the chain is the adjectival suffix *-en* appearing in 42c. It contains a front-vowel jer which palatalizes the preceding velar. The jer of this suffix vocalizes when it is followed by the third link in a chain of jer suffixes, in this case the general Slavic adjectival suffix *-isk*.[13] Thus 42d has three successive jer cycles. On the first, the representation [*spol*]*o̱k* is produced, and no rules apply. (We now use the underbar to mark unvocalized jers). On the second, the adjectival morpheme is suffixed to give [[*spol*]*o̱k*]*e̱n*. The *-e̱n* vocalizes the preceding jer and palatalizes the velar to give [[*spol*]*oč*]*e̱n*.

[13] See Rubach (1984:42) for discussion of this suffix, and for further evidence that it contains a jer.

On the next cycle, *-i̯sk* is suffixed to give [[*spoloč*]*e̯n*]*i̯sk*. The jer of the [*-e̯n*] suffix is now vocalized. On the final cycle, the inflectional suffix *-á* is added, and the jer of *-i̯sk* is not vocalized.

Many other words in Slovak contain chains of jers: in each case, all but the final jer vocalizes. This non-alternating pattern of vocalization also appears in Russian and Polish. It is traditionally assumed that the jers originally vocalized in an alternating right–left mode in late Common Slavic. It is impossible to achieve this alternating pattern under cyclic application; thus jer vocalization must originally have been a postlexical rule. According to Kiparsky 1982 and Rubach 1984, extension of a rule into the lexicon is a common form of phonological change. It raises the question whether all sound changes must originate postlexically.

The proof of the cyclicity of the Rhythmic Law proceeds similarly. In 58a, we have paradigms of stems terminating in the suffix *-ník* (from underlying *-e̯n-ik* with an initial jer) whose long vowel shortens the inflectional adjectival suffix *-ý*:[14]

(43) a.	*čel'ad'*	'hired help'	*súkn-o*	'cloth'
	čel'ad-ník	'apprentice'	*súken-ník*	'draper'
	čel'ad-níc-k-y	'apprentice' adj.	*súken-níc-k-y*	'draper' adj.
b.	*brigád-a*	'brigade'	*čalún*	'tapestry'
	brigád-nik	'brigade leader'	*čalún-nik*	'upholsterer'
	brigád-nic-k-ý	'brigade leader' adj.	*čalún-nic-k-ý*	'upholsterer' adj.

The paradigms in 43b are similar except that the nominal base preceding the *-ník* suffix terminates in a long syllable. If the Rhythmic Law is applied cyclically, then the vowel of the *-ník* suffix will be shortened before the inflectional adjectival suffix *-ý* is added to the representation. Consequently, that vowel necessarily surfaces as long.

There are many other morphological contexts in which a chain with three successive long vowel links can be formed. In each case, Slovak systematically shortens the middle link, confirming the cyclicity of the Rhythmic Law. We are not aware of any morpheme-internal sequences of long syllables; so there is no positive evidence for a derived context limitation on the rule. However, a number of affixes fail to undergo the rule, such as the agentive *-ár* (e.g. *hríb-ár* 'mushroom picker') and the soft stem gen.pl. *-í* (e.g. *básn-í* 'fables').

We close our discussion by citing a paradigm in which a jer chain and a long vowel chain overlap. The fact that our system extends straightforwardly to these complex alternations lends strong support, we believe, both to the validity of the descriptive analysis and to the theoretical framework in which that analysis has been developed.

[14] The *-k* preceding the [*-ý*] is a reflex of the adjectival suffix *-i̯sk*, whose jer palatalizes the velar of the *-ník* affix and later is deleted. A postlexical rule absorbs the *s* trapped between the affricate and the following consonant in the *c-sk* cluster. Since unvocalized jers do not project a nuclear skeletal slot, the presence of *-i̯sk* in the paradigms of 43 has no effect on the Rhythmic Law, and thus may effectively be ignored.

(44)	*vedr-o*	*krídl-o*	nom.sg.
	vedier	*krídel*	gen.pl.
	vedier-c-e	*krídel-c-e*	nom.sg. dimin.
	vedier-ec	*krídel-iec*	gen.pl.
	'pail'	'wing'	

The roots underlying these paradigms have the canonical shape CVC–jer–C, and differ in the length of the initial vowel. The diminutive is formed with the suffix *-e̯c*, in which a jer triggers lengthening of the preceding syllable. The jer of the *-e̯c* suffix is itself vocalized in the gen.pl. by the underlying jer suffix that marks this case of the nominal inflection. We know that the gen.pl. suffix regularly triggers lengthening of the preceding vowel, and it does in *krídel-iec*. This lengthening is undone by Rhythmic Law shortening in *vedier-ec*, since a long vowel precedes—namely the vocalized jer lengthened on the preceding cycle. The gen.pl. dimin. forms of 44 receive the derivations of Figure 15 under our analysis. (We again employ the underbar to indicate an unvocalized jer—i.e. a vocalic segment not linked to a skeletal slot.)

[*verde̯r*]*e̯c*	[*kríde̯l*]*e̯c*	
		second cycle
veder e̯c	*krídel e̯c*	jer vocalization
vedér e̯c	*krídél e̯c*	jer lengthening
inappl.	*krídel e̯c*	Rhythmic Law
vedierе̯c	inappl.	diphthongization
[*vedierе̯c*]*u̯*	[*krídelе̯c*]*u̯*	
		third cycle
vedierec u̯	*krídelec u̯*	jer vocalization
vedieréc u̯	*krídeléc u̯*	jer lengthening
vedierec u̯	inappl.	Rhythmic Law
inappl.	*krídeliecu̯*	diphthongization

FIGURE 15.

Suppression of the unvocalized jer of the gen.pl. suffix yields the surface forms *vedierec* and *krídeliec*.[15]

[15] The Rhythmic Law was cited in Browne 1970 as a rule requiring simultaneous application. This analysis was carried over into subsequent discussions of what came to be known, in the later generative literature, as the multiple application problem (cf. in particular Anderson 1974, Kenstowicz & Kisseberth 1977). Browne's claim for the necessity of simultaneous application was based on the analysis of a single morpheme—the imperfectivizing suffix *-áv*. Consider the following brief paradigms:

vol-ám	'want' 1sg.	*čít-am*	'read' 1sg.
vol-áv-am	imperf. 1sg.	*čít-av-am*	imperf. 1sg.

The *-áv* suffix is short after a long root such as *čít*, which can be accounted for by the Rhythmic Law. The 1sg. suffix *-ám* also shortens after *-áv*. If our cyclic analysis is correct, *čít-av-am* will have a derivation in which [*čít*]*áv* is rhythmically shortened to [*čít*]*av* before the addition of *-ám*. Thus there is no way in which *-ám* can be shortened by the Rhythmic Law.

Fortunately, another analysis is possible for these data. As discussed by Kenstowicz 1972, Slovak has a general rule which shortens a vowel after the glide *j*. There are good reasons to believe that the underlying representation of *-áv* is really *-áj*. A well known rule of Slavic morphophonemics (Flier 1972) changes the [j] of this morpheme to [w], whence [v] is derived in syllable-onset position.

In Table 2, we complete Table 1 for all of the major rules discussed in this paper.

	CYCLICITY	DERIVED ENV.	LEXICAL INF.
jer vocalization	yes	–	–
jer lengthening	–	–	yes
Rhythmic Law	yes	–	yes
contraction	–	yes	–
infinitive lengthening	–	–	yes
diphthongization	–	yes	–

TABLE 2.

No one rule has a 'yes' entry for all three lexical rule diagnostics. Yet if data were to arise which permitted a test for any of the rules in Table 2 with respect to the properties of cyclicity, derived context, or access to lexical information, then our analysis would make a definite prediction on where these rules would stand. The haphazard distribution of 'yesses' in Table 2 suggests that these are features which are not learned by the language learner of Slovak; rather, they are properties supplied in advance by Universal Grammar. Given the architecture of the LP model, these features are necessary properties of the rules, once they are identified as rules of the lexicon.

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So long as this rule is ordered after the jod-shortening rule, the correct surface form results. Since the apparent necessity of simultaneous application is limited to just *-áv*, and all other cases generate an alternating multiple application pattern, there are good reasons to avail ourselves of the alternative explanation that Flier's rule affords.

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