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REGISTER IN KHMER
THE LARYNGEAL SPECIFICATION OF PHARYNGEAL EXPANSION

MARJORY MEECHAN

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UNIVERSITY OF OTTAWA

ABSTRACT

The theory of "feature geometry" is an attempt to organize a finite set of features into a universal hierarchy. This hierarchy has the desirable effect of constraining phonological rules and representations by determining which sets of features may operate together as a natural class and which may not. This thesis investigates pharyngeal expansion as a distinctive feature of Khmer vowels and its representation with respect to this universal hierarchy.

Previous work on Khmer has suggested that the feature of Khmer vowels known as "register" is phonetically articulated as pharyngeal expansion and therefore should be phonologically represented with the feature [Advanced Tongue Root], henceforth [ATR]. Current feature hierarchy proposals have argued that the feature [ATR] is a dependent of the [Place] tier, under which are found features which relate to articulatory gestures of the tongue. The hypothesis advanced here is that "register" involves a lowered larynx and therefore, should be represented by a feature such as [Lowered Larynx], dependent on the [Laryngeal] tier.

In order to investigate this hypothesis, the phonological rules of register harmony in Khmer are analyzed. The distinctive features and structures of Khmer are determined from an examination of consonant and vowel co-occurrence restrictions and nasal assimilation. It is shown that the class of segments which block register harmony must be specified with laryngeal features. Therefore, it is concluded that register is phonologically laryngeal.

Since it has already been established in previous work that [ATR] is a [Place] feature, it is suggested that either feature dependencies are not universal or the feature operating in Khmer is not [ATR]. The feature [Lowered Larynx] is suggested as a potential candidate.

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This thesis is dedicated to my father.

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1.0 Introduction

Khmer is a member of the Mon-Khmer group of languages spoken primarily in Cambodia. It is distinguished by a large vowel inventory which can be divided into two classes by virtue of a property called "register"[1] (Henderson 1952) the phonetic and phonological properties of which have interesting ramifications for phonological theory. In the first place, the exact feature which is at work with respect to register has not been definitively established. An examination of the phonetic properties of Khmer register will show that it is closely related to the feature [Advanced Tongue Root], henceforth [ATR], under the assumption that [ATR] is defined as representing pharyngeal expansion and constriction, rather than tongue movement alone, since register is most likely implemented at the larynx.

Recent works on phonological features have investigated the possibility that features are hierarchically organized and, within the confines of one particular theory, autosegmental phonology, it has been suggested that phonological features are organized into a language-independent hierarchical "tree" structure. An examination of Khmer "register harmony" will show that it is phonologically conditioned by consonant features which are organized under the [Laryngeal] "branch" of the feature tree. Laryngeally specified consonants block the spread of "register". This analysis of pharyngeal expansion conflicts with previous work which shows that [ATR] is organized under the [Place] "branch" of the tree. The possibility exists that, since pharyngeal expansion may be phonetically implemented in several ways, tongue root advancement must be phonologically differentiated from larynx height.

Chomsky and Halle (1968) note that just because a phonetic contrast in one language appears to be similar to that in another language, it is not necessarily the case that the same phonetic feature is at work. In the interest of universality, and without evidence that a further contrast is required, it is preferable to adopt existing features which have been shown to contrast in other languages rather than to posit new features. However, the explanatory strength of "feature geometry" lies in the fact that phonological features can be organized into universal dependency relations. Whether or not register is just another example of [ATR] brings these goals into conflict. Either the dependency relations of the feature tree are not universal, or a new feature must be posited.

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[1]This term will be more clearly defined shortly.

1.1 What is "Register"?

Register is loosely defined in Pittman (1984:114) as "an alternation between enlarged pharyngeal space accompanied by reduced oral space, in contrast with reduced pharyngeal space accompanied by enlarged oral space." With respect to an exact feature specification, the situation is less clear since this particular articulatory setting can be implemented in several ways and have a variety of acoustic consequences.

Features	Constricted Register[2]	Expanded Register
Pitch	Higher	Lower
Vowel Quality	Lower/more open/on-glided/ Tongue root retracted.	Higher/closer/centering/ diphthongs/Tongue root advanced.
Larynx Height	Neutral	Lower
Vocal Cord Tension	Tense	Lax
Consonant Voicing	Voiceless/laryngealized (implosive)/glottal stop	voiced/murmured
Phonation Type	creaky voice(high/head register)	breathy voice(low/chest register)
Other features	slight faucalization	dilation of the nostrils
Subjective Effect	normal voice, clear, bright, head,high-pitched, tense voice quality, lax or oral resonance.	deep, sepulchral, relaxed voice, deep and muffled sound, chest, breathy, spooky, centralized, low-pitched, lax voice quality, tense or pharyngeal resonance, gutteral, articulated from the rear of the mouth

Table 1: Phonetic features associated with Khmer registers.
(Henderson 1952, 1977; Jenner 1966 cited in Gregerson 1976, Huffman 1976)

Larynx height, vocal cord tension and phonation type as well as pitch, variations in vowel quality[3] and laxness or voicing of consonants have all been linked to Khmer register. Since

[2]There are many different labels for register in the literature. Jenner and Pou (1982) refer to it as High and Low register. Jenner (1969) calls it Close and Open register. Henderson (1952), who first coined the term register for this opposition, referred to it as first and second register. It is also widely referred to as chest and head register and there may be others. Given that the assertion of this paper is that pharyngeal expansion is relevant to register, I have chosen, in the interests of clarity, to label the two types of register as constricted/expanded, referring to the state of the pharynx.

[3]The term vowel quality refers to the frequencies of the first and second formant. These two formant frequencies can be correlated with tongue height and advancement and have been shown to account for how listeners perceive different vowels. (c.f Fox 1989 for a discussion) The term, vowel quality, is distinct from "vowel height or advancement" which refers to the set of phonological features [high], [low] and

there are many articulatory and acoustic features involved, a clear-cut, well-grounded representation involves some study. Several different phonological features may be tentatively considered depending on which one of this complex of properties is singled out as significant. The various correlations that have been suggested between phonetic features and register in Khmer are shown in Table 1.

Despite the laryngeal connection suggested by the aforementioned properties, there is also some indication that register is related to tongue movements. Headley et al. (1977) represents Khmer vowels only in terms of vowel quality and length as in (1)[4] while Jacob (1974) also represents them as to register as in (2).

(1) Khmer vowels according to Headley et al. (1977)

Constricted Register			**Expanded Register**		
Simple Vowels			Simple Vowels		
			i iː	ɨ ɨː	u uː
e	ə əː	o oː	eː	əː	oː
a aː		ɑ ɑː	ɛː		ɔ ɔː
Diphthongs			Diphthongs		
ie	iə	uə	ie	iə	uə
eə	əy		iə		
			ea		oa
ay ae aə ao			ey		ɔə

(2) Khmer vowel inventory as represented by Jacob (1974)

Constricted Register			**Expanded Register**		
Simple Vowels			Simple Vowels		
			ì ìː	ɯ̀ ɯ̀ː	ù ùː
e eː	ɤ ɤː	o oː	èː	ɤ̀ː	òː
a aː		ɔ ɔː	ɛ̀ː		ɔ̀ː
Diphthongs			Diphthongs		
iə	ɯə	uə	ìːə	ɯ̀ə	ùːə
eə	ɤy		ìə		ùə
			èa		
ay ae aə ao au ay			èy		ɔ̀ə

[front/back] which, at least nominally, can be linked to the height and advancement of the tongue body (Chomsky and Halle 1968). While vowel quality is correlated with these tongue movements, it can be achieved in other articulatory ways.

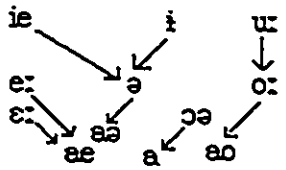
[4]This chart is a result of the combination of the vowel tables on pgs. xvi and xxi-xxii in Headley et al. (1977).

The different implications of these two types of representation is best seen with the three high diphthongs. In (2), it is implied that these diphthongs do differ across registers, while in (1), it is implied that they do not.

How the Khmer vowels are represented partly depends on whether or not the representor believes in the register distinction as separate from the quality distinction. (cf. Pinnow 1980:106-107.) For example, in (1), it can be seen that the low back constricted register vowel is depicted as [ɑ]. Jacob (1974) represents this vowel as [ɔ] which illustrates that it is the counterpart to expanded register vowel [ɔ̀]. As can be seen in both (1) and (2), constricted register vowels tend to be lower than expanded register vowels.[5]

Despite some reported vowel quality differences across registers, the diphthongs /iə/ and /uə/ versus /ìə/ and /ùə/ are reportedly distinguishable only by virtue of register (Jacob 1968, 1974). Even so, Huffman (1976) claims that register is no longer synchronically significant in modern Khmer and that the so-called register distinction is merely one of tongue height and contains no laryngeal distinctions. The direction of vowel shifts are shown in (3). As can be seen, the general shift from expanded register to constricted is towards the lower, more central vowels. As seen above with some of the diphthongs, this does not always involve a change in quality.

(3)



The laryngeal influence is by no means contraindicated by these differences in vowel quality. As Denning (1989) points out, there can be many secondary results of laryngeal manipulations and vowel quality is certainly one of them. In addition, the quality alternations that do occur are not straightforward. For example, when /ùː/ attains (or loses) whatever property expanded register embodies, it becomes /oː/. However, when /ɔ̀ː/ undergoes the same process, it becomes /ao/. This suggests that sometimes /oː/ has this

[5]Generally, the transcriptions in this paper will correspond to that of Headley et al. (1977) where vowel symbols were chosen to reflect vowel quality. In order to facilitate the reader's identification of first and second register, second register vowels will also bear a grave accent as in first register [oː] versus second register [oː]. One other change was made to Headley et al.'s transcription system. The low back first register vowel shown in Headley et al. as [ɑ] is transcribed here as [ɒ] to more clearly show that the vowel is rounded. A complete description of the vowels can be found in Appendix I.

property and sometimes it does not. The main difficulty with this is that one of the most common harmony processes is spreading register from base word vowels to unspecified prefixes and if /o:/ and /o̤:/ are physically and phonologically the same, as a representation limited to tongue height would require, how is it that one triggers register spread and the other does not? In other words, how can a native speaker tell the difference?

Another difficulty posed by Mon-Khmer registers is the way whatever feature it is that defines these two classes of vowels interacts with pitch. In another Mon-Khmer language, Mon, which incidentally also has extensive vowel quality differences between registers, Lee (1983) determined that pitch was a good indicator of the register distinction. Even in running speech, where it was thought that register differences were lost, he discovered that pitch differences remained significant. While Khmer is not considered to be a tone language, in that pitch alone does not have lexical significance (Pike 1948), other register languages such as Kammu and Muong show a correlation between tone levels and register (Svantesson 1989).[6] In addition, Henderson (1952) states that in Khmer, constricted register is generally accompanied by a higher pitch than expanded register. Notice that certain features of these two registers do not correlate in the expected way with pitch. For instance, it is expected that [ATR] or tongue height will correlate with higher pitch since the act of pulling the tongue up or forward should serve to pull the hyoid bone forward and thus rotate forward the thyroid cartilages causing tension in the vocal cords (Honda 1983). However, as Table 1 shows, this is not the case. High, [+ATR], expanded register vowels are associated with lower pitch. In contrast, the lowering of the larynx in pharyngeal expansion has been correlated with lower pitch (Erickson, Baer and Harris 1983) although the reasons for this are still unclear. The hypothesis is advanced here that there is a single phonetic feature which could account for the way register correlates with pitch. Expanded register vowels can be characterized as occurring with a lowered larynx in relation to constricted register vowels.

There is a further indication that register is a laryngeal feature. Register is phonetically correlated with properties that traditionally have been associated with the larynx, most notably, properties of phonation. The patterning of the two classes of vowels distinguished by register has been associated historically with a voicing distinction that is neutralized in the modern language (Huffman 1976) although the causal relationship between voicing and

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[6]The distinction between register and tone is possibly a fuzzy one although the question of exactly where the boundary should be drawn will not be discussed here since that would require a typological survey of tone and register languages to determine what, if any, other phonetic properties can accompany pitch and still allow a designation of the distinction as tonal as opposed to one of vowel height or phonation.

register is disputable. Both may have been the realization of some suprasegmental feature in the proto-language (c.f. Maddieson 1978, Svantesson 1989). Regardless of diachronic possibilities, features of consonants do play a synchronic role in at least one phonological process involving the register distinction. Phonologically, register interacts with consonants that can be distinguished by laryngeal oppositions. In "register harmony" the class of opaque segments includes only the obstruents, a class consisting only of segments which are voiceless or glottalized.[7] As a brief illustration of how the register opposition can be observed to operate phonologically, the infix /-m-/ is shown in (4). According to Jenner and Pou (1982), this infix has an iterative meaning. Depending on the base word, it can either change it to a noun form such as agentive or merely serve to intensify or habitualize the meaning.[8]

(4) (a) Constricted Register

[so:m]	'to ask, beg'	[smo:m]	'beggar'	(J183)[9]
[cam]	'to guard'	[cmam]	'guard'	(J48,52)[10]
[clak]	'to sculpt'	[cɒmlak]	'sculpture'	(J52,41)
[cɓaŋ]	'fight'	[cɒmɓaŋ]	'war'	(J41,48)

(b) Expanded Register

[lò:p]	'greed'	[lmò:p]	'greedy'	(J174,176)
[cùəŋ]	'do business'	[cmùəŋ]	'businessman'	(J57,62)
[clə̀:y]	'uncouth'	[cùmlə̀:y]	'uncouth'	(J62,55)
[krùp]	'complete'	[kùmrùp]	'complete'	(J35,31)
[kcə̀l]	'lazy,unwilling'	[kɒmcə̀l]	'lazy'	(J5,25)

The /-m-/ is infixed into the word right after the first consonant. Where the /-m-/ infix would result in a non-permitted cluster, a 'restricted di-syllable'[11] is created involving the insertion of an epenthetic vowel. In the examples above, this vowel can occur as either [ù] or [ɒ] depending on its register.[12] In words where the vowel of the base is in the constricted register, this vowel occurs in constricted register ([ɒ]). In words where the vowel of the base is in the expanded register, this vowel appears as either constricted ([ɒ])

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[7]A complete inventory of the consonants can be found in Chapter Four.
[8] See Appendix II for further discussion of this infix.
[9]All examples are from Jacob (1974) — indicated by J, or Headley et al. (1977) — indicated by H. The numbers refer to pages.
[10]In some cases, aspiration occurs as a "transition element" (Henderson 1952, Huffman 1972) between consonants in initial clusters. This has been omitted here.
[11]Discussed in section 3.3.2.
[12]This will be discussed more fully in Chapter Five.

or expanded register ([ù]) depending on the nature of the consonant intervening between the epenthetic vowel and the base vowel. If the consonant is voiceless or glottalized, the epenthetic vowel remains in constricted register. If the consonant is a sonorant the epenthetic vowel is realized in expanded register.[13]

Finally, there is a special relationship between one setting of register and glottalized consonants.[14] Cook (1989), in a comparison of Khmer register and fortis/lenis syllable alternations in Babine, has noted the correlations between these different categories of vowels and such acoustic properties as phonation and pitch and also suggests that there is a laryngeal component involved.

In order to investigate the above phonetic and phonological possibilities, it is necessary to show that laryngeal classifications are indeed required for the representation of the structures and operations of Khmer. The analysis will be done in the framework of non-linear phonology with the particular goal of investigating the adequacy, in the sense of Chomsky (1965), of current feature proposals. Before discussing the layout of the thesis, a little background information on Khmer and the approach taken for handling the data is in order.

1.2 Khmer

The dialect of Khmer discussed here is standard educated Khmer as represented by Headley et al. (1977). The description of register is greatly complicated in the literature by the fact that it appears to be a variable feature of Khmer. Even in standard educated Khmer, which is reportedly the dialect most characterized by register, variation occurs. Huffman (1967) reports that its occurrence is conditioned by various extralinguistic factors such as education and social class. Since there may be considerable variation depending on the source of the data, some care has been taken to ensure that examples are uniform. Any examples taken from a source other than Headley et al. (1977) have been checked against that source, particularly with respect to the vowels. Huffman (1967) warns that dialect differences in Khmer centre chiefly around the vowels and /r/. Headley et al. (1977) was chosen as the primary data source because the data base was the largest and least abstract with respect to vowel quality of any other source and since the study of the interaction of vowel quality with register is a primary goal of this paper, this aspect was considered important.

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[13]Other forces can also affect the quality of this vowel. This will be noted as it comes up in the discussion.
[14]Following Painter (1978) and McCarthy (1989a) implosives are considered to be glottalized consonants.

Besides register, one of the most controversial issues in Khmer linguistics is that of the morphology. The most debated point is perhaps the question of whether or not there is any. Some examples of disputed points are such things as whether or not two affixes are variations of the same morpheme and how much of the morphology is actually productive. Most sources suggest that a large part of the morphology and, in particular, infixation, is dead, although no-one has completely committed themselves one way or another. Jenner and Pou (1982) who have compiled what is perhaps the most definitive work on the subject are still unprepared, after over ten years of research, to make an unqualified statement as to the life or death of the affixational system.

All morphology in Khmer is derivational and the connection between derived and non-derived forms of Khmer words is made unclear by two factors. In the first place, word classes are not sharply defined in Khmer. Consider the /-m-/ infix described above. Although it can act as a noun-forming affix as in [criəŋ] 'to sing' and [cɒmriəŋ] 'song', the affix can also give a verb a more habitual aspect or make an adjective more stative. Therefore, the same affix does not produce the same kind of word relationship between the non-derived and derived form in all cases. In one instance a verb may become a noun while, in another instance, it may not. In the second place, as many of these derived forms have become more common in the language than they were previously, they have taken on other nuances, probably by virtue of morphological extension and sometimes the trail of meaning can be difficult to follow (cf. Arɑ.off 1976 for a discussion of this problem in morphological analysis). For example, Jacob (1974) claims that the two words in (5), which seem semantically distant, are related through /-m-/ infixation.

(5)	[sɒmrɔːt]	'slither down (a pole, tree, etc.)'(J191)
	[srɔːt]	'swiftly and directly'(J214).

Where the original meaning for a derived word is lost or obscured, the connection between derived forms can be faint.

In order to ensure that the words used to illustrate the processes described here are truly related in some way, independent verification of relatedness as indicated by either Jacob (1974), Headley et al. (1977), Huffman (1967), Jenner (1969) or Jenner and Pou (1982) has been sought out. Jenner and Pou (1982) was used only as a source for verifying morphological relatedness for two reasons. In the first place, the phonetic transcriptions found there were quite different from other sources consulted. Secondly, they give a

disclaimer stating that the authors "make no claim that the derivatives collected here were necessarily created in Khmer or by Khmer speakers or, for that matter, even in Cambodia." (Jenner and Pou 1982:lvii). Since it was somewhat unclear exactly what this remark meant, the use of Jenner and Pou (1982) was restricted to the verification of word relationships where this was ambiguous in other sources. Very few instances arose where the use of Jenner and Pou (1982) for this purpose was necessitated.

1.3 Organization of the Thesis

In the next chapter, the hypothesis that the larynx is involved in the articulation of Khmer register will be examined. Phonetic studies will be reviewed to show that laryngeal involvement in register is phonetically possible. Manipulations of the larynx can account for the level of interaction that takes place between the seemingly widely divided areas of glottal constriction and vowel quality. In addition, what is known (or guessed) about the phonetic properties of implosives will be reviewed in this section since these segments have a special relationship with register. Also in the second chapter is a review of the phonological features that have been proposed to account for either laryngeal, tonal, vowel quality, along the line of the [ATR] feature, or other expanded pharynx oppositions. While other theories are acknowledged, the examination is limited to the various proposals that have been advanced under the name of "feature geometry" (Clements 1985).

In the third, fourth and fifth chapters, an analysis of Khmer vowel phonology with particular attention paid to the effects of register is undertaken. The goal is to account for the vowel harmony rules discussed above. A description of Khmer syllables is needed since register harmony operates with reference to this structure. In addition, there is an account of the vowel and consonant systems of Khmer and how they are to be specified in order to determine the phonological role of vowel quality or pharyngeal expansion in Khmer.

In the sixth chapter, register harmony is related to the theory of feature geometry. While an analysis assuming a laryngeal tier will work for Khmer, an analysis involving the place tier may be equally acceptable and, in fact, desirable given similar processes in other languages involving [ATR] and in the interest of limiting the universal feature set. It will be argued that the evidence from Khmer shows that either there are two features with roughly the same phonetic result which form part of the universal feature set, [ATR] and [Lowered Larynx], or the same feature must depend from (at least) two separate class nodes on the feature tree depending on the language to be described.

Chapter Two
Phonetics & Phonology of Register

2.0 Introduction

There have been many proposals as to what is the best way to represent those elements of speech which result from articulations located in the laryngeal and pharyngeal area of the vocal tract. One main difficulty lies in the fact that we are not entirely certain as to what it is we are supposed to be representing. On the one hand, there seem to be distinct acoustic properties involved which feature in the recognition and production of certain sounds. On the other hand, there is the tantalizing notion that these properties all result from manipulating the same articulators along different parameters. However, the same acoustic result can be achieved with different articulators, for example the lowered first formant characteristic of [u] results from the elongation of the vocal tract, either through lip protrusion or lowering of the larynx (Borden and Harris 1984). An additional difficulty results from the fact that, although extensive phonetic research has been undertaken, we are still not exactly certain what is going on during the articulation of certain laryngeal sounds. As Henderson (1977) has pointed out, many interesting distinctions occur in languages spoken in remote regions where the kind of equipment needed to get a good look at what is actually going on is not available, even if the speakers were amenable to undergoing the procedures necessary to find out. Assuming that this difficulty was circumvented, it has often been noted that several articulatory and acoustic properties may be involved with "one" feature of a sound and it is unclear that the specific property designated by that feature is equally important for the recognition of the same sound in all languages. Since the aim of a "universal" set of features is to represent some universal fact about language, hence the name, these considerations are critical aspects of any potential feature proposal.

2.1 The Phonetics of Register

All of the impressionistic features noted in Table 1 of Chapter One to describe register differences can be directly or indirectly associated with laryngeal height. Erickson, Baer and Harris (1983) point out that larynx height and fundamental frequency have been correlated in both singing and speech. Lower pitch correlates with a lowered larynx while a higher pitch correlates with a raised larynx. Larynx height has also been suggested as a factor in phonation type. Sundberg and Askenfelt (1983) found a relationship between a raised larynx and what they refer to as "pressed phonation", which is typified by a rise in pitch and a high degree of glottal medial compression. They characterize the opposite extreme to this as "flow phonation" or "breathy phonation". It is unclear if this opposite

value can be linked to a lowered larynx but, in any case, it is not ruled out. In fact, Catford (1964) claims that lowered versus raised larynx is a phonological opposition operating in Javanese. He says that the lowered larynx is "observed acoustically as a downward shift of formant 1, and auditorily as a 'muffled' or 'centralized' vowel quality" (Catford 1964:35). Hombert, Ohala and Ewan (1979) suggested (albeit skeptically) that a raised larynx, in shortening the length of the vocal tract, could serve to raise the first formant and lead to a "somewhat lower vowel quality" (p.52). They claimed that this effect would be very small and would have the greatest effect on low vowels. The other alternative, lowered larynx, was not discussed but ostensibly it is also possible, in that a lowered larynx could raise the first formant and produce an effect of perceived vowel height .

Denning (1989) gives an excellent overview of what is currently known or suspected about interconnections in the vocal tract with respect to the complex of effects associated with Khmer register. Among possible factors which he describes are laryngeal height, tongue root advancement and retraction, contraction of the pharyngeal wall and tongue blade or tongue body height. He comes to the conclusion that all of these factors may play a role in distinctions such as register. Of all the choices, however, he favors the hypothesis that laryngeal height is central. He cautions, however, that attributing a causative role to any of the above articulations would be premature and requires a great deal more study.

In addition to "biomechanical" factors, Denning also considers "neuromuscular" factors such as, for example, the possibility that the innervation of the aryepiglotticus in the operation of pharyngealization could also involve the innervation of the oblique interarytenoid, which, in fact, is just the same muscle extended into the larynx causing some adduction of the arytenoids and therefore, higher pitch. "Aerodynamic" factors such as are proposed below in the discussion of implosives are also considered. Denning notes that laryngeal lowering may be a result of attempting to prolong phonation in an environment where this might be difficult. He suggests that in order to maintain a breathy phonation, the rate of air flow must be high, the rate of pressure drop across the glottis must be large and the pharynx must be large.

In conclusion, Denning states that he suspects that one phonetic solution is not likely to be discovered and says "What is perhaps most interesting in the end is that more than one of these various possibilities may well be at work, thus comprising a 'conspiracy' whereby various originally independent phonemena (with given probabilities of occurrence) all of which tend to lead to a similar result compound each other and significantly increase the likelihood of that result" (Denning 1989:95).

The association of register and glottalized consonants requires a discussion of implosives. In studies of the relationship between phonation and pitch (Painter 1978, Hombert, Ohala and Ewan 1979), implosives, which are characterized by a sharp downward motion of the larynx, are generally found to condition higher pitch on a following vowel. Since generally laryngeal lowering occurs with a lowered pitch, this is unexpected.

Painter (1978) studied implosives with a particular emphasis toward answering the question of why a set of consonants generally considered voiced should pattern with voiceless consonants with respect to pitch effects. He suggests that, despite laryngeal lowering, implosives raise pitch because they differ in glottal timing from voiced stops, the set of segments in which laryngeal lowering is most often correlated with lowered pitch. He points out that, for a voiced implosive, the vocal folds are tightly adducted prior to laryngeal lowering which causes a supraglottal pressure drop and a consequent rise in pitch as air rushes through the narrow opening. This is contrasted to the pitch lowering effect of laryngeal lowering noted in singing and voiced stops (Wingate 1982), where glottal adduction takes place after lowering the larynx.

Painter concludes that the large difference between high subglottal pressure and low supraglottal pressure caused by the rapid lowering of the larynx results in a high pitch after the release of the consonant. This pitch rise is ostensibly caused by a rapid release of air past abducting vocal folds during the vowel. The pressure difference hypothesis is supported by the fact that the same sort of pitch rise is associated with labiovelar stops which are also characterized by low supraglottal pressure. Painter suggests that although glottal constriction and vocal fold tension are not the direct cause of higher pitch, they are linked to its implementation and therefore features based on these articulations should be useful in describing implosive-pitch connections phonologically. Lindau (1984) proposes that high frequencies during the articulation of implosives are correlated with tightly constricted vocal folds but notes that the exact physical articulation of implosives can be highly variable from language to language.

The findings from phonetic research show that it is not impossible for the articulation of register to be implemented at the larynx. However, it is not at all clear that that is how it should be represented phonologically. The same property may not be equally important for the recognition of the same feature in all languages. Any potential feature proposal should be compatible with feature proposals made for other languages. A survey of feature proposals may give an appropriate feature for representing Khmer register.

2.2 The Phonology of Register

2.2.1 Features

The idea of distinctive features may be traced to the theory of oppositions as described by Trubetzkoy (1939), where he hypothesized that certain features of the acoustic spectrums of speech sounds were universally used to semantically distinguish sounds in the world's languages. According to Trubetzkoy, certain features of speech could be shown to "oppose" each other in a kind of "either/or" relationship. For example, if a segment was voiced, it could be assumed that, at the same time, it would not also be voiceless. Voicing and voicelessness are in "opposition" to one another. This type of opposition was termed "equipollent" in that the presence of one implied the lack of the other. Trubetzkoy also claimed that there existed "privative" oppositions where the existence of a feature did not necessarily imply the absence of something. An example of this would be something like labiality where the use of the lips in articulation does not necessarily imply the non-use of some other feature such as retraction of the tongue root. The idea that the system of oppositions is a human universal underlies modern feature theories.

Jakobson, Fant and Halle (1969), employing the idea of universal feature opposition in relation to speech perception, presented a set of binary distinctive features based on the acoustic properties of sounds. In the case of phonation, a large part of the theory was based on the idea of source and transfer function in speech. Three basic properties of the source were isolated. These were: 1) the type of source - periodic or noise, 2) the number of sources and 3) the "transient effects" of the source - abrupt or smooth.

As for transfer functions, they noted that constriction in the vocal tract can produce resonances and anti-resonances which can cause certain frequencies in a sound to be either amplified or suppressed. In particular, if a source of periodic noise is located in the supralaryngeal tract, anti-resonances will suppress certain frequencies depending on exactly where the source is located. Information on the location of anti-resonances in the signal is used to define major classes although the acoustic effects are also correlated with certain specific articulatory gestures. Since their emphasis was on acoustic features, all segments containing laryngeal involvement were not necessarily represented as a natural class. Those features which may be relevant to Khmer are shown in Table 2.

Features	Consonant Characteristics	Oppositions	Vowel Characteristics	Oppositions
Tense/Lax	Longer duration Greater energy in the explosion following release tense has more subglottal airflow	Aspirated versus Non-aspirated	sum deviation of the formants from neutral position is greater in a tense vowel than a lax one	Retracted versus Constricted
Voiced/Voiceless	presence or absence of a harmonic source at the vocal folds	Voiced versus Voiceless	Same as consonants	Same as consonants
Acute/Grave	acute segments have a smaller more broken up mouth cavity	Coronal versus Labial and/or Velar	Same as consonants	Back versus Front
Flat/Plain	downward shift of a group of formants in a spectrum	Lip rounding or vocal tract expansion	Same as consonants	Same as consonants
Sharp/Plain	rise of the second formant	Oral Tract Constriction	Same as consonants	Same as consonants
Checked	"checking" of the airflow by means of the sharp compression of the glottis	Glottalization	Same as consonants	Same as consonants

Table 2: Overview of Acoustic Features of Jakobson, Fant and Halle (1969) Relating to the Larynx

Chomsky and Halle (1968) modified these original features, orienting them to the articulatory or production aspects of sounds. In Chomsky and Halle's formulation, each "independently controllable aspect" of the speech signal can be described by a feature. With this in mind, Chomsky and Halle introduced a series of possible phonetic features based on independent articulators which could be used to represent "the phonetic capabilities of man" (Chomsky and Halle 1968: 299). Of their features, nine are relevant for a discussion of laryngeal features. These are: [covered], [glottal constriction], [suction], [pressure], [tense], [heightened subglottal pressure], [voice], and [pitch].

Features	Consonant Characteristics	Oppositions	Vowel Characteristics	Oppositions
Covered	constricted pharynx	pharyngealized	same as consonants	pharyngealized vowels
Glottal Constriction	narrowing of the glottis	Glottal stops	same as consonants	Laryngealized
Suction	a downward closure movement at velum or glottis	clicks or implosives	same as consonants	unclear
Pressure	upward closure movement	ejectives	same as consonants	unclear
Tense	"supraglottal musculature" is employed deliberately and with some effort	interacts with others to inhibit or excite voicing	same as consonants	Tense vowels
Heightened Sub-Glottal Pressure	aspiration	aspirated consonants	same as consonants	breathy vowels
Voice	neutral position of vocal tract for voicing		same as consonants	voiceless vowels
Pitch	Position unclear, see discussion.			

Table 3: Overview of Articulatory Features of Chomsky and Halle (1968) Relating to the Larynx

Since each feature has both a phonological and phonetic function, it is possible, as Chomsky and Halle themselves point out, that the designation of features may not always be clearcut. Languages will most certainly differ as to the linguistic use of possible articulators. For example, in English, glottal constriction does not appear to play a distinctive role while in a language with a series of ejective stops (constrasting with voiced, voiceless, aspirated, murmured, and a laryngealized or implosive series of stops) such as Uduk, Siswati or Beja (Ladefoged 1973) it can serve to delineate an entire class of segments.

As for pitch, other than listing a set of possible features, Chomsky and Halle (1968) make no firm proposal and refer the reader to Wang (1967) where certain tone features are suggested. Wang claimed that the maximum number of level tones which needed to be

distinguished in any one language was five and that, although tone is phonetically a continuum, binary features can be supported given the phenomenon of tone flop which occurs in many languages where a high tone, rather than losing some degree of highness, loses the value of high completely and becomes low. He notes that tone representation based on a tone continuum is hard pressed to account for this. While Wang admitted that laryngeal articulations could have an effect on tone, he suggested that this was primarily a phonetic dependence and that tone should be phonologically represented as an independent feature. In addition, he claimed that it should be represented on the syllable rather than as part of an individual segment since these features could appear phonetically as part of the initial consonant, vowel or final consonant in Chinese languages. Therefore, it is irrelevant to speak of tone as a segmental feature phonologically and the laryngeal interactions are merely a result of the realization of tone over a larger element than the segment.

Halle and Stevens (1971) noted that voicing, aspiration, glottalization and tone all involve laryngeal manipulations and isolated three main acoustic effects resulting from the manipulation of laryngeal musculature. These are : (a) no vocal cord vibration, negligible airflow, and no turbulence noise at the glottis, (b) no vocal cord vibration, appreciable airflow and turbulence noise at the glottis, and (c) vocal fold vibration which may or may not have turbulence noice. The principal muscle movements required to produce these effects are (i) "adduction or abduction of the vocal cords by appropriately positioning the arytenoid cartilages" (changes static glottal opening) and (ii) "stiffening or slackening of the vocal cords through adjustment of the thyroarytenoid and cricothyroid muscles which changes the flexibility of the glottal walls". From this research they proposed four features designed to capture the interdependence of tone and other laryngeal features. These are:

(1) (i) *Spread Glottis:* rotation and displacement of the arytenoid cartilages to enlarge glottal width — combined with stiff vocal cords, this will inhibit vocal cord vibration - combined with slack vocal cords, vibration will occur (also [±s.g.]).

(ii) *Constricted Glottis:* adduction of the arytenoid cartilages — narrows the glottal opening - combined with stiff vocal cords, inhibits vocal cord vibration (also [±c.g.]).

(iii) *Stiff vocal cords:* makes the area of juncture between the upper and lower edges of vocal cords larger — no matter what size of glottal opening, the vibration is affected. If (a) there is an obstruction in the vocal tract causing intraoral pressure to build up, stiff vocal cords inhibit voicing. If (b) the glottis

is spread or constricted, stiff vocal cords inhibit voicing. This tends to narrow the range of transglottal pressure and glottal openings over which voicing occurs (also [±stiff]).

(iv) *Slack vocal cords:* makes the area of juncture between the upper and lower edges of vocal cords smaller — allows vocal cord vibration to occur with either a spread or constricted glottis (also [±slack]).

Some combinations of spread glottis/constricted glottis and stiff/slack are impossible.

(2) $*\begin{bmatrix}+\text{spread glottis}\\+\text{constricted glottis}\end{bmatrix}$ $*\begin{bmatrix}+\text{stiff vocal cords}\\+\text{slack vocal cords}\end{bmatrix}$

One characteristic of Halle and Stevens's four features is that they are all somewhat monovalent in that the minus values tend towards a kind of rest point. This is different from a vowel feature like [back] (or, alternatively, [front]) where both + and – values indicate some kind of dynamic movement.

This set of features is designed to account for both pitch in vowels and voicing/voice quality features and in particular, the correlation between consonant voicing and tone. If vocal cords are stiff, they will not vibrate if pressure across the glottis is reduced so voiceless consonants are [+stiff]. The features [stiff] and [slack] also serve to characterize tone. High tone is represented as [+stiff, –slack], low tone as [–stiff, +slack] and mid tone as [–stiff, –slack]. This accounts for the fact that voiceless consonants tend to cause a rise in fundamental frequency of a following vowel. Both high tone vowels and voiceless consonants are [+stiff].

The combination of the two features [spread glottis] and [constricted glottis] delineate, at most, three classes of segments since, as already mentioned, one combination is ruled out as impossible. These three classes are further divided according to the action of the vocal cords. If vocal cords are stiff, they will not vibrate if pressure across the glottis is reduced. Therefore, they correspond to voiceless consonants. In addition, Halle and Stevens propose, on the basis of evidence received in personal communication with L. Maran and D.H. Klatt as well as Kim (1970), that voiceless consonants all cause a rise in fundamental frequency of a preceding vowel. Their designation as [+stiff] is designed to account for this. Halle and Stevens also note that the lack of acoustic energy caused by the complete closure of both ends of the vocal tract causes a necessity to raise the larynx in the glottalized stops to decrease the volume of the vocal cavities and increase supraglottal pressure (ejectives). Non-stiff vocal cords can vibrate for smaller transglottal pressures. This set of

consonants would include lax voiceless, moderately aspirated, and voiced implosive stops. The voiced implosives also involve the lowering of the glottis.

If the vocal cords are slackened, vibrations are facilitated producing voiced stops. If these stops are also aspirated ([+s.g.]), they become breathy voiced. If glottalized, they are creaky voiced (laryngealized). Slack vocal cords allow for vocal cord vibration without the decrease in supraglottal pressure produced by a lowering of the glottis. "In the case of non-obstruents, voicing is impossible when vocal cords are stiff and the glottis is either constricted or spread, but vocal cord vibration can occur for the combination [+stiff] and [–c.g., –s.g.]. All non-obstruents designated as [+slack] are voiced. (p.208).

Vowels are classified in this system as follows:

(3) $\begin{bmatrix}-\text{c.g.}\\-\text{s.g.}\end{bmatrix}$ = normal vowels and glides

$\begin{bmatrix}-\text{c.g.}\\+\text{s.g.}\end{bmatrix}$ = voiceless or breathy voiced vowels

$\begin{bmatrix}+\text{c.g.}\\-\text{s.g.}\end{bmatrix}$ = glottalized or creaky voiced vowels

Voicing is impossible when vocal cords are stiff and the glottis is either constricted or spread. Therefore, in this system, a high tone should be impossible to represent on a glottalized vowel.

Halle and Stevens' system also predicts a voiced glottal stop which, on the basis of personal communication from Maran, they claim exists in Jinghpo. Maddieson's later inventory of this language does not include such a segment although that may be due to dialect differences (Maddieson and Ladefoged 1985). In the dialect studied by Maddieson and Ladefoged (1985) no voicing distinction existed. In fact, Maddieson (1978) speculated that the evidence for original voiced stops in languages like Khmer is not conclusive since it is based almost solely on the orthography. Since the orthography was developed from the Devanagari alphabet of India, it is always possible that symbols for voiced and voiceless consonants were merely used to code an aspect of syllables which the Devanagari was poorly equipped to handle and that a voicing distinction never actually existed. Register may have always been a feature of syllables in Khmer. Therefore, a "voiced" glottal stop is just as possible as any other voiced segment since the actual phonetic realization is on the entire syllable and not just the consonant. It is interesting to note that the speakers analyzed by Maddieson and Ladefoged (1985) claimed that they spoke the same dialect as that

spoken in Kachin and described by Maran (1971) cited in Maddieson and Ladefoged (1985). However, substantiating phonetic evidence is not available for the Kachin dialect and the question remains to be resolved.

Ladefoged (1973) criticizes Halle and Stevens (1971) on several grounds. In the first place, he says that their claim that voiceless obstruents and high tone vowels are both characterized by stiff vocal cords is wrong. As a result of his research (Ladefoged 1967), indicating that there is decreased airflow through the glottis in voiced sounds, he concludes that lower tone after voiced consonants does not result from adjustments of the larynx, but rather, from a decreased Bernoulli effect due to decreased airflow. Presumably, voiced consonants are articulated with less lung power than voiceless consonants. From this he hypothesizes that the opposite effect, that of higher pitch after voiceless consonants is merely the reverse of this. In the second place, Ladefoged notes that phonation types may occur over a range of pitch values (e.g. Mpi (Ladefoged 1982)) and that a feature system must account for this. Finally, he notes that Halle and Stevens's representation of the voiced/voiceless feature is too complex given the widespread occurrence of voicing and devoicing rules crosslinguistically. It is necessary to keep the voiced/voiceless feature to account for this.

Ladefoged (1973) describes three independent forces acting in the larynx. These are: 1) moving the arytenoid cartilages outward or inward thus decreasing or increasing the size of one end of the glottis, 2) the stretching of the glottis along the anterior-posterior dimension by virtue of manipulating the thyroid cartilage (probably by contraction of the cricothyroid muscle as described in Stevens (1977)) and 3) moving the entire larynx up or down, thus stretching the glottis along the superior-inferior dimension. These forces are largely associated with three kinds of laryngeal phenomena. These are 1) phonation, 2) pitch and 3) airstream mechanism respectively. He proposes three multivalued features to represent these three forces: phonation is *glottal stricture,* glottal timing is *voice onset,* and airstream mechanism is *glottalicness*. As for tone, this is left as an independent feature, but it is not well defined and its values are not completely justified.

According to Ladefoged, the largest number of phonation types required to be distinguished is six. He hesistates to describe the various states of the glottis as discrete events since, in real life, languages may choose any point along a continuum to articulate a distinctive element but proposes that a multivalued feature called *glottal stricture* might be proposed to represent some admittedly arbitrary points along that continuum. As a range of possibilities for values of this feature, Ladefoged suggests eight. These are shown in (4):

(4)
1) glottal stop
2) creaky voice
3) stiff voice - corresponds to Halle and Stevens (1971)
4) voice - corresponds to Chomsky and Halle (1968)
5) slack voice - corresponds to Halle and Stevens (1971)
6) murmur or breathy voice
7) voiceless
8) spread - corresponds to Halle and Stevens (1971)

Since, as Ladefoged points out, Halle and Stevens (1971) are capable of handling the range of values required in any one language, it is not clear why finer divisions of the laryngeal opening continuum are required. In addition, although it may be true that Halle and Stevens are erroneously suggesting interrelationships between features which do not exist, it is also true that Ladefoged's system fails to characterize interrelationships which may exist (e.g. phonation and tone). Ladefoged's complaint that the representation of voicing as consisting of subsets of articulatory features gives complexity to natural rules is well taken although it may be seen that this is not necessarily a good argument against a feature representation which can properly characterize the interrelationships between these laryngeal gestures. As Ladefoged points out, a good feature system must account for the independence of these features but phonetic and phonological studies of various languages indicate (Yip 1982, Denning 1989) that it should also be able to account for their interdependence.

On the basis of the continuum formed by a hierarchical relationship between the segments that conditioned tone split in Proto-Tai, Gandour (1975) finds both the theories of Halle and Stevens (1971) and Ladefoged (1973) inadequate. In Proto-Tai, although different sets of consonants conditioned different splits in different languages, the classes of consonants involved can be grouped along the following continuum:

(5)
a) voiceless aspirated stops and /h/
b) voiceless fricatives and voiceless sonorants
c) voiceless unaspirated stops
d) glottal stop and preglottalized stops and preglottalized glides
e) voiced obstruents and sonorants

In the case of Halle and Stevens, Gandour claims that their theory predicts that only vocal cord stiffness will be relevant for tone split while, in fact, the width of the glottis was also relevant for Proto-Tai. He notes that Halle (1972) claims that pitch and voicing are directly correlated on the basis of historical developments in Far Eastern languages which Gandour's evidence shows is not always true. For example, in Siamese, the set of consonants described in (5a) and (5b) above conditioned one tone while those in (5c), (5d)

and (5e) conditioned another. If voicing was the only factor, the set of consonants described by (5c) should have patterned with the other group. In addition, Gandour claims that which consonants operated as a set to condition tone varied from language to language, indicating that a binary system is inadequate to describe Thai tone split.

As for Ladefoged's (1973) proposal for multivalued features for glottal opening, Gandour notes that it is better able to deal with Thai languages because it clearly indicates that pitch and glottal opening are independent. However, he notes that it also predicts that no natural phonological rule would refer to a class of speech sounds that includes both glottal stop and an aspirated segment without referring to intervening segments, something he claims is required to account for the tone splitting data. Recalling that aspiration can be represented in more than one way in Ladefoged's system, this may not pose a serious problem. However, he also notes that in order to account for the Thai data it is necessary to switch [stiff] and [closed] on the scale. This, he says, is an ad hoc non-explanatory solution and reveals a fault in the system.

As for the particular problem posed by Khmer register, Gregerson (1976) argues that the feature [±ATR] is the best characterization of the register distinction in Mon-Khmer languages. He compares the situation in Khmer with that of African languages like Twi and Akan where [ATR] has been proposed as the relevant feature in various harmony processes (Stewart 1967, Pike 1967). The main brunt of his argument focusses on the fact that some pharyngeal expansion is doubtless going on in the articulation of expanded register vowels and that [ATR] can account for this.

As previously noted, register is thought to have arisen from the loss of a voicing distinction. The correlation of register with voiced consonants poses some problems in that [ATR] is a tongue root feature while voicing is generally considered to be a laryngeal feature. Gregerson argues that [+ATR] vowels would serve to widen the pharyngeal cavity and lower supraglottal pressure, thus favoring voicing while [–ATR] vowels would have the opposite effect. He suggests that laryngeal lowering is merely an unmarked cooperative gesture associated with the widening of the pharynx. In other words, he claims that the natural thing is for speech organs to cooperate with each other to achieve certain vocal tract configurations and therefore laryngeal lowering is an expected (although not essential) cooccurrence in expanded register vowels. This is merely speculation, however, since there have been no studies done to ascertain which articulatory or acoustic feature can be best correlated with register.

As for register associations with pitch, Gregerson is at a loss to explain this but considers that "regarding the relationship of tongue-root movement and laryngeal function (both voicing and pitch), it seems possible to say that a fundamental liaison exists between them such that it is natural, though not inevitable, for certain cooperative activities to take place in speech production" (Gregerson 1976:357). Laryngeal activity is merely an unmarked relationship tied to [ATR] by virtue of a tendency to enhance whatever effect is happening.

Lindau (1979), in a study of the vowel classes of Akan, concluded that the important acoustic element in vowel harmony in that language was the height of the first formant since it had much more intensity than the other formants. A cineradiography study of the articulation of Akan vowels revealed that both pharynx width and larynx height were significantly correlated with the harmonizing feature and the frequency of the first formant. Since, as Lindau claims, there is no particular physical reason for the position of the tongue root to influence the height of the larynx, she suggests that there must be some other reason. She suggests that the reason that tongue root advancement and larynx height are correlated is because the phonological feature in question requires both these factors to be effectively implemented. She proposes that this is the binary feature [expanded] and that it will cover any distinctions made by any language in regards to the size of the pharynx. With both articulatory gestures tied to one cover feature, Lindau is predicting that there will be no language which contrasts segments for both larynx height and tongue root position. As far as I know, that prediction is borne out for Khmer although Denning (1989) proposes exactly that contrast for Bor Dinka. In any case, pharyngeal expansion is not necessarily just a function of the tongue root. It may be implemented at the larynx.

This conclusion is also that of Trigo (1991), who suggests that an additional feature relating to pharyngeal expansion should be added to the universal feature inventory. She equates this feature to the Chomsky and Halle (1968) feature [covered] and like Denning (1989), she suggests that this feature be called [Lowered Larynx]. Unfortunately, Trigo provides no evidence that [Lowered Larynx] is phonologically independent from the feature [ATR]. She is more successful in arguing for the phonological independence of [Lowered Larynx] from Halle and Stevens's (1971) four laryngeal features. She notes that Halle and Stevens's system makes the prediction that all ejectives should be voiceless and all implosives should be voiced, although Igbo (Maddieson 1984) contradicts this prediction. In addition, she claims that the variable cross-linguistic effects of ejectives on the pitch of following vowels shows that "the vertical displacement of the larynx is not a mechanical consequence of the intrinsic laryngeal features" (Trigo 1991:118). In other words, such

features as stiff/slack vocal cords and constricted/spread glottis can be activated independently of larynx height.

2.2.2 Organization of the Features

Besides the particular features associated with the larynx is also the question of how these features relate to each other and to other non-laryngeal/pharyngeal features. Lass (1976) proposes that features be considered as articulatory gestures within a segment. He suggests that every segment is (at least) bi-gestural in that it contains both a laryngeal and supralaryngeal articulatory configuration. He terms the laryngeal gesture as "categorial" and the supralaryngeal gesture as "locational". Glottal stops and [h] which have phonemic status in a language have merely "shifted" the locational gesture to the laryngeal area. He notes that this property of laryngeal segments makes them "defective" in that they lack a gesture. Lass states "while [ʔ] is not distinctive in English except categorially, [h] is as distinctive as any other voiceless fricative. The laryngeals can be terms in distinctive oppositions: but they are different in TYPE from other segments, and historically they tend more often than not to originate through shifted gestures." (p.154). As evidence of this Lass makes the supposition that word final glottal stops in Burmese are actually the final stage in final voiceless obstruent deletion.

Lass's case for [h] as a reduced fricative is not as clear. He cites historical evidence from Indo-European, Dravidian, and Uralic which shows that /h/ is generally not a protosegment. From this he surmises that [h], like glottal stop, is a stage through which a segment may pass on the way to deletion. In other words, [h] is also a segment which has lost all oral features. Lass notes that this evidence is not conclusive however and that this characterization of the role of [h] as "the last stage before deletion" may be more due to perceptual characteristics (it's harder to perceive) than its characterization as "defective". In other words, the lack of oral features associated with [h] may not be the result of deletion but rather, the reason for it.

Based on these observations, Lass proposes formally that segments be represented as two part matrixes with submatrixes headed as oral and laryngeal. He notes that by giving these two parameters notational independence, we imply that each can operate as the domain for a rule. In addition, these rules can operate just on the basis of features. The submatrices are not necessarily significant. In other words, rules may still appeal to individual features, they just also have the added power of appealing to a higher level of organization. Lass's ideas are largely incorporated in current dependency theories of phonology such as Dependency Phonology (Anderson and Ewen 1987) and feature geometry.

The theory of feature geometry is designed to account for the interdependence of features in a principled way. In feature geometry (Clements 1985, 1989, Sagey 1986, 1988, Kingston 1986, Pulleyblank 1988, McCarthy 1988, 1989a,b, Avery and Rice 1989a,b, Piggott 1989), features are organized under various "class" nodes which are also meant to represent the componential nature of the production of speech. In other words, each node is hypothesized to be capable of operating independently of the others. Unlike other dependency theories such as charm and government (Kaye, Lowenstamm and Vergnaud 1985), particle phonology (Schane 1984) and dependency phonology (Anderson and Ewen 1987), the relationships between these nodes are supposed to be fixed and universal for all languages. Those areas of production which Clements claims have a "high degree of independence" are "1) laryngeal configuration, 2) degree of nasal cavity stricture, 3) degree and type of oral cavity stricture and 4) pairing of an active and a passive articulator". (p. 231) As a result of this observation, Clements suggests five class nodes under which distinctive features are arranged. These are: the root node, the laryngeal node, the supralaryngeal node, the manner node and the place node.

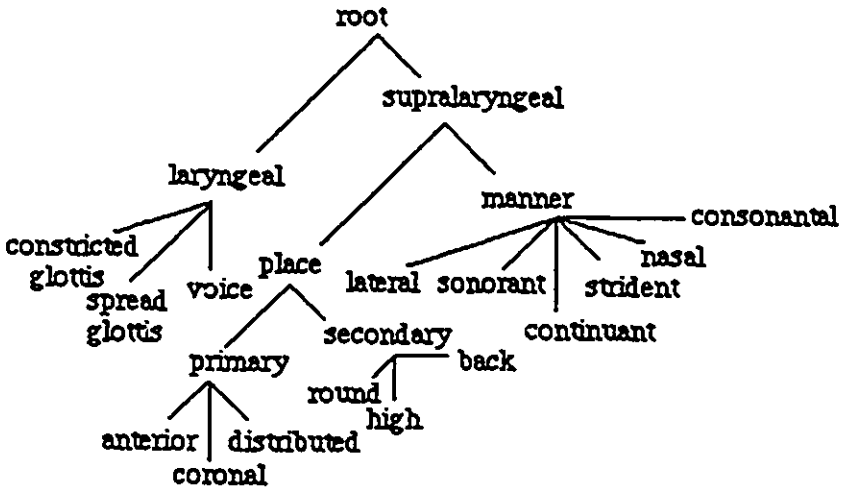


Figure 1: Feature Hierarchy Proposed by Clements (1985)[1]

Under the laryngeal node, Clements groups the features [spread], [constricted] and [voiced]. He has replaced Halle and Stevens' features [stiff] and [slack] by [voiced] since he assumes that tone features are distinct from laryngeal features although he acknowledges that there appear to be some interrelationships.

[1]Clements (1985) suggested that the primary and secondary classes of features might be organized under separate nodes but also acknowledged that they might attach directly to the place node. As the former option was decisively implemented in his later work, it is represented here.

Sagey (1986) further develops this idea with a hierarchy that is based on articulatory phonetics whereby features are grouped under class nodes which represent articulators in the vocal tract. In addition, the laryngeal nodes and the supralaryngeal nodes can be differentiated acoustically in that, unlike supralaryngeal features, the laryngeal features do not affect the shape of formant structure. This model is intended to make some clear claims about feature systems. In the first place, features grouped under one class node serve to define a natural class of segments. In addition, assimilation rules require that features from one segment spread to an adjacent segment (on some level). Intervening segments not specified for a particular level will thus be invisible to assimilatory processes involving that level allowing seemingly non-adjacent elements to be characterized as adjacent.

Sagey gives several arguments for the existence of a laryngeal node. In the first place she notes that there are many processes which affect everything except laryngeal features whereby all supralaryngeal features are omitted leaving only glottal stop or /h/ (Lass 1976).

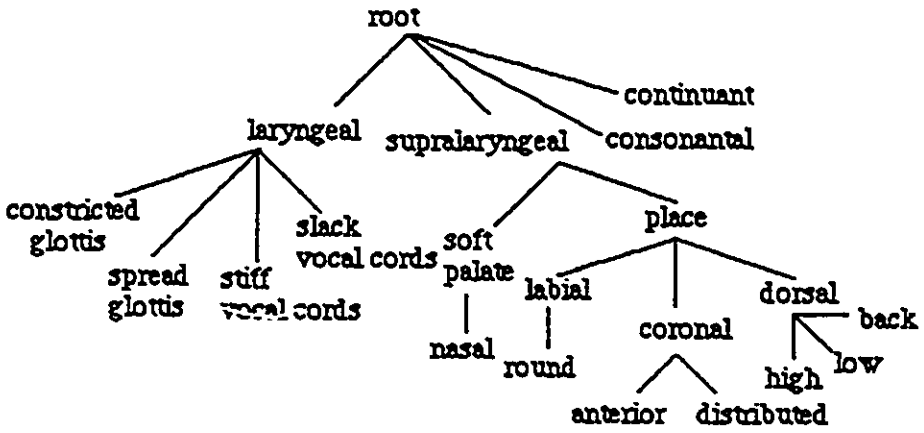


Figure 2: Feature Hierarchy Proposed by Sagey (1986:1)

She also notes that the spreading of supralaryngeal features across segments articulated only in the larynx ais quite common. To support the idea that laryngeal features act as a group, she points to such processes as Icelandic preaspiration (Thráinnson 1978) where the laryngeal features of geminate aspirated stops are thought to split out from the supralaryngeal features leaving two segment sized slots, one containing the laryngeal feature and one containing the supralaryngeal features. Thráinsson argued that this explanation is good in that it reflects the fact that preaspiration occupies a segment sized timing slot and also concretely echoes the fact that what is happening here is aspiration (or

laryngeal elements of the phoneme) being timed prior to the supralaryngeal elements of the phoneme.

One big argument against Halle and Stevens' original four laryngeal features (Ladefoged 1973) was the fact that it complicated greatly the characterization of voicing assimilation[2], a process which is very widespread and therefore considered extremely natural. Sagey's tree eliminates this problem by grouping laryngeal features under one class node. Voicing assimilation must then be represented as the spreading of a class node in the same way that place assimilation is handled (McCarthy 1988).

One main difficulty with feature geometry is that, although the tree is supposed to be fixed, there is wide disagreement as to the specific way that the tree must be arranged (c.f. den Dikken and van der Hulst 1988 for a survey). Maximally constrained, the dependency relations of the features on the tree would be universal, allowing clear predictions of what assimilatory/dissimilatory processes could or could not occur crosslinguistically. A feature tree with this property would certainly have achieved a high level of explanatory adequacy. However, there have been various proposals for modifications to Sagey's feature tree and they are not all compatible. One area where some difficulty still lies is the question of exactly what features comprise the universal set. Many linguists are still not convinced of the value of the four laryngeal features proposed by Halle and Stevens (1971). There has been a reluctance to give up the feature [voice] in favor of some combination of glottal opening and vocal cord tension settings. Therefore, most feature trees have replaced [stiff] and [slack] with [voice].

The removal of the stiff/slack vocal cord features from the tree has necessitated the addition of tonal specifications although, since languages with as many as five level tones have been described (e.g. Hei Miao and Dahua Yao (Chang 1953)), it is possible that these features were inadequate. There have been various proposals as to where tone features should be represented. Laryngeal features are usually placed under the laryngeal node but there is some question as to exactly what constitutes a laryngeal feature. Tone has been proposed as a laryngeal feature in that tone features and glottal features tend to interact (Halle and Stevens 1971, Yip 1982). However, in agreement with Wang (1967), who suggested that tone was more likely a feature of higher prosodic constituency, Pulleyblank (1988) and Piggott (1989) represent tone as a sister node of the root node dependent on the skeletal tier while voicing and glottal specifications are dependents of the laryngeal node. Kingston

[2]Ladefoged's criticism is based on the assumption of the time that all feature matrixes were fully specified at all times.

(1986) proposes that, in order to account for laryngeal interactions with tone, both consonants and vowels be specified for tonal and non-tonal features.

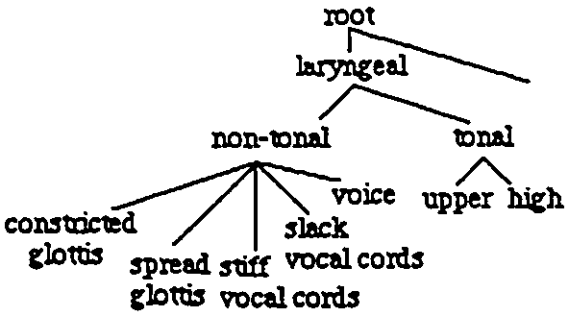


Figure 3: Laryngeal Specifications Proposed by Kingston (1986)

Those languages where laryngeal features of vowels interact with laryngeal features of consonants would be characterized as either sharing non-tonal features or sharing tonal features. Kingston's (1986) version of the feature tree is essentially that of Sagey (1986) with modifications to the laryngeal node.

He notes that the features [stiff] and [slack] are generally predictable from the feature [voice]. In fact, since one of the original purposes of [stiff] and [slack] was to give a derived representation for the feature [voice], this is expected. Kingston notes that the specification of implosives is where the voicing feature is required in addition to [stiff] and [slack]. This is not clear however since, while it may be phonetically necessary to specify implosives as voiced or voiceless, no language exists which would need to differentiate between voiced and voiceless implosives. Even Igbo, which has voiceless implosives (Ladefoged 1973), does not contrast them with voiced implosives.

With regard to the voicing feature, Avery and Rice (1989b) have pointed out that there are two aspects to voicing. On the one hand, voicing is a result of tightening of the glottis as proposed by Halle and Stevens (1971) and on the other hand, it is a result of modifications in the size and shape of the vocal tract which optimize the conditions for voicing by lowering supraglottal air pressure and therefore increasing airflow. This produces voicing even when the vocal cords are at a neutral setting. The laryngeal voice occurs under the laryngeal node but the other type of voicing, since it constitutes more of a "manner" feature constitutes another class node. This node is termed the "spontaneous voicing node" and dominates those features which distinguish sonorant segments such as nasal and lateral.

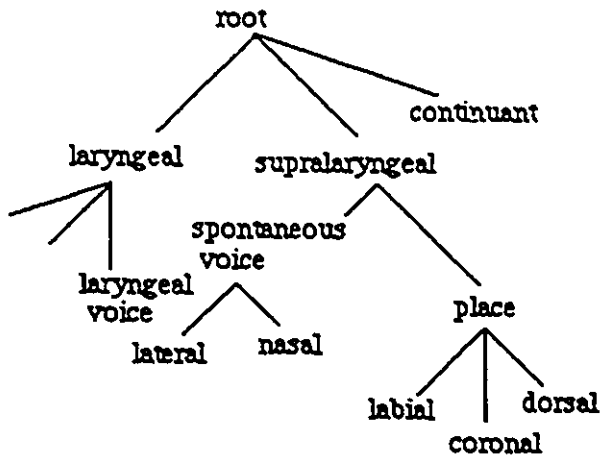
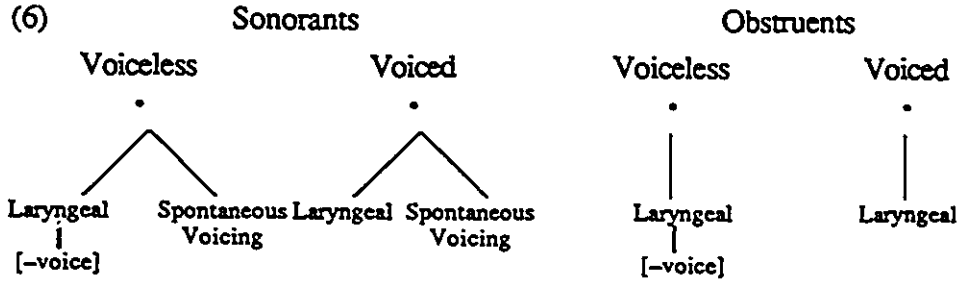


Figure 4: Feature Hierarchy Proposed by Avery and Rice (1989b:65)

As a result of this, Avery and Rice (1989b) claim that there may be three types of languages with respect to voicing. In one type, voiced obstruents are unspecified, in another they are specified as laryngeally voiced and in the last, they are specified for both laryngeal voice and spontaneous voice. Under this analysis, such features as nasal, lateral and some instances of voicing are dependent on the spontaneous voicing node. In a language where both sonorants and obstruents are distinctive for voicing, they might be specified for voice as in (6).



If the laryngeal feature [–voice] involved in the original voicing opposition is lost, two classes of segments are left; those specified for spontaneous voicing (sonorants) and those which are not (obstruents). What voicing specification is relevant for any particular language is dependent on how obstruents and sonorants pattern phonologically in the language.

A final point of contention with feature trees with respect to Khmer is the representation of the tongue root feature of [ATR]/[Expanded] since many trees do not incorporate this feature.

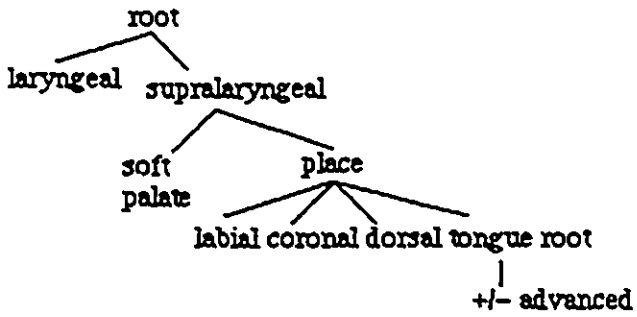


Figure 5: Feature Hierarchy Proposed by Cole (1987:93)

Cole (1987) argues that Faucal harmony in Coeur d'Alene involves the spreading of a tongue root node on the basis of the classes of transparent and opaque segments with respect to harmony. Cole motivates both regressive and progressive spreading of [–ATR] with uvular and pharyngeal consonants acting as triggers for the regressive harmony and "lax" vowels as triggers for the progressive harmony. Progressive harmony is blocked by uvular and pharyngeal consonants. Cole (1987) explains this by determining that uvular and pharyngeal consonants, along with the "lax" vowels, [a,o], are all specified with the tongue root node. A rule spreading the tongue root node from right to left from consonants to vowels gives the regressive harmony rule. As for progressive harmony, this is also spreading of the tongue root node, this time from vowel to vowel and from left to right.

McCarthy (1989a) also argues quite convincingly for the specification of uvular and pharyngeal consonants as a natural class on the basis of evidence from various Semitic languages. He does not include [ATR] as a feature and accounts for rules of [ATR] harmony as the spreading of the class node termed [Pharyngeal].

This is somewhat equivalent to the treatment of Cole (1987) for Coeur d'Alene since, in her formulation, the feature [advanced] is merely filled in later as a default feature of vowels bearing the [tongue root] node. However, unlike previous accounts of class nodes where the different nodes are supposed to correspond to active articulators in the vocal tract, McCarthy proposes, on the basis of a proposal in Perkell (1980) relating to the distribution of tactile receptors in the vocal tract, that place nodes actually correspond to areas of the vocal tract and not necessarily active articulators. McCarthy also claims that the

[pharyngeal/tongue root] node dominates the feature [glottal] and operates to characterize several types of natural classes including glottalized and pharyngealized consonants. The evidence from Coeur d'Alene may be a counter-example to this claim since the class of opaque segments to faucal harmony does not include glottalized segments although Coeur d'Alene is blessed with many.

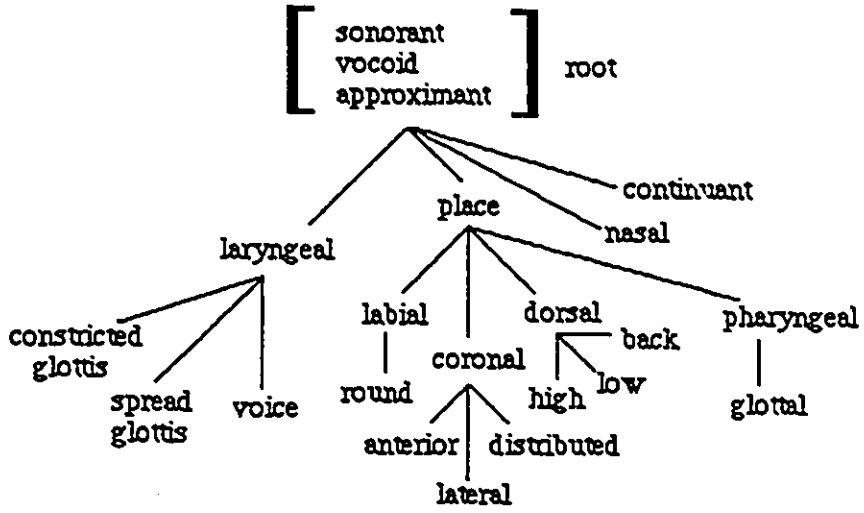


Figure 6: Feature Hierarchy Proposed by McCarthy (1989a:3)

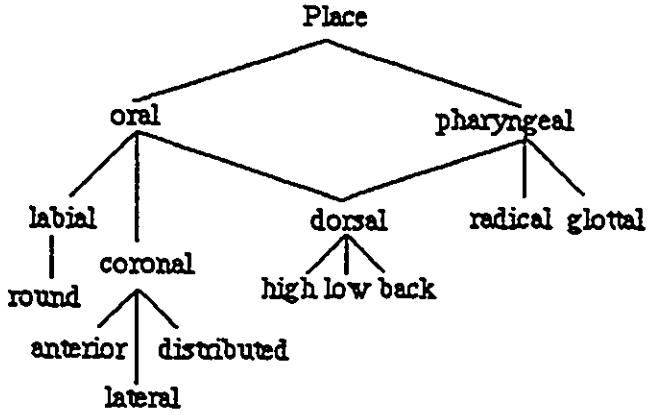


Figure 7: Feature modifications Proposed by McCarthy (1989b:12)

McCarthy (1989a) slightly modifies the tree in Figure 6 to include dorsal features as doubly dependent on both an oral and pharyngeal node. This formulation of features allows velars to be included in the class of back consonants.

However, although McCarthy suggests that glottalized segments may be doubly articulated, he does not do away with the feature [constricted glottis] at the laryngeal node. This leaves

the way open for glottalized segments to be laryngeally specified in some languages and pharyngeally specified in others. As faucal harmony shows, glottalized segments in Coeur d'Alene must be specified at the larynx since they are not opaque to harmony and not the [tongue root/pharyngeal] node (Cole 1987).

Maddieson and Ladefoged (1988) and Clements (1989) suggest that the features of consonants and vowels, although practically the same in terms of articulators, belong on separate tiers. As evidence for this, Clements (1989) cites rules of vowel harmony that treat all consonants as transparent. With regard to [ATR] or [Expanded], he terms it [radical] and suspends it from both the consonant and the vowel tier. Unlike major class features in other hierarchies, features like [labial] and [radical] are binary in Clements' account so both constriction and expansion of the pharynx can be characterized. Essentially [+radical] is the same thing as [–ATR]. The name is changed to indicate that pharyngeal manipulation can be a feature of both consonants and vowels. Consonants involving pharyngeal articulation can potentially be specified with either consonantal or vowel features. If the pharyngeal articulation is the primary articulation of the consonant, it is specified with the consonantal feature [radical]. If the consonant is pharyngealized, in other words, the pharyngeal articulation is secondary, a vowel feature is used. It is only consonants with secondary articulation, that is, those which are specified with vowel features that can serve as opaque segments in vowel harmony rules.

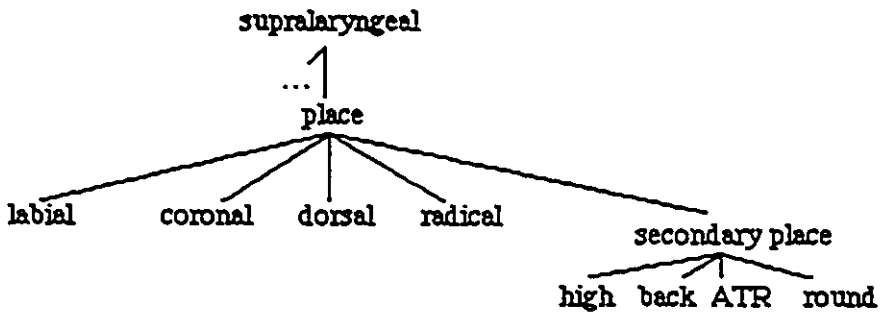


Figure 8: Feature Hierarchy Proposed by Maddieson and Ladefoged (1988:118)

Both the question of spontaneous voicing and that of [ATR] bring up the issue of double dependency (Yip 1990). Yip suggests that a laryngeal feature, tentatively named [murmur], is doubly dependent on both the tonal and laryngeal node. She comes to this conclusion as a result of evidence from Shanghai where murmur, a prosodic feature of vowels, has a conditioning effect on both the voicing characteristics of an onset consonant and the tone levels of the vowel. In addition, deletion rules operate to delete some tones in Shanghai and

when that happens, the murmur feature deletes also. Yip explains this by asserting that prosodic licensing (Itô 1989) of [murmur] in Shanghai requires that both its dominant nodes license it to be realized. Two features involving the same articulator must be specified under different nodes phonologically, but also require some degree of interdependence. The ambiguity of representation posed by glottalized segments which may be represented under the place node or under the laryngeal node suggests that double dependency may also be an issue in the representation of register.

There are many different themes running through all these proposals for features that have come together into current feature theory. In the first place is Trubetzkoy's differentiation of equipolent and privative oppositions whereby features may be opposed to each other or merely to their own absence. In addition is the notion of markedness where the presence or absence of a specific feature may imply the presence or absence of another. There is also the idea of cover features which serve to represent various points on a phonetic continuum. Finally, the discussion of cooperating articulatory gestures leads to the recognition that features may be organized hierarchically since it is clear that, while to some extent, the oral tract and the laryngeal tract may operate highly independently, other articulatory organs, being tied together, are somewhat interdependent.

Three possibilities for the representation of Khmer register are revealed in this survey. Register may be [ATR], [Expanded] or [Lowered Larynx]. The place of each of these features in a feature hierarchy has also been reviewed. The feature [ATR] has been previously established as a [Place] feature by Cole (1987) and McCarthy (1989a,b). The location of the feature [Lowered Larynx] has not yet been established although, intuitively, it would seem to fit under laryngeal. In the case of [Expanded], it may be that, following Yip (1991) this is a case of double dependency. An additional option is that of Avery and Rice (1989a) whereby, since register is, at least historically, related to voicing, it may be a spontaneous voicing feature. Only an analysis of how different features interact in the phonology of Khmer can establish what feature is operating and how it should be organized hierarchically.

In the next three chapters, register in Khmer will be discussed in depth, incorporating current ideas of feature geometry and non-linear phonology into the analysis. Using this analysis, three of the above possibilities for the representation of register, spontaneous voicing (Avery and Rice 1989b), place features (McCarthy 1989a,b, Clements 1989 and Maddieson and Ladefoged 1988), and a laryngeal solution will be evaluated as to how well they can represent the facts of Khmer.

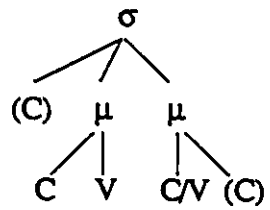
Chapter Three
Syllable Structure

3.0 Introduction

The understanding of syllable structure in Khmer is important to the discussion of register for three reasons. In the first place, in Chapter Five, it will be argued that there are two separate systems of vowels which differ as a result of how they are associated to the syllable. In particular, it will be claimed that some vowel features are prosodically licensed, in the sense of Itô (1986) and Goldsmith (1990), by the second mora of the syllable. To that end, it is necessary to show that Khmer syllables are bimoraic and that differing vowel associations of this type are distinctive in Khmer. It is also important to establish the structure of the Khmer syllable since it will be argued that the target for one type of register harmony is created by the insertion of epenthetic vowels resulting from constraints on the structure of syllables in Khmer. Thirdly, it will be assumed that the mora forms part of the environment for the rule of register harmony.

The syllable structure of Khmer is assumed to be that of (1) where σ is a syllable, C indicates a segment specified as [+consonantal], V, a segment which is [–consonantal], and μ stands for mora.

(1)



The moraic syllable structure adopted here is not the only method that could have been chosen for the representation of Khmer syllables and, in particular, two other prominent approaches to syllable structure proposing an intervening level between syllables and melodic units can be mentioned. One approach, proposed by Clements and Keyser (1983), involves a skeletal tier composed of slots represented as either C (consonant) or V (vowel). In some languages, this tier is preset, with melodic units associated to it in an appropriate manner. The advantage of an approach of this type is that it allows the syllabicity of segments to be determined by whether or not they are associated to a slot marked V on the skeletal tier and not as a result of some inherent property of the segment. Other approaches (Kaye and Lowenstamm 1984, Levin 1985) propose that this tier is made up of Xs, skeletal positions which serve only as place holders for segments. The syllabicity of

segments in this approach is coded above the skeletal tier with higher structure such as the nucleus or rhyme. A distinction of these approaches is that they imply a constituent relationship for nucleic elements apart from the initial consonants which form the onset.

A closer relationship between onset and nucleus is a feature of the moraic approach of Hyman (1985) because it allows the nuclear vowel and the onset to form a constituent under the mora. Katada (1990) argues that Japanese language games require this kind of relationship. In later chapters, it will be seen that by allowing a close relationship between the pre-nuclear onset consonant and the mora, an elegant representation of the interaction between the register of the vowel and the distinctive features of implosives and /r/ is allowed.

The first section of this chapter will establish the bimoraic requirement on Khmer syllables and will show that Hyman's (1985) onset creation rule can be used to build syllables in Khmer. The requirement that the onset and the vowel and the coda and the vowel be tied in this intimate relationship will be illustrated in the next part. Finally, it will be shown that mismatches between the melodic level and the well-formed syllable, as a result of affixation, give rise to repair strategies which syllabify additional morae. It is around these morae that register harmony takes place.

3.1 Monosyllabic Words as a Bimoraic Template

The vast majority of native Khmer words are either monosyllables or disyllables (Henderson 1952, Huffman 1967, Jenner 1969, Jacob 1968, Huffman 1972, Nacaskul 1978). Monosyllabic words may occur in one of the following eight canonical shapes (Huffman 1967):

(2)	(a)	CVC	[kap]	'to chop' (H28)
	(b)	CVV	[ka:]	'ewer' (H24)
	(c)	CVVC	[ka:p]	'frame'(H28)
	(d)	CCVC	[krap]	'castenets'(H76)
	(e)	CCVV	[kra:]	'small caterpillar'(H75)
	(f)	CCVVC	[kra:p]	'to bend down'(H76)
	(g)	CCCVC	[sthət]	'to stand, be located'(H1222)[1]
	(h)	CCCVVC	[stha:m]	'place, station' (H1221)

[1]According to Huffman (1967), the shapes in (2g) and (2h) are rare in relation to the others. In a survey of roughly 15,000 entries in Headley et al. (1977), only twenty four words can be found with initial clusters of three consonants and only seven of these are monosyllables.

As can be seen by the examples in (2), monosyllabic words in Khmer never end with more than one consonant. This is also true of longer words. Glides are considered consonants for the purposes of this restriction. This is illustrated by the fact that while both words like [chaɯ] 'to copy something down rapidly' (H213) and [chau] 'raw' (H215) exist, there are no words with the structure C_1^2VCC even if the first consonant following the vowel is a glide.[2] Additional support for the claim that this is a word-final consonant cluster constraint comes from loanwords. The French word *poste* is pronounced [poh] (Jacob 1974:112) without the final consonant. This restriction on final clusters is general. Without exception, words do not end with a consonant cluster in Khmer.

The property of monosyllabic words that is crucial to this discussion is that there is a restriction on the size of the syllable. A monosyllabic word must minimally contain either a long vowel or a short vowel followed by one consonant. In addition, it can maximally contain a long vowel and be closed with one consonant. While the consonant final restriction can be handled by a constraint forbidding consonant clusters in word final position, the other restriction must refer to syllable size. By proposing that monosyllabic words in Khmer must fit a bimoraic template along the lines of those proposed by McCarthy and Prince (1986) with the structure in (1), the restriction on the size of monosyllabic words is accounted for.

The minimal size restriction on monosyllabic words can be shown by an alternation between [l] and Ø in final position as seen in the examples in (3).

(3) [kpùl] ~ [kpù:] 'to gargle' (H101)[3]
[ptùl] ~ [ptù:] 'oxcart roof' (H618)
[pùl] ~ [pù:] 'to be bruised' (H658)
[prùl] ~ [prù:] 'to panic (birds)' (H680)

Hayes (1989) claims that compensatory lengthening of vowels in some languages is a result of the loss of a consonant in a moraic position. In the example in (3), since the vowel of the word is short, the[l] must occupy the second mora. When (and if) the [l] is lost, the vowel lengthens, as would be predicted by Hayes. The fact that only a consonant

[2]The consonantal classification of glides does not fall out from the syllable structure in (1). The representation of glides will be discussed more fully in Chapter Four.
[3]There are very few examples of this in the data. One possible reason for this is that this is a feature of colloquial speech that would not ordinarily make its way into anything so formal as a dictionary. Whatever the reason, since there are so few of these examples, they must be taken with a grain of salt.

following a short vowel is moraic is shown by the fact that there are no alternations between long and extra-long vowels in a similar environment. In other words, there are no examples of words containing a long vowel in a closed syllable which alternate with an open syllable containing extra-long vowel. This is evidenced by the set of words spelled with final /r/. In the standard dialect, /r/ is deleted in word final position. Where it has been deleted, the remaining vowel is always long and there is not resulting length differentiation. Assuming that prior to deletion, both short and long vowels could be found prior to /r/, this would indicate compensatory lengthening has taken place only in the case of the short vowels. If a bimoraic requirement is assumed, this is expected.

In order to account for Khmer syllabification, at least some part of the syllable structure of Khmer must be coded in the lexicon since there is a contrast between long and short vowels in closed syllables as shown by the examples in (4).

(4) [tùl] 'to jut out'(H396) [tùːl] 'to carry on one's head'(H399)
[ɓac] 'bunch' (H518) [ɓaːc] 'to throw, scatter' (H518)

In order to keep the long/short contrast, it is necessary to either map a bimoraic template onto a skeletal tier, where the length contrast is represented by mapping a single vowel onto either one or two skeletal positions, or to stipulate that vowels are underlyingly attached to morae (Hayes 1989). In that case, long vowels are attached to two morae and short vowels to one. It is the second of these two approaches which is adopted here.

Hyman (1985) proposes that syllables and segments are mediated by a middle layer composed of weight units or morae.

Syllabification takes place as a result of the "onset creation rule" (henceforth OCR) which operates to attach an onset to its appropriate mora. In addition, since onsets do not carry syllabic weight, the OCR also eliminates the mora that was underlyingly associated with the onset segment.

(5) 

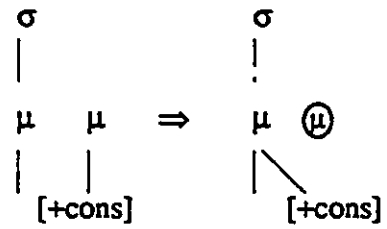
(Hyman, 1985: 15)

Mora (μ) has been substituted here for the x in Hyman's original formulation of this rule. The circle indicates deletion. Hyman claims that this rule is universal but that, along with

the OCR, languages may optionally have rules which will adjoin additional consonants directly onto the syllable.

These rules are sensitive to language particular consonant cluster formation restrictions. So, for example, there is a rule in Khmer which will allow the adjunction of one additional consonant in word-final position. The adjunction of the consonant must also destroy its link to its mora since there is no evidence that syllables containing a long vowel plus a consonant are any heavier than those without the consonant. This is borne out by the example given earlier where the loss of [r] after long vowels resulted in no compensatory lengthening while after short vowels, compensatory lengthening occurred. This rule is sensitive to the constraint on adjacent consonants in syllable-final position. Therefore, if the final mora of the syllable is already attached to a consonant, this rule will be blocked.

(6)

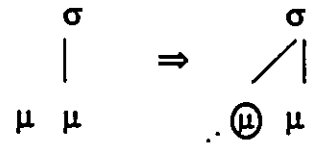


Final Consonant Adjunction

It is also possible that this final consonant adjoins to the syllable. However, in the following two chapters, it will be argued that vowel-consonant cooccurrence patterns result from the licensing capabilities of this word final mora. If it is assumed that the consonant is, in fact, associated to the mora and not the syllable, then these cooccurrence patterns can be traced to the OCP operating within the domain of the mora. The fact that these same vowel-consonant constraints do not hold between the onset and the vowel or between any consonant and short vowels is a result of the fact that the initial mora, which governs the initial consonant and short vowels is not a licenser of the features in question.

In addition to the above adjunction rules, it is also possible to add one more consonant in initial position. This rule is described in (7).

(7)



Initial Consonant Adjunction

The class of segments which can occupy this position is limited. If the implosives and [r] are not considered, since, as it will be argued shortly, their non-occurrence in this position

is because some feature which distinguishes them must be licensed by a mora, then it can be seen that vowels, glides and almost all the nasals are excluded from this set of consonants. It may be that more research would reveal that only obstruents are allowed in this position since the status of [m] and [l] with respect to adjunction is a little unclear. As for the interaction between these rules, it is assumed that the OCR takes precedence over all other rules. Therefore, the only time a consonant is adjoined directly to the syllable is when there is no other option.

3.2 A Closer Relationship Between the Vowel and Preceding Consonant

It has been suggested that the vowel is tied in an intimate relationship with the consonant which immediately precedes it. This is evident with the examination of the distribution patterns of the implosives, [ɓ] and [ɗ], and [r]. The implosives and [r] are not found in word final position in the dialect discussed here, although, [r] is apparently found there in other dialects of Khmer. In addition, implosives along with [r], and most other sonorants, with the exception of the bilabial nasal and [l], may not occur as the initial element of a cluster. This cannot be merely a restriction on sonority, since both [l] and [m], although possibly subject to some restrictions related to place of articulation, are free to occur in initial position before practically any other segment. In fact, implosives can only occur if followed by a vowel, and in the vast majority of these cases, this vowel must be constricted register. As an inspection of Table 4 in Chapter Four will show, there are no examples of a Khmer word containing an implosive or [r] in the initial position of a consonant cluster.[4] With this in mind, consider the examples in (8), taken from Huffman (1967:91-92).

(8)	(a)	[ɓaek]	'to break'(H548)	[pnaek]	'fragment'(H620)
		[ɓo:l]	'to augur'(H543)	[pno:l]	'omen'(H620)
		[ɓuəŋ]	'to knot'(H544)	[pnuəŋ]	'chignon'(H620)
	(b)	[ɗak]	'to put'(H28ĭ)	[tnak]	'rank'(H356)
		[ɗaol]	'to pole a boat'(H295)	[tnaol]	'boat pole'(H357)
		[ɗo:]	'to trade'(H288)	[tno:]	'a trade'(H356)
	(c)	[rɔ̀:c]	'days of waning moon' (H889)	[rɔnɔ̀:c]	'period of waning moon' (H817)
		[rɔ̀ŋ]	'to support' (H796)	[rɔnɔ̀ŋ]	'fish line with many hooks' (H817)

[4]Jenner (1969) claims that [r] does occur in cluster initial position. However, all examples of [r] in cluster initial position in Headley et al. (1977) indicate that there is a vowel located between the [r] and the second consonant. See the later discussion of the continuum between monosyllables and disyllables in Khmer.

When, as a result of infixation, the implosive is put in initial position as in (8a-b), it loses its distinctive element and becomes a plain voiceless consonant. In the case of [r], as in examples (8c), an epenthetic vowel must break up the cluster or, as will be seen in Chapter Five, it changes to [l]. From this, it can be seen that both [ɓ] and [ɗ] along with [r] are restricted to occurring in one place in the syllable, right before the initial vowel and the fact that they do not occur as initial members of clusters or in coda position serves to represent this.

It is suggested here that implosives and [r] carry some feature which can only occur when positioned right before the vowel. Since non-implosives [p] and [t] may also occur prior to a constricted register vowel, the source of the distinction between plosives and implosives cannot be the vowel. Without this feature, implosives occur as plain stops and [r] occurs as [l]. The feature in question must be either closely related to, or the same feature which produces register in vowels. If the structure claimed in (1) is assumed for the syllable in Khmer, this can be accounted for by licensing restrictions on individual morae. The feature must be licensed by a mora in order to be realized. In particular, only the initial mora of a syllable may license the feature connected to implosives and register. This accounts for the fact that these segments only occur in the position directly before the vowel. This is the only place where association to the initial mora by a consonant occurs.

A moraic view of the syllable has been used to represent Khmer syllable structure. The mora serves to represent the fact that Khmer monosyllabic words have both a minimal and maximal size related to syllable weight and also to show that there is an intimate relationship between the nuclear vowel and the consonant which immediately precedes it. In the next section, the structure of disyllabic words will be examined and it will be shown how the initial syllable of these words does not constitute a counter-example to the claim for a bimoraic syllable in Khmer and is, instead, predicted by current theory as a repair strategy on mismatches between the syllabic template and the melody.

3.3 Disyllables

In describing the structure of Khmer words, Huffman (1972:54) states "there appears to be a phonetic continuum from monosyllables on the one hand to disyllables on the other". The reason for this continuum is that there are at least three kinds of disyllables in Khmer (Henderson 1952: 171). Of these three, only two are truly disyllabic underlyingly. The third is a derived monosyllable while still a fourth form is only phonetically disyllabic.

3.3.1 Full and Reduced Disyllables

The first type of Khmer disyllabic word is marked by the fact that both syllables may constitute what is commonly referred to as "major" syllables (Henderson 1952, Nacaskul 1978). Major syllables are exactly those which may occur as a monosyllabic word. They correspond to one of the canonical shapes noted above and observe all the same restrictions on clusters and syllable shape as monosyllabic words. In addition, major syllables are always stressed. Full disyllables can be straightforwardly characterized as a combination of two major syllables.

In addition to the aforementioned "full" disyllables, Khmer also has disyllabic words in which the initial syllable is "reduced" (Huffman 1967, 1972). Henderson (1952) claims that these chiefly comprise loanwords. While it is true that many of the examples given are listed as loanwords in Headley et al. (1977), it is also possible, as Huffman (1972) claims, that many of these words are a result of vowel shortening, especially since there is some long/short alternation going on in just this environment. Some examples of this are shown in (9).

(9) [pì?sa:] ~ [pìsa:] ~ [pìsa:] 'to eat - polite form'
(H651, Huffman 1967: 51)

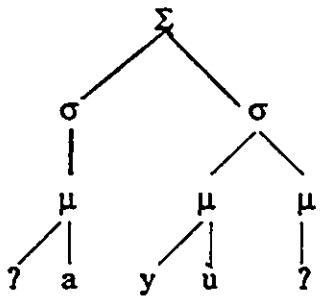
The chief requirement for the appearance of these reduced disyllables is the destressing of the initial syllable. Huffman (1967) reports they generally occur in rapid colloquial speech as a result of the first syllable in a full disyllabic word becoming unstressed. In that case, the vowel shortens or may even disappear. Some examples of this are shown in (10).

(10) [pì:prɔ̀əh] ~ [pìprɔ̀əh] 'because'
[?a:yù?] ~ [?ayù?] 'age' Huffman (1972: 59)

This has the effect of turning two full bimoraic syllables into one mono-moraic syllable plus a bimoraic syllable. The initial syllable is always the syllable which is shortened. Effectively, what this process creates is an iambic foot as described in McCarthy and Prince (1986, 1990).

The structure of the iambic foot is shown in (11). The symbol, Σ, indicates a foot.

(11)



When the initial syllable destresses, one mora is lost and the vowel shortens. In cases where the initial consonant is an acceptable candidate for adjunction to a syllable, it is possible for the mora and vowel of the initial syllable to be completely deleted (Huffman 1976). The iambic foot can also be seen with respect to restricted disyllables.

3.3.2 Restricted Disyllables

Restricted disyllables (Jacob 1968) are distinguished by the fact that they contain one major syllable preceded by a "minor" syllable (Henderson 1952). A minor syllable roughly has the shape in (12). Note that the (r) and the (N) (indicating a nasal homorganic with the following consonant or [m]) are generally mutually exclusive although Huffman (1967) does cite one counterexample. For the most part, if (r) is there, then (N) cannot be and vice versa.

(12) C(r)V(N)

Where a major syllable can have any permitted consonant cluster up to a maximum of two, a minor syllable is restricted to a one consonant onset, with the exception of the cluster containing [r] as the second segment. The above analysis is counter to Jenner (1967) who claims that vowels in minor syllables with the shape PrV are phonemically long. He makes this claim even though these vowels are phonetically short because the syllable is open and because the vowel never occurs as [ù]. However, this argument does not hold up given that a closer examination of the data shows that /ɔ̀/ does not become [ù] unless it appears before a tautosyllabic bilabial. In the example in (13a), the bilabial following the vowel is shown to be connected to the initial syllable since the vowel appears as [ù]. This is clarified by (13b), where the following bilabial must be the onset of the following syllable, since no other candidate exists for this position. In this case, the vowel occurs as [ɔ̀].

(13) (a) [rùmlù:t] 'abort'(J161) (b) [rɔ̀mɔ̀ɔt] 'fugitive' (H826)

This indicates that the labialization of the minor syllable vowel is restricted to occurring prior to tautosyllabic bilabials. Since, in the account given here of minor syllables of the shape PrV, the vowel is syllable final, the non-occurrence of [ù] is expected. The environment for the vowel rule changing [ɔ̀] to [ù] is not fulfilled.

The vowel quality in a minor syllable is also restricted. It must be one of [ɔ̀], [ɔ̀ə], [ù] or [ɒ] which are all variants of the epenthetic vowel.[5] In addition, according to Henderson (1952), the final consonant of a minor syllable, if there is one, is always a nasal. This syllable final nasal is restricted to either being homorganic with the onset of the following major syllable or [m]. Huffman (1967) claims that the nature of the final consonant is less restricted than that and can be any consonant with the exception of [ɓ, ɗ, r]. It is interesting to note that in all his examples, the non-nasal consonant in question is homorganic with the following consonant but it is difficult to check this since, as other sources do not mention stress, it is not always possible to tell if words with the structure CVCCVVC are restricted disyllables or full disyllables because, speaking purely in terms of the skeletal structure, the two types of disyllable are ambiguous. Finally, all minor syllables are unstressed in relation to the following syllable and must occur prior to a stressed syllable. A minor syllable may never occur word finally or before another minor syllable. For this reason, a minor syllable is also referred to as a presyllable.

In contrast to the reduced disyllable, the restricted disyllable is derived, not from reduction, but from expansion. They are not disyllabic in the same way as those previously discussed in that they are not underlyingly composed of two syllables but are derived from monosyllables. Restricted disyllables often occur in environments where clusters consisting of three (or more) consonants might be expected as a result of prefixation or infixation or where a non-permitted two consonant cluster occurs. This can be illustrated with the infix /-m-/, discussed earlier. When it is infixed to a base form which already contains an initial consonant cluster, the resulting three consonant cluster must be broken up.

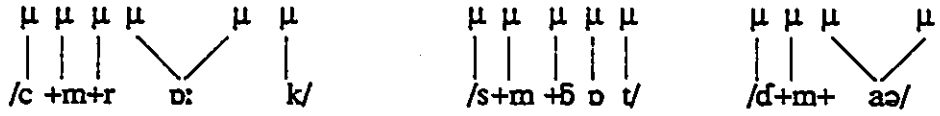
(14)	(a)	[cɒmrɒ:k]	'filling'(H170)	[crɒ:k]	'to fill'(H202)
	(b)	[kùmlùəŋ]	'leprous'(J31)	[klùəŋ]	'leprosy'(J37)
	(c)	[sɒmɓɒt]	'oath'(J190)	[sɓɒt]	'swear'(J209)
	(d)	[tmaə]	'time'(J80)	[ɖaə]	'walk'(J66)

[5]See Chapter Five for the environments where these vowels occur.

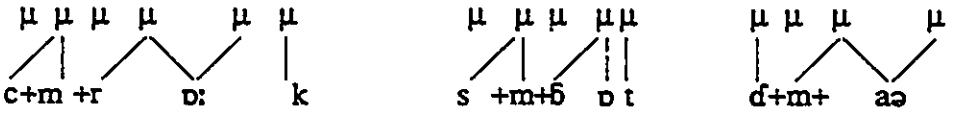
Itô (1989) argues that "prosodic licensing", which requires that every element of structure form part of some higher level of prosodic structure, can account for various phonological processes. Some examples are "stray erasure" (McCarthy 1979,1981; Steriade 1982, Harris 1983, Itô 1986) and epenthesis. She notes that epenthesis takes place where syllable structure conditions require it and where prosodic licensing allows it. Because a monomoraic syllable may adjoin to the left edge of a bimoraic foot and still produce an acceptable structure, an iambic foot, it can be syllabified and so "prosodically licensed". Any syllable final material has no such option and must delete.

Syllabification takes place as in (15). Plus signs indicate morpheme boundaries.

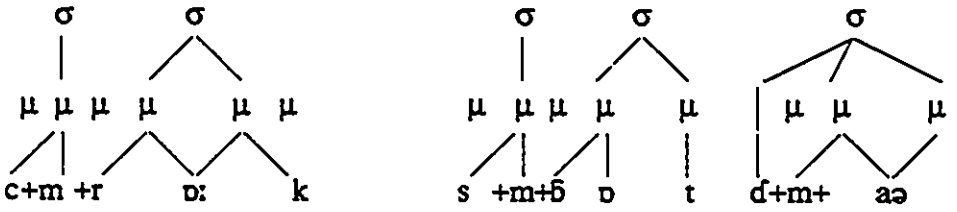
(15) (a) *Underlying Form*



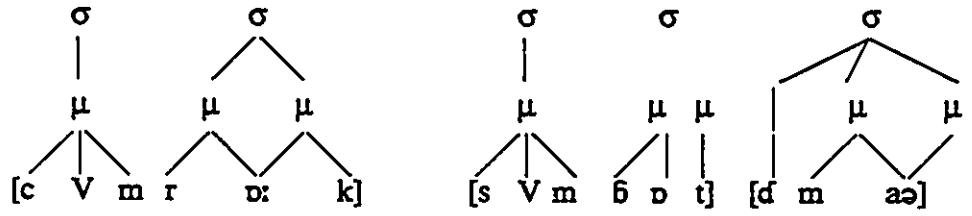
(b) *Onset Creation*



(c) *Syllabification*



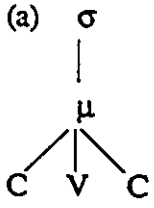
(d) *Epenthesis and Stray Erasure*



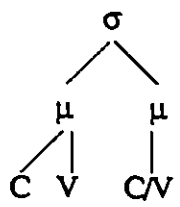
There is a difficulty with the structures proposed above for minor syllables. Zec (1988) has proposed that, although both the structures shown in (16) can exist in the same language, their existence is restricted by virtue of a distinction between moraic and non-moraic

segments which is determined by sonority. In her analysis, the set of consonants which may adjoin to the syllabic mora as in (16a) must always be less sonorous than those which may exist alone (without a vowel). However, as noted above, this appears to be contradicted by syllabification in Khmer where nasals, arguably very sonorous segments, are the only segments which adjoin to the syllabic mora as in (16a).

(16) (a)



(b)



One solution to this is to assume that the final consonant in (16a) is, in fact, associated to the following syllable and not the presyllable. This is supported by the fact that, with the exception of [m], which, as will be seen, is a permissible initial element of a major syllable initial cluster, the nasal must be homorganic with the following consonant. However, this analysis fails to account for the conditioning effect of [m] on the epenthetic vowel. It must be somehow associated with the presyllable since the effect is not noted when the following consonant is unambiguously connected to the following syllable as was seen in the examples in (13).

The exact structural associations of these segments are not crucial here so, for the sake of convenience, the structure noted above is merely assumed for the Khmer presyllable. Further study is needed to decide whether or not this is truly a counterexample to Zec's predictions about moraic classes of segments.

McCarthy and Prince (1986:10) claim that there are three major quantity sensitive prosodic systems. These are "(I) using both feet [σμ σμμ] and [μ μ], (II) using only [σμ σμμ], (III) using only [μ μ]." The best match with Khmer is a type (I) prosodic system. The minimal word is a foot with both major syllables, corresponding to the foot structure, [μ μ], and reduced or restricted disyllables that have the iambic foot structure [σμ σμμ].

(17)	[σμ σμμ]		[μ μ]	
	[kɒko:]	'to stir often, many times'(H3)	[ko:]	'to stir (soup)'(H42)
	[kɒɲcah]	'worn out, very old'(H6)	[cah]	'old, mature'(H178)
	[ɓɒnnae]	'to show how'(H491)	[nae]	'to show, explain'(H309)
	[prɒkap]	'to fight with swords'(H563)	[kap]	'to chop, to cut'(H28)

There is a typological problem with this analysis of Khmer foot structure. As in other languages, feet with the shape CVCV should also be expected to occur along with monosyllabic feet. This is not the case. The reason that this should be is not clear. It may be linked to differential licensing properties of the individual mora, a possibility discussed by Zec (1988) when she requires that the initial mora of the syllable be headed by a member of the class of syllabic (c.f. Zec 1988 for the definition of syllabic versus moraic) segments while the second mora is unrestricted. If we assume that the second mora in Khmer cannot singlehandedly license a syllabic constituent, then the absence of CVCV feet is explained. The second CV in the foot would require that the second mora license a syllabic constituent. This explanation is very speculative and would require a great deal more research. Since the answer is not crucial to this analysis, it will not be further pursued at this time.

An additional type of word form in Khmer is what Henderson (1952) calls an expanded monosyllable. These forms are essentially monosyllabic but due to the resemblance of the excresent vowel (Levin 1987) inserted into the initial cluster to facilitate the transition between consonants to a reduced version of the epenthetic vowel, there is ambiguity as to whether they are truly monosyllabic or disyllabic. Sloan (1988), in an analysis of several other Mon-Khmer languages, described these derived disyllabic words as "sesquisyllabic" (Sloan 1988: 320) or containing "one and a half syllables".[6] She does not attempt to classify these kinds of syllables and provides no clear evidence for them. If these derived disyllables are, in fact, just syllables, they are very unusually shaped with respect to earlier work on the syllable and their justification is beyond the scope of this work. It should be noted, however, that the characterization of all these derived structures including restricted disyllables as "sesquisyllables" would allow the minimal word in Khmer to be defined as the syllable. Given that register operates over the domain of just these "sesquisyllables", as would be expected of a phenomenon historically relating to the laryngeal properties of initial consonants, this is intuitively attractive. More research would need to be done to justify this kind of analysis.

[6]In fact, Sloan does not explicitly discuss Khmer, but it is possible that her definition of sesquisyllables would also include restricted disyllables.

Examples of the three kinds of disyllables are shown in (18).

(18)

True Disyllables		Reduced Disyllables[7]		Restricted Disyllables	
[pìːsaː]	'to eat'(J136)	[pìsaː]	'to eat'(J136)	[kɒŋcah]	'old'(J2)
[t̃eyìet]	'heir'(J84)	[sapɓaːy]	'happy' (J1072)	[dɒɗael]	'alike'(J64)
[capchaːy]	'chopsuey'(J42)	[ɓɒrom]	'great' (H508)	[cɔ̀cùh]	'fluff up'(H225)
[təktaŋ]	'evidence'(J72)	[pìprɔ̀əh]	'because'(H653)	[crɒŋɒk]	'rising up'(H203)
[ɓaːsɒk]	'layman'(J110)	[ʔayù?]	'age'(H1418)	[prɒhael]	'perhaps'(H591)
[prèːsət]	'envoy'(J125)	[ɓaraŋ]	'French'(H527)	[cɔ̀əɲcɔ̀ək]	'suck'(J53)

The continuum between the monosyllable and the disyllable in Khmer is accounted for by proposing that there are three kinds of disyllable and two kinds of monosyllable as a result of adjustments in syllable and foot structure. These are listed in (19).

(19)				
	Full Disyllable	- Two Bimoraic Feet	[μ μ][μ μ]	
	Reduced Disyllable	- One Iambic Foot	[σμ σμμ]	(reduction)
	Restricted Disyllable	- One Iambic Foot	[C̆μ σμμ]	(epenthetic expansion)
	Expanded Monosyllable	- One Bimoraic Foot	[μ μ]	(excrescent expansion)
	Simple Monosyllable	- One Bimoraic Foot.	[μ μ]	

Since the phonetic boundaries between these types are somewhat blurred, ambiguity results on the surface creating the effect of a continuum between monosyllable and disyllable.

In the next chapter, the consonant system of Khmer will be discussed. The close relationship between the vowel and its immediately preceding consonant will be shown to be required to account for the distribution of certain Khmer consonants.

[7]Citations of reduced disyllables are taken from Huffman (1967:37,46) and Huffman (1972:59).

Chapter Four
Consonants

4.0 Introduction

An account of the consonant system is relevant to a discussion of Khmer vowels because the interactions between vowels and consonants provide crucial evidence for the distinctive feature specifications of the vowels. In particular, in order to establish the feature dependency relations of register, it is necessary to show what types of features are distinguishing the two types of consonants which are serving as either transparent or opaque for the rule of register harmony. To establish the consonantal features, two kinds of evidence will be considered. In the first place, consonant cluster co-occurrence patterns will be examined in hopes of establishing what classes of consonants exist. It is assumed, following Leben (1973), Goldsmith (1976, 1979, 1990), McCarthy (1986), Yip (1988) and others, that the Obligatory Contour Principle (henceforth OCP), which disallows adjacent identical features to be specified on the same autosegmental tier, is in operation. Therefore, where two consonants are permitted to be adjacent, it is assumed that they are differently specified. Another type of evidence which will be considered is that of assimilatory rules. These will show that certain features in Khmer are active and can spread. On the basis of these two arguments, a tentative feature specification for consonants in Khmer will be advanced. What will make this specification less than tentative is the way that it can be coordinated, in Chapter Five, with the specifications for vowels. The specification of Khmer consonants, when matched to that of the vowels, provides a very clear indication of the phonological feature specifications of both major systems of segments.

4.1 The Consonant System

The Khmer consonant system as described in Henderson (1952), Huffman (1967), Jenner (1969), Nacaskul (1978) is reported to be very stable from dialect to dialect. The only points of variation mentioned concern the voiced implosives and [r]. Most sources describe the secondary system of occlusives as voiced implosives (Henderson 1952, Nacaskul 1977, Jenner 1969, Jacob 1968, 1974) although they are also described as prevoiced fortis stops (Huffman 1967) and preglottalized (Headley et al. 1977, Jenner 1969). The system is shown in (1). Sounds which occur only in loanwords are omitted.

(1)

	Labial	Dental	Palatal	Velar	Glottal
Stops					
Voiceless unaspirated	p	t	c	k	ʔ
Voiced implosive	ɓ	ɗ			
Nasal	m	n	ɲ	ŋ	
Fricatives					
Voiceless		s			h
Liquids					
Glides	ʋ		y		
Lateral		l			
Rhotic				r	

A few remarks on the phonetic realizations of the segments in (1) are in order. Phonetically, [ʋ] is generally described as a labial semi-vowel and is transcribed variously as [w], (Henderson 1952, Huffman 1967, Jenner 1969) [v] (Jacob 1974, Headley et al. 1977) and [ʊ] (Henderson 1952, Jacob 1968). Jacob (1968) reports that it also is velarized. This is supported by the rule of nasal assimilation which will be discussed below. As for [r], it is described as "strong lingual roll, with back alveolar contact" (Henderson 1952), "alveolar trill" (reducing to a flap when in second position of an initial cluster) (Huffman 1967), "voiced apical flap (occasionally a trill) with alveolar contact" (Jenner 1969), "frictionless continuant" or "one-tap uvular" and "rolled"(Jacob 1968). The exact manner (and point) of articulation that is exhibited by [r] may vary depending on dialect, formality of the situation or other social factors (Huffman 1967). Noss (1966) describes [r] in standard Khmer as a "frictionless grooved-tip continuant" but claims that, for the most part, in Phnom Penh speech, this is replaced by a voiced pharyngeal spirant. In addition, standard [r] is preglottalized in some instances.

4.2 Consonant Co-occurrence Patterns

The patterns of consonant co-occurrence in clusters are one source of evidence as to the feature specifications of consonants. The chart of attested clusters (Nacaskul 1978, Headley et al 1977, Jacob 1974) is shown in Table 4 with the number of monosyllabic words appearing in Headley et al. (1977)[1] noted for each cluster. In addition to the clusters shown, there are four instances of the cluster [ʋh] and one instance each of the clusters [nh] and [nʔ]. Other than these few instances, [n] or [ʋ] are not listed as the first element of a cluster.

[1]Headley et al. (1977) contains approximately 20,000 entries although only a subset of these is monosyllabic.

The first thing that can be noticed in Table 4 is that there are gaps where both elements of a cluster would bear the same place of articulation. So, while there are thirty-five examples of words beginning with [pd] and eleven with [tɓ] in the data, there are none beginning with [pɓ] and only one with [td]. From this, it can be ascertained that a restriction on adjacent segments with the same place of articulation, such as the OCP, is operating in Khmer syllables.

	Labial				Alveolar							Palatal		Velar		Glottal	
1st \ 2nd	p	ɓ	ʋ	m	t	d	s	n	l	r	y	c	ɲ	k	ŋ	ʔ	h
p	*	*	*	*	30	35	26	51	102	200+	36	23	10	31	14	25	200+
m	*	*	*	*	1	6	5	11	11	21	5	5	2	2	2	2	8
t	6	11	53	31	*	1	*	33	42	200+	3	*	*	14	13	5	200+
s	29	25	63	54	63	24	*	47	66	200+	3	*	13	45	12	21	*
l	2	25	18	17	*	*	*	*	*	*	*	*	*	7	6	23	12
c	6	24	16	20	*	4	*	31	33	100+	*	*	*	18	15	15	100+
k	14	30	57	29	29	31	42	39	79	200+	3	29	24	*	15	20	100+
ʔ	*	*	4	*	*	*	*	*	*	*	*	*	*	*	1	*	18

* =non-occurring cluster

Table 4: Consonant Cluster Occurrence in Khmer

Given that most versions of feature geometry discussed in Chapter Two uncontroversially feature a [Labial] node under the [Place] node, an examination of clusters in Table 4 shows that the the four bilabial consonants can be non-controversially specified as [labial].

(2) o — Place
|
[Labial]

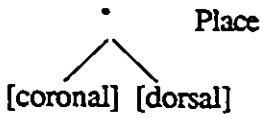
/p/, /ʋ/, /m/, /ɓ/

The three palatal consonants, /c/, /ɲ/, /y/ also act as a class in this regard since they too are prohibited from cooccurring. In Sagey (1986), both palatal and alveolar segments are specified as members of the natural class of [coronal], distinguished by virtue of the feature [anterior] (see Stevens and Keyser 1989 for further support for this view), while velar segments are specified as [dorsal]. Keating (1991) claims that more than two distinctions are required among coronal consonants and that, while [anterior] will serve to distinguish between alveolar and palatal-aveolar, another method of distinction is required between palatal-alveolar and palatal. She suggests, following an earlier paper (Keating 1988) that

this is best represented by considering palatal segments as complex and representing them as bearing both a [coronal] and a [dorsal] node.

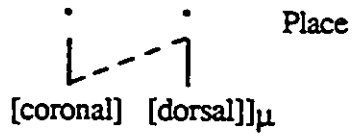
Keating's representation of palatal consonants is supported by a process of velar fronting reported in Huffman (1967). According to Huffman, /k/ and /ŋ/ are strongly fronted when they occur after the set of front vowels, [i:], [e:] and [ae]. (cf. 5.2.3 for specifications.) In fact, /k/ and /ŋ/ after these vowels are virtually indistinguishable from /c/ and /ɲ/. Huffman argues that fronting is taking place since by considering some of the instances of [c] and [ɲ] in this environment as /k/ and /ŋ/, the distribution of /ŋ/ becomes complete.

(3)



This can be represented by the rule in (4). During velar fronting, the coronal node is shared by the velar consonant and the vowel. According to Edwin Pulleyblank (1989), various cross-linguistic processes support an argument for the set of front vowels to be specified as [+front] rather than [–back] and for the feature to be dependent on the coronal node. If this analysis is taken for Khmer, velar fronting is merely the spreading of the [coronal] feature of the vowels back onto the consonant.

(4) *Velar Fronting*



Huffman also notes that, in certain polysyllabic forms where the /k/ appears as a geminate, it does occur after the above three vowels. Assuming that the rule of velar fronting is subject to Hayes's (1986) linking constraint which interprets association lines as exhaustive, /k/ is immune to fronting in this environment. If /c/ and /ɲ/ are represented as in (3), then this process can be simply represented.

A look at the complete set of consonants which would be specified as coronal shows that, among these segments, the patterns are less clear-cut than for the labials. Out of nine consonants which might potentially be represented as coronal in the Khmer inventory, only four can occur both as the initial and second member of a cluster. These have been enclosed in the box in Table 5. As noted previously, none of these segments cooccurs with itself. If

all these consonants were distinctively coronal, one might expect that if a general restriction on coronals co-occurring existed, none of them could occur with any of the others at any time. However, this is not the case as there are some asymmetries in the clusters that do occur.

1st / 2nd	t	c	l	s	n	ɲ	ɗ	r	y
t	*	*	42	*	33	*	*	200+	3
c	*	*	33	*	31	*	4	100+	*
l	*	*	*	*	*	*	*	*	*
s	63	*	66	*	47	13	24	200+	3

* = non-occurring cluster

Table 5: Co-occurrence Patterns for Initial Clusters among Coronals in Khmer

In the first place, while [l] is perfectly free to occur as the second member of a cluster containing any other coronal (excluding itself), it can never occur as the first member. This is not a general restriction on [l] in initial position because it occurs as the first member of a cluster before consonants with other places of articulation. The second asymmetry occurs with [s]. It can occur as the initial member of a cluster with almost all segments, but can never occur as the second member of a cluster containing only coronals. Again, as Table 3 and 4 show, this restriction on [s] is specific to coronals. Yip (1989) proposes that initial /s/, as an appendix, is exempt from co-occurrence restrictions. This explanation does not account for [l], however, since it is only in this appendix position that [l] is subject to the restrictions. It is also worthwhile to note that it is only among stops and nasals that a distinction between alveolar and palatal coronal segments is required. In the case of fricatives like [s] and liquids like [l], there is no distinction. All members of these classes are coronal.

A possible explanation for asymmetries among coronal consonants in Khmer comes from an examination of the morphology. Operating under the hypothesis that all words beginning with a consonant cluster in Khmer are polymorphemic, Jenner (1969) was able to reanalyze all but nine percent of cluster initial words as an affix and a primary word base. The occurrence of unpredictable clusters may arise if the morphemes in question are not yet specified at the time of affixation. Among the affixes listed in Jenner (1969), there are two affixes consisting only of [l], a prefix and an infix, and only one affix consisting of [s], a prefix. Therefore, [s] and [l] in initial position are either prefixes or the initial element of a word which has undergone infixation while [l] in second position is either an infix or

the initial element of a word which has undergone prefixation. Some further discussion on the exact properties of these affixes is warranted.

The perfective or specializing prefix, which Jenner (1969) represents as /L-/[2], may be realized as one of two allomorphs. It may occur variably as either [rɔ̀-] or [l-] with the overwhelming majority of derivations surfacing as [rɔ̀-]. Jenner does not elaborate on the particular factors involved in determining which variant occurs but he does note one phonological environment where /l/ categorically does not appear. Before [n, c, ɲ, s] only [rɔ̀-] occurs. There are two possibilities for the representation of this morpheme. It either contains a vowel underlyingly, as / rV-/, or the vowel is epenthesized. As was discussed in Chapter Three, [r] must occur on the surface before a following vowel. When the vowel is not realized[3], the distinguishing feature of [r] cannot be realized and [l] appears.[4] If the vowel is underlyingly there, then the loss of the vowel is a later process, occurring after default specifications have been assigned. This is most likely deletion rather than epenthesis because the vowel occurs in all environments at one time or another and only optionally may not occur in a certain subset of those environments; those where the OCP would not be violated by the coming together of two coronal elements. Since the vowel occurs in all environments, it would be more general for a native speaker learning the language to assume that it is underlyingly there and undergoes deletion in some circumstances. Its loss is blocked when it would result in the conjunction of two consonants specified for the same place of articulation, an obvious OCP violation.

(5) * [α F] [α F]

This operation of the OCP with respect to the /L-/ prefix is shown by the derivations in (6) of the word [rɔ̀ɓaək] 'dislocated' (J160) and [rɔ̀nɔ̀ːc] 'day of the waning moon' (H817).

(6) (a) *Affixation*

/rɔ̀ + ɓaək/	/rɔ̀ + nɔ̀ːc/

(b) *Default Coronal Insertion*

rɔ̀ + ɓaək	rɔ̀ + nɔ̀ːc

[2]A capital letter is used by Jenner to indicate a morpheme which undergoes some sort of morphophonemic alternation depending on environment. In this way, he avoids positing an underlying variant where this is unclear.

[3]The deletion of the vowel is a variable process, the conditioning factors of which are not discussed by any source. I assume that they are probably related to speech rate, formality or possible some other extralinguistic factors.

[4]In Chumburung (Snider 1984) an alternation between /r/ and /l/ is linked to the presence of [-ATR].

(c) *Vowel Deletion (Optional)*

[l + ɓaɔk] [rɔ̀ + nɔ̀ːc]

$$\mu]_\sigma \Rightarrow \mu]_\sigma$$
$$\quad | \qquad\quad \ddagger$$
$$\quad V \qquad\quad V$$

Without the vowel, the prefix consonant occurs as [l].[5] Where the structure in (5) is created, the rule in (6c) is blocked from applying. As pointed out by Ann Laubstein (p.c.), this formulation of the process requires the OCP to "look-ahead" beyond the adjacent segment. The only way to save this analysis is to assume that the OCP is acting as a filter in this case and that vowel deletion is not blocked, but that the resulting structures are filtered out and never make it to the surface.

The other option is to assume that the vowel is not there underlyingly and is generally epenthesized as has been suggested for other structures in Chapter Three. If that is the case, it must be assumed that the epenthesis rule may variably fail to apply . If this should occur, there are consequences such as the loss of the element which distinguishes /r/ and /l/. This option also involves problems. If we assume that /r/ is specified for [coronal] and [Pharyngeal], there should be no problems with affixing it to any other segment specified only as [coronal]. Therefore, the only reason for inserting the vowel is to allow the realization of the distinctive element of /r/. However, if epenthesis fails to apply, neutralizing /r/ and /l/ in that environment, the resulting structure is now in violation of the OCP. Ostensibly, at this point, epenthesis must reapply. If that was the case, we would expect to find forms such as *[lɔ̀nɔ̀ːc] alongside of [rɔ̀nɔ̀ːc] since, assumedly, /r/ has already lost its distinguishing element before epenthesis must reapply. This is not the case. The facts appear to support the operation of the OCP as a filter rather than a trigger in this case.

Jenner also notes an infix, /-l-/ which he describes as a specializing affix. There appear to be no restrictions attributable to place of articulation resulting from this infix. Therefore, it is probably unspecified for place of articulation, acquiring coronal as a default. Paradis and Prunet (1991) have argued that coronals are universally underspecified in relation to other consonants. Their argument center on three properties of coronals. In the first place, coronal consonants occur most frequently, both in individual segment inventories and in general. Secondly, coronals are more likely to undergo assimilation hinting that they are underlyingly unendowed with place of articulation features of their own. Thirdly, coronals are often transparent to harmony processes. As for [l] as the initial element of a base word, there may be some restrictions on the occurrence of infixes. According to Jenner (1969),

[5]The distinction of /l/ from /r/ will be discussed in connection with register.

there are only potentially three coronal infixes, /-l-/, /-r-/, /-n-/ and /-c-/ and only /-n-/[6] is cited as appearing in a word beginning with [l]. Of these three, only one, /-c-/, is clearly distinctively coronal as will be shown by nasal assimilation. With the exception of /-c-/, which is rare[7] and potentially its non-occurrence after [l] is merely an accidental gap, all the non-occurring infixes can be argued to be incompatible with [l] for other reasons than place of articulation. What can be garnered from the above discussion is that the non-occurrence of [l] in initial position of clusters before coronals is a result of the fact that the situation whereby this cluster could occur is severely limited and not because of underlying coronal specification.

As for [s], it is argued here that /s-/, the prefix, is maximally underspecified for all places of articulation and merely acquires coronal as a default. Its non-occurrence in second position after coronals is probably a result of two factors. In the first place, there are only three potentially coronal prefixes. These are /t-/, /c-/ and /s-/. In the case of /s-/, it has already been established that identically specified segments, whatever their specification for place of articulation are prohibited. As for /c-/, there is no asymmetry since [s] is prohibited from occurring in any position in a cluster with [c]. This is presumably a result of conditions on stridency and not related to place of articulation.[8] As for /t-/, Jenner (1969) reports that this morpheme alternates with /k-/ although he does not specify the circumstances. Therefore, it is unclear what, exactly, the specifications of the segment making up this morpheme are.

There are also several other reasons to suggest that coronal is a default place specification for consonants in Khmer. In the first place, there are more coronals than any other kind of segment. Out of seventeen consonants, nine, or almost half, are coronal. In addition, in the case of fricatives and laterals, where there is only one example of the category

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[6]Jenner cites only one example of -n- appearing in a base beginning with /ʔ/. Recall that no examples appeared in Headley et al. (1977).

[7]In fact, Jenner (1969) cites only seven examples, all in words beginning with /k/.

[8] Doug Pulleyblank (p.c.) has suggested that possibly /s/ in initial position is an affix specified only as [+strident] with coronal specifications filled in later by default. The absence of the cluster [sc] could then be an OCP restriction on stridency rather than coronality. Darlene LaCharité (personal communication) suggests that frequently opposition between alveolar and palatal stops can be represented equally well by the feature [anterior] or [strident]. Therefore, the reason that /s/ is exempt from co-occurrence restrictions is because, at the time of affixation, it has no place features to conflict with adjacent segments and not because of any special status with respect to syllable structure. The problem with this idea is that it fails to account for the opposition between the alveolar and palatal nasal which by no means can be distinguished by the feature [±strident]. Since the anterior dimension, represented as a complex articulation, is already necessary for this distinction, [strident] must be a redundant specification on the palatal stop.

exhibiting place features, the place of articulation born by the single example is coronal. Additional evidence comes from the /-N-/ infix.

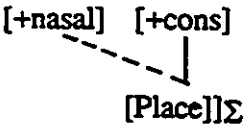
The primary function of this affix, according to Jenner (1969:153), is a restrictive type of function which "designates the place, in space or time, in which the predication of the base is accomplished, or the place, part or state achieved by accomplishment of the base". Infixation always occurs right after the initial consonant of the word. So, for example, when it is applied to [pɛn] 'to sit upon crossed legs', the result is [pnɛn] 'lap'.

(7)	(a)	[kɒŋʊɒl]	'worry'(H5)	[kʊɒl]	'troubled'(H107)
	(b)	[kɔ̀ɔŋʊ̀iel]	'guardian'(H116)	[kʊ̀iel]	'to guard'(H151)
	(c)	[kɒndʃap]	'bunch'(H10)	[kdʃap]	'hold tightly in hand'(H60)
	(d)	[sɒnlɒŋ]	'plug'(H1070)	[slʊŋ]	'close a hole'(H1263)
	(e)	[knaɔt]	'period of the waxing moon'(H100)	[kaɔt]	'day of waxing of the moon'(H42)
	(f)	[knaɔy]	'pillow'(H100)	[kaɔy]	'lay head down'(H43)
	(g)	[kǹiep]	'press'(H149)	[k̀iep]	'to press'(H123)
	(h)	[knuɔc]	'short lengths of twisted fresh bamboo'(H100)	[kuɔc]	'to make a knot'(H42)
	(i)	[knuɔt]	'anything used to smooth out threads'(H100)	[kuɔt]	'to improve a material or fabric'(H42)
	(j)	[tɒ̀ɔh]	'fish barrier'(H433)	[tɔ̀ɔh]	'to bar, to stop'(H373)
	(k)	[ɪtɒ̀ː]	'a board or shelf'(H433)	[tɔ̀ː]	'to place on a shelf'(H400)

The /-N-/ infix can be shown to be unspecified by the fact that when the infixation process causes it to emerge in the environment for the rule of nasal assimilation, it assimilates, unlike the /-m-/ infix shown earlier and in Appendix II. When it is not in the environment for nasal assimilation, it emerges as [n].

The rule of nasal assimilation can be formulated as in (8).

(8)



The specification of the domain of this rule as the foot is necessary to account for the fact that it takes place only in restricted disyllables. In other words, while a derived environment is, for the most part, a necessary requirement for these rules, it is not sufficient. The resulting structure must be a restricted disyllable. In compounds, where a

restricted disyllable is not formed, nasal assimilation does not take place. If no place specifications are supplied for the infix by this rule, the infix surfaces with the default specification of coronal.

The non-specification of the nasal is supported by the fact that it undergoes assimilation at all. The rule cannot simply refer to any nasal since this would not account for the fact that the nasal /m/ in the same environment does not undergo assimilation, as shown by the examples from /-m-/ infixation illustrated in Chapter One. A stipulation that the target nasal in the rule be specified for a coronal place of articulation prior to assimilation and delinking would be required.[9] One counter to this argument would be to claim that the feature [coronal] is merely a feature of possible targets in this rule. However, this would constitute a complication of the rule especially since the positing of default [coronal] allows a simplification of the underlying representations of some morphemes and the underlying segment inventory. Since there is no contrast among fricatives, it is unnecessary to specify /s/ for place features if [coronal] is adopted as default.

The argument for a default coronal feature is not without question. In the first place, there is no evidence to indicate that a [coronal] consonant ever appears when epenthesis of a consonant is required. For example, in order to satisfy a bimoraic requirement on syllable size, the short open syllables of loanwords are checked with a glottal stop. In addition, onsets are obligatory in Khmer and when a vowel-initial word is borrowed into the language, it is generally provided with a glottal stop as its onset.

(9)	[ʔaːmeːrik]	'America'	–French *Amérique*	[coːlaː]	'tuft of hair'	–S.Pali *cūlā*
	[ʔihslaːm]	'Islam'	–origin unclear	[coʔteʔ]	'death'	– Pali *cuti*
	[ʔəːrop]	'Europe'	–origin unclear	[caʔlat]	'mobile'	–Pali *calata*
	[ʔoːtoːkaː]	'truck'	–French *autocar*	[collaʔ]	'small'	–Pali *culla*

[9]Jenner and Pou (1982) speculate that this prefix arose by analogy with the presyllables constructed as a result of infixation. In fact, Jenner (1969) suggests that -m- and -N- actually may be the same affix. It is true that they appear to have many functions in common. He comes to this conclusion as a result of the fact that -m- is less common before /t, ɗ, c, k/ than before /ʔ, r, l, s, h/. He suggests that -m- tends to assimilate before the first set of consonants and does not before the second. Notice that this analysis would support the idea that coronal is the default specification since it might be assumed that /r, l, and s/ are receiving coronal by default and therefore do not have a coronal feature to spread while /ʔ/ and /h/ are laryngeally specified and therefore also do not have a place feature to spread. The status of the morphology is complex and cannot be decided here.

It is not clear, however, if glottal stop insertion is the result of general epenthesis or merely a Khmer interpretation of the structure of loanwords. In both English and French,[10] a glottal catch (or even a full stop depending on the emphasis of the word) occurs frequently with the onset of voicing in vowel-initial words. Since there are no vowel-initial words in Khmer and there are words which begin with a glottal stop, these loan words could merely have been borrowed into the language as glottal stop initial words. There appears to be no evidence in native Khmer words for glottal stop epenthesis. One would expect that if glottal stop insertion was some kind of repair strategy, prefixation or infixation processes could also operate to satisfy the condition on onsets. In other words, we should expect to find situations where bimorphemic words with the structure P+VC, where P is a single consonant morpheme such as the causative /p-/ and VC is a vowel initial base word, alternate with monomorphemic base words with the structure ?+VC. So far as can be ascertained, there are no word relationships of this kind. In addition, there are no examples of native Khmer words containing a glottal stop to satisfy a requirement for bimoraic syllables or feet. Glottal stop insertion applies only to loanwords requiring a short-vowel distinction in an open syllable. In native words, where a final consonant alternates with something it is vowel lengthening, not glottal stop insertion as was shown in Chapter Three and repeated in (10).

(10)	[kpùl]	~	[kpù:]	'to gargle' (H101)
	[ptùl]	~	[ptù:]	'oxcart roof' (H618)
	[pùl]	~	[pù:]	'to be bruised' (H658)
	[prùl]	~	[prù:]	'to panic (birds)' (H680)[11]

Potentially the most damaging argument against coronal as a default specification is the fact that unusual cluster combinations occur among velars as well. Notice in Table 4 that there are fifteen examples in Headley et al. (1977) of the cluster [kŋ]. The cluster, [kʊ] is also a problem since it appears that /ʊ/, in addition to being labially specified, is also specified as velar. Consider again the process of nasal assimilation with the examples in (11).

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[10]It has been pointed out to me (Guy Chamberland, p.c.) that in French, these words are almost always spoken with an initial article or pronoun making them subject to liaison and therefore not likely to have a glottal stop so this generalization is probably only true for citation forms. This argument suffers from the general problem with evidence from loanwords relating to the uncertainty of the structure of the borrowed form. (Yip 1991)

[11]These examples are given as alternate pronunciations in Headley et al. (1977). It is always possible that the /l/ is inserted rather than deleted here but, in any case, what does not occur is glottal stop insertion.

In (11), the causative prefix, characterized as /ɓVN-/ by Jenner and Pou (1982), is shown. The nasal element, like the /-N-/ infix, is non-specified for its point of articulation which it subsequently receives from the following consonant.

(11)	[ɓɒmplaːŋ]	'to cause to become wild'(H556)	[plaːŋ]	'wild, untamed'(H621)
	[ɓɒmɓaːn]	'to cause to possess'(H554)	[ɓaːn]	'get, obtain'(H522)
	[ɓɒnɗuəl]	'to cause to fall'(H488)	[ɗuəl]	'fall over'(H289)
	[ɓɒntèː]	'to cause to lean'(H496)	[tèː]	'leaning over'(H404)
	[ɓɒnsaːp]	'to dilute'(H499)	[saːp]	'bland, tasteless'(H1120)
	[ɓɒnləc]	'to cause to emerge'(J105)	[ləc]	'come out'(J173)
	[pɔ̀ənyùl]	'to cause to droop'(H631)	[yùl]	'drooping'(H786)
	[ɓɒɲcoːl]	'to cause to enter'(J102)	[coːl]	'enter'(J44)
	[pɔ̀əɲɲèak]	'to astonish'(H629)	[ɲèak]	'sudden jerk '(H272)
	[ɓɒŋkɒːk]	'to solidify'(H462)	[kɒːk]	'frozen'(H2)
	[pɔ̀əŋrìːŋ]	'to cause to dry up'(H628)	[rìːŋ]	'drying up'(H869)
	[ɓɒŋʊae]	'to send'(H467)	[ʊè:]	'bestow, confer'(H1027)
	[ɓɒŋʔaːc]	'to make brave'(H471)	[ʔaːc]	'to dare to'(H1403)
	[ɓɒŋhɒːk]	'to cause a relapse'(H468)	[hɒːk]	'to relapse'(H1276)

The assimilations in (11) are interesting in several respects. In the first place, note that before the palatal stops, (oral and nasal), assimilation to a palatal point of articulation occurs while before the palatal glide, the alveolar nasal occurs. It might be suggested that since there is no contrast between alveolar and palatal glides, the palatal glide is specified only as [coronal] and acquires the feature [dorsal] by virtue of the redundancy rule in (12).

(12) $\begin{bmatrix} +\text{sonorant} \\ +\text{continuant} \end{bmatrix} \rightarrow$ [dorsal]

However, vowel-consonant cooccurrence constraints discussed in Chapter Five indicate that [y] must be specified as [dorsal]. The lack of assimilation before [y] requires further study. In the case of all other coronals, the alveolar nasal occurs indicating either a default specification or spreading of the place tier containing the lone coronal node.

The class of consonants before which the velar nasal occurs is especially intriguing. The variety of this group suggests that [dorsal] could be a default point of articulation in

[12]The alternation between /pɔ̀ɔN/ and /ɓɒN/ will be discussed later.

Khmer. However, all these segments, / k, r, ʋ, ʔ, h / may share an articulatory property.[13] In all cases, they can be connected with articulations further back of palatal. Since the only possible underlying nasal further back of palatal is [ŋ], that is the one that occurs. Therefore, in all these cases, assimilation is taking place. This class of segments can be handled by the proposal in McCarthy (1989b) where place specifications occur between one of either an [oral] or [pharyngeal] node with [dorsal] dependent on both (See Figure 7 in Chapter Two). In Khmer, the velar articulation is represented by the [dorsal] node depending from the [pharyngeal] node. In Chapter Five, the inclusion of velars and pharyngeals in one class will also be supported by consonant-vowel cooccurrence facts.

Finally, although [ʔ] and [h] appear to be specified as [pharyngeal] as shown by nasal assimilation and therefore should be expected not to cooccur in initial clusters, this does not appear to be the case. In light of the large number of instances of the cluster [Ch] shown in Table 4 above, it is tempting to suggest that these are, in fact, aspirated stops (Henderson 1952). Under that assumption, the cluster [ʔh] is not a cluster at all but an aspirated glottal stop. Further indication that this is a possibility is that C^h, unlike other combinations of consonants, is spelled in the orthography with a single symbol. For example, in the combination of /k/ and /l/, the /l/ is indicated by a diacritic placed beneath the symbol for /k/.

(13)

/k/ /kl/ /kh/ /khl/

To represent /kh/, there is one entirely different symbol. In addition, the symbol for /kh/ can also take the /l/ diacritic which means that the sequence of consonants pronounced [k^hl], can be spelled either with a plain unaspirated /k/ or an aspirated /k^h/. This suggests

[13]Lindau (1985) notes that the classification of /r/ crosslinguistically must be characterized as more of a "family resemblance" (Wittgenstein 1958) than the presence or lack of any particular articulatory or acoustic feature. Some possible clues to /r/ include closure duration, formant structure and pulse patterns. She goes on to note that the exact specification of features for /r/ in any particular language must be primarily deduced from its phonological behavior. Therefore, although all instances of /r/ in Khmer speech may not actually involve a pharyngeal articulation, its alternation between glottalization and pharyngealization indicate that, at least in some cases, this can occur. This connection with pharyngealization, however tenuous, is a common feature of all the segments in the class of segments before which occurs a velar nasal.

that a contrast may exist between aspirated and unaspirated /k/ which is merely neutralized in the initial position of a consonant cluster. The most common argument against this analysis is the instability of the transitional aspiration occurring between clusters and the stability of [h] as part of a cluster (Henderson 1952, Huffman 1967) in processes such as /-N-/ or /-m-/ infixation (Jenner 1969). On the one hand, consonant cluster constraints indicate that /h/ is merely aspiration on the consonant, on the other, stability argues that it is a separate consonant. Exactly how /h/ should be represented is not clearly indicated.

In fact, there are other anomalies with respect to [h] in Khmer. Huffman (1967) claims that the articulation of this segment varies depending on its position in the word. Initially, he describes it as pharyngeally articulated, finally, it is "post-velar" and only in second position of a consonant cluster is it glottal. Secondly, not all instances of word final [h] are necessarily underlyingly /h/. This is shown by the fact that /s/ variably reduces to [h] word finally. Underlying /s/'s are still accessible to (at least educated) native speakers since the information is available from the orthography and, in very formal situations, the /s/ is actually pronounced as [s]. The difference lies in the fact that, while both short and long vowels may occur prior to an underlying /s/, only a short vowel may occur prior to an underlying /h/. The shortening of vowels prior to underlying /h/ is a result of the fact that /h/ is somehow exempt from the coda adjunction rule and so can only associate by attaching itself to the nearest mora. The representation of /h/ will be discussed further in Chapter Six.

In addition to distinctions resulting from place of articulation, there are also major class distinctions such as those in (14) given by Chomsky and Halle (1968).

(14) [consonantal]
[syllabic]
[sonorant]

The features [consonantal] and [syllabic] were originally proposed to account for the distinction between vowels and consonants with consonants specified as [+consonantal, –syllabic], glides as [–consonantal, –syllabic], and vowels as [–consonantal, +syllabic]. In more recent work (Selkirk 1984, Levin 1985 and others), it has been suggested that the feature [syllabic] can be derived from the position that the segment in question occupies in the syllable rather than any intrinsic feature specification. The result of this assumption is that [syllabic] is not available to distinguish segments in a segment inventory. As for [consonantal], as argued in Chapter Three, this feature is required to indicate the consonant cluster constraint in word-final position. In order to show this, the specified value must be

[+consonantal]. The difficulty with this is that certain segments in Khmer do not appear to match Chomsky and Halle's definition of this feature which requires that [consonantal] be articulated with a "radical obstruction in the midsagittal region of the vocal tract", namely [h, ʔ, ʊ and y]. In fact, in Chomsky and Halle (1968), glides were specified as non-consonantal. However, this definition is subject to interpretation since the property of "radical obstruction" operates along a continuum. It all depends upon the degree deemed necessary to be called "radical". Chomsky and Halle themselves determined that the approximant obstruction involved in [r] and [ʁ] was sufficiently radical to qualify as [consonantal]. It seems possible that, as approximants, the glides [y] and [ʊ] might also meet this definition. In addition, if, as is claimed here, the segments [h] and [ʔ] are, in fact, pharyngeally specified, they do involve some degree of vocal tract obstruction since, in Khmer consonant specifications, the glottis is included as part of the vocal tract.

As for the feature [sonorant], this is potentially an important distinction in Khmer. According to Chomsky and Halle (1968: 302), this feature is defined as being "produced with a vocal tract cavity configuration in which spontaneous voicing is possible." Using the feature [sonorant], two main classes of segments can be delineated in Khmer, the obstruents and the sonorants. As will be seen in Chapter Six, these two classes define the distinction between transparent and opaque segments for register harmony. According to markedness conventions, in the unmarked case, [+consonantal] implies [–sonorant] so, [+sonorant] can be inserted by default on all non-consonantal segments and sonorant consonants are marked as such.

Within the class of sonorant consonants, it is necessary to distinguish glides, nasals and liquids. With respect to nasals, the clearest solution is merely to consider these as [+nasal]. As for its dependency relation, this is immaterial here so it will merely be assumed that the feature [nasal] depends from the root node of the segment (but c.f. Avery and Rice (1989b) and Piggott (1989) for a further discussion of this issue). Since the liquids, /l/ and /r/, are alternating as a result of register, they should be minimally distinguished. Because /r/ can be shown to be specified pharyngeally, by virtue of nasal assimilation, this is done with a pharyngeal place specification where /l/ is unspecified for place. Both of these can be specified as [–continuant]. The glides and /h/ are specified as [+continuant]. Except for the possible exception of depending [nasal] from a spontaneous voicing node, no major class nodes must be utilized for the distinction of sonorants. With respect to obstruents, this is not the case. The fact that the class of obstruents includes /s/ and implosives as well as plain voiceless stops shows that some distinction is required. Following Sagey (1986) this

distinction is made by proposing that /s/ is laryngeally specified with the feature [+spread glottis] and implosives are specified as [+constricted glottis]. According to the type of underspecification proposed by Avery and Rice (1989a), if one value of a particular feature is activated, then even though the other value of that feature is inserted by default, the class node which dominates that feature must be present on all segments to be distinguished by that feature. Therefore, if the class of obstruents is to be distinguished by the laryngeal features [±spread glottis] and [±constricted glottis], then even though the plain stops receive the values for these features by default, they must also carry a laryngeal node. Unfortunately, there is no other evidence from Khmer phonology that can show this. Since both the glottal features proposed to be dominated by the laryngeal node are antagonistic to each other (Archangeli and Pulleyblank, to appear) there can exist no assimilatory processes which can be shown to require that both these features be dominated by a single node. In other words, there is no assimilatory process in Khmer which spreads an entire set of laryngeal features. Although support for this is not apparent, if the Node Activation Condition of Avery and Rice is adopted, then certain facts relating to cooccurrence restrictions between vowels and consonants, which will be discussed in Chapter Five, as well as the opacity and transparency of consonants in register harmony, discussed in Chapter Six, is more easily derived. Therefore, it will be adopted here.

Based on the previous discussion, the consonants of Khmer are assumed to be underlyingly specified as in (15).[14]

(15)

Features	p	ɓ	ʋ	m	t	ɗ	s	l	r	n	y	c	ɲ	k	ŋ	ʔ	h
Consonantal	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Continuant			+								+						+
Nasal				+						+			+		+		
Oral	+	+	+	+	+	+	+	+	+	+	+	+	+				
Labial	+	+	+	+													
Coronal																	
Dorsal			+								+	+	+	+	+		
Pharyngeal			+						+					+	+	+	+
Laryngeal	+	+			+	+	+					+		+		+	
Const. Glottis		+				+										+	
Spread Glottis							+										

In this chapter, using evidence from cooccurrence patterns and nasal assimilation, the consonants of Khmer have been specified as in (15). Many problems still exist. The requirement for the [oral] class node has not been motivated. In addition, the feature

[14]Major articulator features (underlined) are assumed to be monovalent. They are merely indicated as + in the chart to show their presence in the specification of the segment.

[continuant] has been called in to distinguish the glides from the other sonorants. It is possible that this distinction should be represented in some other way as the feature [continuant] has not been motivated for any other reason than distinctiveness. In the case of place of articulation, it has been argued that [coronal] is a default place of articulation in Khmer. Apparent counterexamples have been accounted for by resorting to underspecification and morphological information. It has been suggested that the view of underspecification proposed by Avery and Rice (1989a), whereby content nodes such as [laryngeal] which dominate distinctive features must be specified where those features are minimally distinctive, can be used to describe the facts of Khmer. In the next chapters, these specifications will be called upon to justify certain claims that will be made about the phonological structure of Khmer and, in particular, the process of register harmony.

Chapter Five
Vowels and Harmony

5.0 Introduction

Khmer register is phonetically characterized by vowel quality differences but it remains to be seen whether these differences have any further phonological significance. In order to check this, it is necessary to outline the specification of Khmer vowels independently of the register distinction. Since there are few clear phonological processes involving strictly vowel height features, the evidence for these features will be garnered in three ways. In the first place, it will be argued that the default features are realized on the epenthetic vowel in that it is underlyingly completely unspecified. Secondly, this will be supported by vowel-consonant co-occurrence restrictions which, in combination with the specifications argued for in Chapter Four, will be shown to be observing the OCP with respect to underlying representations. It will be argued that these features differ with respect to when they may occur, with certain features only occurring under specific prosodic licensing conditions. Finally, it will be argued that register does not operate to change underlying specifications. In fact, diphthongization, which takes place across registers, will be argued to result from antagonistic specifications between register and underlying vowel quality specifications.

5.1 Khmer Vowel Systems

Khmer vowels can be described in terms of at least four systems.[1] There is one system which contains all the long vowels and another with all the short vowels. As discussed in Chapter Three, long vowels are those which can appear syllable finally while short vowels are those which cannot. The third and fourth vowel system are that which occur with constricted register and that which occur with expanded register. If all the vowels are divided up in this way, they can be organized into the four vowel systems illustrated in Table 6.

The arrangement of Table 6 requires additional explanation. First, there is a distinction between two kinds of diphthongs in the Khmer vowel system. One set of diphthongs alternates across registers with simple vowels. This is illustrated by the diphthong [ae], designated in the chart as constricted register, low and front, which alternates with expanded register [ɛ:]. The other set of diphthongs remain diphthongs no matter in what register they occur. This alternation can be illustrated by examining the word [pŋaəy] 'to cause to be face up' (H614) which is derived from [ŋə̀:y] 'face up'(H156) and involves a

[1]See Appendix I for a complete description of the vowels.

register distinction. Along with the change of register, diphthongization occurs. In Table 6, only the set of diphthongs which remain diphthongs regardless of register are labelled as diphthongs.

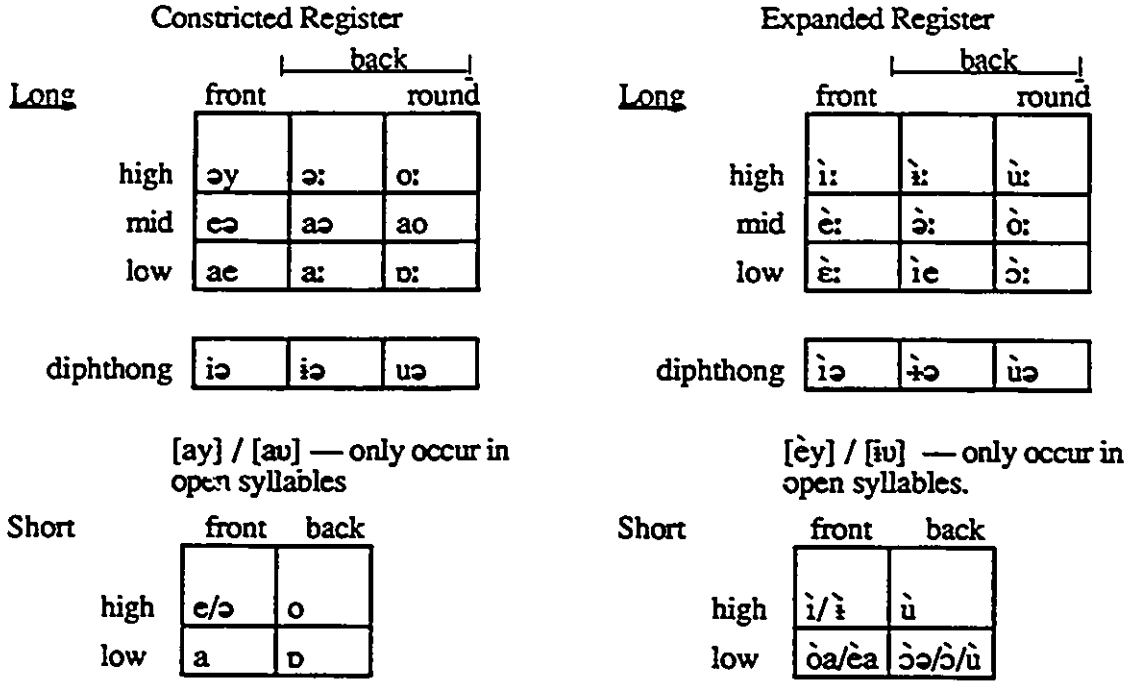

Table 6: Vowel Oppositions in Khmer

One of the points on which descriptions of Khmer differ is the representation of vowels. This is not purely a result of dialect differences although vowel differences are a prime locus of variation between dialects in Khmer (Huffman 1967). The main point of disagreement is the role of register in the phonological system. Jenner remarks that "distinctions of openness are for the most part obligatory; when these are lost, registral contrast is neutralized" (Jenner 1969:22) and Huffman comments that "while it is perhaps doubtful that the difference in vowel height involved in the long vowel contrasts /ɪ/:/e/, /ʏ/:/ə/, and /ʊ/:/o/[2] would be sufficient to the ear of a Cambodian speaker without the concomitant features of register, there is no reason why the contrasts cannot be thus represented phonemically" (Huffman 1967:246). In other words, while with his choice of phonetic symbols, Jenner represents the vowels of Khmer as primarily differing along the lines of register and Huffman uses a notation highlighting the vowel quality differences, neither is completely ready to assert that only vowel quality cues or only phonatory cues are

[2]Huffman uses different vowel symbols than those used by Headley et al. (1977).

important in the specification of register. It is this representational confusion over what is important in the articulation and perception of Khmer vowels which led Pinnow (1980:103) to comment that "the situation is all the more complicated by the variety of transcriptions employed by different writers, who disagree in many cases in their interpretation of the articulation of vowels and consonants and of their place in the phonemic system". Therefore, while many of the phonetic details of vowel quality are possibly not relevant in a discussion of register, it is important that they be included at this stage of the discussion. The data in Headley et al. (1977) is quite complete in this regard.[3]

Where the register distinction appears to be truly independent of vowel quality is with the group of vowel nuclei specifically labelled in Table 6 as diphthongs. Henderson (1952) claims that although they do not vary in terms of vowel quality, the constricted and expanded register versions can be distinguished by virtue of the phonatory aspect of register. However, the appearance of words like [ciəh] 'avoid' (J57), spelled as both constricted and expanded register, has led to the claim that the register distinction is nonexistent in these diphthongs and possibly elsewhere (Huffman 1976). This supports the position that the openness of the vowel is a crucial component in the recognition of register. In fact, Jenner (1969) reports that these diphthongs can be distinguished for register only about fifty-five percent of the time. Without vowel quality cues to indicate register, native speakers have difficulty determining it. The distinction of "openness" between classes of vowels is an important clue to register and when it is no longer there, register is neutralized. However, as will be seen in a discussion of vowel harmony, the diphthongs participate phonologically along with other vowel types in the rule of register harmony and need to be classified as one or the other.

The position that will be argued here is that the diphthongs which alternate with basic vowels reflect readjustments resulting from conflicting goals stemming from how these segments are underlyingly specified and the articulation of register. In order to illustrate this, the underlying vowel quality specifications will first be determined followed by a discussion of how these proposed features interact with register.

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[3]One difficulty encountered with the data in Headley et al. (1977) is the classification of words as to register. Since Headley et al. (1977) was compiled with the assistance of several native speakers and spelling generally reflects register, it is assumed here that the spellings chosen reflect native speaker intuitions on this point. In Jacob (1974), where register is more clearly indicated, it can be seen that spelling is generally a good indication of register. In order to facilitate the identification of each register, the notation of Jacob (1968) is followed and an accent mark is placed over the second register vowel.

5.2 Feature Specification of Khmer Vowels

5.2.1 Vowel Occurrence Patterns

There are very few phonological rules, with the exception of register, which will be discussed in the second half of this chapter, that implicate vowels. Where distinctive features of vowels are relevant is with co-occurrence restrictions and restrictions on syllable structure. There are several such restrictions that can be noted for Khmer.

The first restriction occurs with respect to the structures discussed in Chapter Three. As a result of the bimoraic requirement, only long vowels can occur in open stressed syllables. Martini (1946) reported that if the vowel in an open syllable is not pronounced with sufficient length, a native speaker perceives it as a short vowel followed by /h/.

Of the long vowels shown in Table 6, all occur in open monosyllables. Notice, however, that of eight possible short/long vowel alternations, only two clearly differ as to vowel quality as well as length. These are /ɔ̀ː/ versus /ɔ̀/ (occurring as [ɔ̀ə], [ɔ̀] or [ù]) and [ìe] versus its short form (occurring as either [òa] or [èa] depending on environments to be discussed shortly). In other cases, the vowel quality differences occurring between long and short vowels are not so clear. For example, it might be thought that the short vowel, /ə/, is merely the short version of /əː/. However, as will soon be seen, it is not so straightforward. In at least some cases, short /ə/ opposed /aə/. As for other long/short correspondences, it is necessary to establish more clearly that where vowels agree as to register and differ in length, vowel quality differences also occur. In other words, length and register are not the only source of vowel quality differences.

5.2.2 Short Vowels versus Long Vowels

As noted earlier, the short set of vowels is phonetically shorter than the long set and generally occurs only in closed syllables. If for any reason, the vowel appears in its long form, its quality may be altered as is seen in (1).

(1)	[knol] ~ [knao]	'jackfruit'(H100)
	[snol] ~ [snao]	'motionless because of illness(poultry)'(H1215)
	[həl] ~ [haə]	'hot, burning'(H1286)
	[pìl] ~ [pìː]	'two, a pair'(H653)

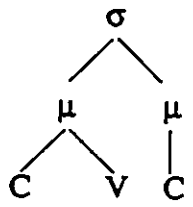
Recall that, in Chapter Three and Four, it was mentioned that several words vary between short vowel plus /l/ and long vowel.[4] In the examples in (1), short [o] can have the value [ao] when long and short [ə] can be [aə].

The most radical change in terms of difference in vowel quality is the variation claimed to occur between the long and short expanded register mid low vowel. When it is long, it apparently occurs phonetically as [ìe] and when short as either [èa] before those consonants described in Chapter Four as [Pharyngeal] or [òa] elsewhere. Unfortunately, there are no clear examples in the data of this alternation. Complicating this is the fact that although [òa] is supposed to be a short vowel, it does occur occasionally in an open syllable. In an open syllable, Jenner (1969) reports that the diphthong is phonetically longer than in a short vowel environment. All the examples of long [òa] occur in words which are spelled with a final [r] that has since been deleted. Some examples are shown in (2).

(2) / pòar / [pò:a] 'the Pear tribe'(H637)
/ kòar / [kò:a] 'embryo'(H120)

The processes shown in (1) and (2) can be analyzed as compensatory lengthening (Hayes 1989). Presumably, before deletion, the words in (1) and (2) have the following structure.

(3)



When the final consonant drops, its corresponding mora cannot also disappear since that would violate the restriction on minimal size. Either another consonant must be epenthesized or the features of the vowel must spread onto the empty mora. It is the second of these two possibilities which takes place.[5]

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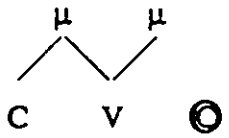
[4]These are all the examples of this kind of lenghthening that could be located in Headley et al. (1977). Since this appears to be a variable process, it is possible that more examples exist but were simply not noted in the dictionary. Anne Laubstein has pointed out to me that the first two examples here could also be a result of /l/ changing to [o]. Henderson (1952) describes /l/ as having "medium to dark resonance." While this is a possibility, one might expect that /l/ should also occur as [o] everywhere and not just after [a].

[5]Notice that this would appear to contradict an earlier claim that /r/ is pharyngeally specified since the vowel expected in these words is [èa]. However, although these words are spelled with final /r/, other cases of alternation with word final [l] and Ø are also spelled with a final /r/. Therefore there may be an

(4)



There is another interesting property of short vowels versus long vowels that needs to be discussed. Notice that short vowels exhibit alternations depending on environment. For instance, the vowels [èa] and [òa] are in complementary distribution depending on the following consonant. [èa] occurs only prior to /k,ʔ, ŋ, and h/ while [òa] occurs elsewhere. This is a dissimilatory process whereby the back variant of this vowel is prevented from occurring prior to back consonants.

(5)	(a)	/cnèah/	'to win, vanquish' (H269)
		/pèak/	'to hang, to wear' (H641)
		/pèaŋ/	'to block' (H668)
		/kèaʔcèaʔ/	'elephant' (H116)
	(b)	/còam/	'saturated' (H259)
		/còan/	'period of time' (H240)
		/còap/	'link together' (H241)
		/khòat/	'to dissuade' (H147)
		/kòas/	'to dig up using a stick as a lever' (H124)
		/kòal/	'to have an audience with the king' (H123)

Consonant vowel interaction can also be seen with the low back rounded vowel. The short version, /ɔ̀/, occurs as [ù] before labials, [ɔ̀] in open minor syllables and [ɔ̀ə] elsewhere.

(6)	[tɔ̀ənlèak]	'fall (of water)' (H369)	[tlèak]	'to fall down' (H434)
	[tùmlèak]	'to drop, to let sthg fall' (H372)	[tlèak]	'to fall down' (H434)
	[lɔ̀lòːt]	'to jump frequently' (H914)	[lòːt]	'to jump' (H941)

This is supported by the fact that there are no words in Khmer containing the tautosyllabic sequence -ɔ̀p- and no cases of [ɔ̀ə] occurring in an open syllable. A word such as *[kɔ̀p], for example, could not, and does not, exist. The long vowels do not undergo the same degree of interference from adjacent consonants. The only long vowel opposition reported

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intermediate stage where the final consonant is [l] at which time the default features of the vowel are inserted.

[6]The final /s/ occurs on the surface as [h].

to be neutralized is [ɨ:] versus [i:] although some cooccurrence conditions exist with long vowels and will be discussed shortly.

As for short vowels, other than being restricted to appearing in closed major syllables or minor syllables, there is no clear domain where they can be phonologically isolated since generally, both long and short vowels can occur in closed syllables. It can only be stated here that short vowels are those which do not occur in open syllables in monosyllabic words.

5.2.3 Determining Distinctive Features

As discussed in Chapter Three, the short low back vowel (either [ɔ] or [ɒ] depending on register) enjoys a special status in Khmer in that it has a wider distribution than other short vowels. It is the only vowel that is allowed in the first syllable of a restricted disyllable. It is also the vowel which occurs in all native prefixes. In addition, as will be discussed presently, it is the only vowel that undergoes expanded register harmony. Finally, as the discussion of restricted disyllables in Chapter Three shows, this vowel often occurs when otherwise syllable structure constraints would be violated. Since the only requirement is that the repair element in syllable structure and melodic adjustments be a vowel, the unspecified vowel should appear. For these reasons, the short low back vowel is considered to be completely unspecified in Khmer.

Since the two realizations of the unspecified vowel in Khmer both surface as low and round, and assuming that the values of the unspecified vowel represent default features of the language, it is expected that Khmer vowels are distinctively specified as [–round] and [–low].

As depicted in Table 6 above, the system of long vowels (including the diphthongs) consists of twelve vowels (Huffman 1967: 243). In order to determine the features required for long vowels, their interaction with consonants must be examined. The specification of vowels and consonants in the theory of feature geometry is a point of disagreement. There has been an implicit assumption in the past that the distinctive features of vowels are drawn from a different set than those of consonants (Chomsky and Halle 1968). Halle (1983) motivates this separation phonetically with the assertion that vowels are mainly articulated with the tongue body involving the extrinsic muscles of the tongue while consonants, although they also involve use of the tongue body, are articulated with the tongue blade, largely controlled by the intrinsic muscles of the tongue. While consonants and vowels do appear to be somewhat separate as is shown by the fact that many vowel harmony rules are

oblivious to intervening consonants, there are also consonant and vowel interactions in many languages which are related to some kind of shared properties (c.f. E. Pulleyblank 1989). It is this kind of interaction between segments that feature geometry is specifically designed to handle and the exact dependencies of vowel features vary. Sagey (1986) places all vowel features under the [dorsal] node, with the exception of [round], which is under the labial node, and [ATR], which is not mentioned. Edwin Pulleyblank (1989) has presented a strong argument for changing the feature [back] to [front] and relocating it below the [coronal] node.

Cooccurrence patterns in Khmer support E. Pulleyblank's (1989) view that the active value for this feature is [+front] and that the coronal node is involved. In the first place, there is the process discussed in Chapter Four and reviewed here. Huffman (1967) reports that the velar consonants /k/ and /ŋ/ are fronted after front vowels. In fact, he claims that they are virtually indistinguishable from /c/ and /ɲ/ and he only recovers their original character by referring to distribution patterns and the fact that when the velar following a long front vowel is a geminate, it does not occur as a fronted consonant. Following Keating (1988), as discussed earlier, the process of velar fronting can best be characterized as the spreading of the coronal node of the vowel to the following consonant. From this it can be surmised that front vowels are specified as having a coronal node from which, in vowels and glides, depends the feature [+front].

In addition, long front vowels generally do not occur prior to /y/.[7] This tendency can be expressed by the constraint in (7).

(7) [*[+front][+front]]$_{\mu}$

In the view of underspecification adopted here, only one value of a particular feature is permitted but another cooccurrence restriction may require that [–front] also be specified. Only front vowels can occur before /ʊ/. However, recall that the specification of /ʊ/ is not [coronal] with [–front] depending from it but, [dorso-pharyngeal], secondarily specified as [labial]. This was indicated by nasal assimilation. Therefore, if a co-occurrence restriction is occurring as a result of an OCP constraint, then all non-front vowels should be specified as [pharyngeal]. This result falls out from the view of underspecification adopted earlier, that of Avery and Rice (1989a). Note that all vowel features, with the exception of [front], which has just been motivated as a [coronal] feature, and [round] are specified under the

[7]A very small number of examples of /ɛɛ/ occur before /y/. No second register front vowels occur before /y/. This constraint holds across registers.

[dorsal] node (Sagey 1986). Under Avery and Rice's notation (1989a), this would require that all vowels be minimally specified as [dorsal] with the exception of those vowels specified minimally with the features [round] and [front] since these depend from the [labial] and [coronal] nodes respectively.

The use of the feature [high] is also supported by cooccurrence restrictions operating between long vowels and /y/. High long vowels generally do not occur before /y/ although there are many instances of them occurring after /y/.[8] This restriction is expressed by the constraint in (8).

(8) *[[+high][+high]]$_{\mu}$

In order to distinguish a nine vowel system, four features are required. It has just been shown that the features [high] and [front] are required to account for cooccurrence restrictions. The feature [low] is required to distinguish [ɔ̀ː]/[ɒː] and the mid back rounded vowel [ò:]/[ao][9] although it does not appear to be playing any other phonological role. In Table 6, in relation to the other vowels, both versions of the unspecified vowel are low so the default value is assumed to be [+low] and the other vowels are distinguished by virtue of the value [–low]. To distinguish between back sounds, the feature [round] is needed. Since the short default vowel is [+round], the distinctive value is considered to be [–round].

(9) a. [ ] [+ high] [+ front] [– low] [– round]

[+ high, + front] [+ high, – round] [+ front, – low] [– low, – round]

b. [+ high, – low] [+ front, – round] [+ high, + front, – low] [+ high, + front, – round] [+ high, – low, – round]

[+ front, – low, – round] [+ high, + front, – low, – round]

If the features [+high], [–low], [+front] and [–round] are used, there are 16 logical possibilities for combinations. Of these sixteen possibilities, the seven in (9b) can be eliminated by assuming the following six redundancy rules. This is motivated by the

[8]Headley et al. (1977) cite only one counterexample to this which is the word /yùːy/ 'ouch' which also has the alternate pronunciation of /yùy/. It is possible that this is merely a lengthening of the short vowel due to emphasis rather an a counterexample to the restriction on long vowels.

[9]Both registers are shown for each vowel.

simplicity metric (Halle 1961, 1962) whereby the simplest representation (involving the least number of feature specifications and the smallest number of rules) is the highest valued.

(10) (a) [ ] → [–high, –front, +low, +round]

(b) [+front] → [–round]

(c) [+high] → [–low]

The redundancy rules in (10a) are a direct result of the simplicity metric which, assuming radical underspecification, requires only one value of a feature to be underlying with other features filled in by default.

In the last rule, the feature [+high] intuitively implies that any corresponding specification for [low] be minus. In support of this kind of rule, Archangeli and Pulleyblank (in prep) argue that a grammar containing the type of "grounded" redundancy rules such as (10c) which is motivated by markedness (Kean 1975) or considerations of phonetic enhancement (Stevens and Keyser 1989), should be simpler than one without it. It appears that Khmer has very few of this type of rule, suggesting that it is a marked system. In Maddieson (1984) only 4.1% of vowel inventories contain more than seventeen vowels. Khmer is a member of this set with 18 vowels, including both the long and short set and not including the diphthongs. Typologically, this is an unusual set of vowels.

The application of the redundancy rules leaves nine feature combinations which is exactly the number of distinctive combinations required.

(11)

	iː/əy	ɨː/ɔː	uː/oː	eː/eɔ	ɛ̀ː/aɔ	òː/ao	ɛː/ae	ie/aː	ɔː/ɒː
high	+	+	+						
low				–	–	–			
front	+			+			+		
round		–			–			–	

Archangeli (1984, 1988) hypothesized on the basis of universal preferences in vowel systems that the redundancy rules in (12a) are unmarked and therefore preferred by Universal Grammar. Any language for which these universal redundancy rules must be suppressed or different redundancy rules are required is considered to have a marked inventory. Compare the set of universal redundancy rules in (12a) to those hypothesized

for Khmer in (12b). Virtually every redundancy rule proposed here is the opposite of those proposed to be universal by Chomsky and Halle (1968) and Archangeli (1984, 1988). This is not necessarily an unwanted result since, as just noted, the Khmer vowel set is unusually large and, therefore, marked.

(12)	(a)				(b)			
		[ ]	→	[–low]		[ ]	→	[+low]
		[ ]	→	[+high]		[ ]	→	[–high]
		[ ]	→	[+front]		[ ]	→	[–front]
		[ ]	→	[–round]		[ ]	→	[+round]
		[+low]	→	[–high]		[+high]	→	[–low]
		[+low]	→	[–front]		[+front]	→	[–round]

However, in addition to the large vowel inventory, in a sense the vowel system of Khmer appears to be "upside down" in terms of markedness. It is the converse of the proposed universal system. An examination of the short vowels corroborates this.

For the short vowels, only four vowels need to be specified and for this, only two features are required. To determine which of the above four features are active for short vowels it is only necessary to reexamine the cooccurrence restrictions noted above with glides.

(13) [key] 'to embezzle'(H130)
[kùy] 'kind of vine'(H127)

Since the cooccurrence restrictions noted above for long vowels do not appear to be active for short vowels as shown by the examples in (13), short vowels are not specified for the features in question, namely [front] and [high]. Additional evidence for eliminating front as a distinctive feature of short vowels comes from the fact that unrounded vowels undergo fronting before palatals. There are also quite a few instances of central/front alternations in other environments as well, as is evidenced by the alternate pronunciations in (14) indicating that short [ì] and [ɨ̀] are not distinctive.

(14)				
[kel]	~	[kəl]	'to move on one's buttocks'(H37)
[ɓet]	~	[ɓət]	'to close'(H530)
[lìt]	~	[lɨ̀t]	'to lick'(H922)
[kep]	~	[kəp]	'to keep something'(H37)

Finally, among monosyllabic words in Headley et al. (1977), the short vowels [ì] and [e] contrast with [ɨ] and [ə] only in limited environments. A short [ì] or [e] occurs only in a

loanword, before /h/ or as an alternative to [ɨ] as in (14). Assuming that short [ɨ] or [e] result from shortening of the long vowel after the full specification of features, it appears that, underlyingly, short unrounded vowels do not contrast in Khmer. Short /ɨ/ and /e/ are either a reflex of the long vowel or a borrowed sound.

At this point, the question of differences in vowel features with respect to long and short vowels should be considered with reference to the occurrence of long [ɔ̀a] mentioned earlier and short [ɨ]/[e] before /h/. The position taken here is that these vowels carry underlying features and receive default features on the basis of which mora they are associated to. Only vowels associated to the second mora of the syllable may be licensed for the features [high] and [front].[10] Vowels associated to only the initial mora may not. In the case of [ɔ̀a], the insertion of default features occurs prior to the deletion of final /r/ (or [l]) so the vowel can only lengthen, it does not change in quality. As for the fronting of short vowels prior to palatals, they are sharing the [coronal] node with the following consonant. Variable fronting as in (14) just shows the non-distinctiveness of this feature for short vowels. In the case of vowels prior to /h/, there are several possibilities. One possibility is that the final mora is linked to both /h/ and the long vowel thereby licensing the long vowel features but causing the vowel to surface phonetically shorter.

In order to reflect the fact that both [ɨ/ɯ] and [e/ə] are subject to alternations of frontness, it is necessary to represent them as a natural class. The feature used for this cannot be front, since it is frontness that is alternating. It can only be rounding. Non-round vowels alternate as to frontness.

There is one problem with utilizing the feature [round] in relation to the default short vowel. If the default value is [+round], then it should be impossible for the unspecified vowel, [ɔ̀], to acquire the feature [+round] since it is already rounded by default. However, it appears to. Before labial consonants, the default vowel surfaces as [ù]. It is unclear, however, if this requires a phonological solution or if this is merely a phonetic result. It may also be that rounding is just the physical manifestation of [back] and that in fact, it is the feature [–back] rather than [–round] which is distinctive here. In other words, both [back] and [front] are active in Khmer. Henderson (1975) also calls this into question by pointing to [ɛ̀a] and [ɔ̀a] which, judging from the conditioning elements, namely back consonants versus front consonants, appears to be a front/back alternation but which is also realized as unrounded versus rounded. If we assume that [ɛ̀a] / [ɔ̀a] is unspecified for the

[10]cf. Goldsmith (1990:124) for the proposal that feature licensing can be a property of suprasegmental structures.

front/back dimension, and that backness is a default feature of vowels, an argument that will be pursued shortly, then this process is due to the constraint in (15).

(15) * μ μ
| |
[Place] [Place]

When the default rules are applied, the standard default feature cannot be applied to the vowels before the pharyngeal consonants since it would violate the above constraint so the vowel appears as non-back. The phonetic realization of this vowel will be further discussed with reference to register.

As noted, since short [ù] can freely occur preceding /y/, the feature [high] is not operating to distinguish short vowels.[11] However, some height distinction is required. Therefore, the distinctive feature adopted here is [low].

Given the two distinctive features of [–low] and [–round], the logical possibilities for combinations are:

(16) [ ] [–low] [–round] $\begin{bmatrix} -\text{low} \\ -\text{round} \end{bmatrix}$

The short vowels are therefore specified as in the following chart.

(17)

	[ì/e̞]/[ɨ̀/ə]	[ù]/[o]	[òa/èa]/[a]	[ɔ̀]/[ɒ]
low	–	–		
round	–		–	

One set of vowel nuclei has not yet been discussed. These are the diphthongs, [uə/ùə], [ɨə/ɨ̀ə] and [iə/ìə]. In fact, these diphthongs have co-occurrence patterns similar to the central set of vowels and do not have the restrictions associated with high vowels. One possibility is that these are some kind of contour segments such as those proposed in Sagey (1986) specified as [+high] on the left edge and [–high] on the right so cooccurrence effects with following consonants are not felt. There is no evidence one way or another to establish even a tentative feature specification for these diphthongs. For this reason, they

[11]Huffman (1967) claims that /y/ can occur after short [ɨ] but gives no examples and I cannot find any. Supposedly [ɨ] is fronted, however, before palatals so it is not clear that /ɨy/ would be distinguishable from /iy/.

are not dealt with in the feature specifications although it is acknowledged that their specification is important.

5.2.4 Register and Vowel Features

Both short and long vowels are either underlyingly specified for register or not. As noted earlier, Lindau (1979) has argued that the feature [ATR] be replaced with [Expanded] to better denote the fact that the crucial result of advancing the tongue root is an expanded pharynx and that this may be accomplished in several ways. At this point in the discussion, [Expanded] will be used to represent register in order to avoid making a commitment at this time as to whether the feature is uniquely associated with the tongue root, the larynx or both. The exact nature of the feature or features involved in the register distinction will be discussed in Chapter Six. Phonetically, [+Expanded] corresponds roughly to [+ATR] while [–Expanded] corresponds to [–ATR].

Archangeli and Pulleyblank (in prep) propose that, in the unmarked case, there are co-occurrence conditions operating between tongue body features and the tongue root in the operation of rules and representations involving [ATR]. If [ATR] is closely connected with larynx height, these co-occurrence conditions may also be expected with respect to larynx height. At any rate, given that some of their evidence for these conditions includes Akan, which Lindau used to argue for [Expanded], it is expected that the conditions will also hold for [Expanded]. Assuming this, constricted register and expanded register are henceforth represented as [–Expanded] and [+Expanded] respectively. Archangeli and Pulleyblank's co-occurrence conditions are summarized in (18) with [Expanded] replacing [ATR] and [Constricted] replacing retracted tongue root ([RTR]):

(18)

Expanded/High	If +Expanded then +high If +Expanded then *not* –high	Constricted/High	If –Expanded then –high If –Expanded then *not* +high
Expanded/Front	If +Expanded then +front If +Expanded then *not* –front	Constricted/Front	If –Expanded then –front If –Expanded then *not* +front
Expanded/Low	If +Expanded then –low If +Expanded then *not* +low	Constricted/Low	If –Expanded then +low If –Expanded then *not* –low

(Archangeli and Pulleyblank, in prep)

If the register value of the vowel is [–Expanded], a conflict arises between the articulation of register and some of the underlying representations for vowel quality proposed here as shown in (19). Those features which conflict with [–Expanded] as hypothesized by the conditions in (18) are bracketed.

(19)	əy	ə:	o:	eə	aə	ao	ae	a:	ɒ:
high	<+>	<+>	<+>						
low				<–>	<–>	<–>			
front	<+>			<+>			<+>		
round		–			–			–	
Expanded	–	–	–	–	–	–	–	–	–

The posited underlying values of Khmer vowels are very incompatible with a constricted pharynx. It is claimed here that the conflict caused by the "antagonistic" (Archangeli and Pulleyblank, in prep) values between [Expanded] and the other features exert pressure on the system and phonetic readjustments in the direction of preferred values is seen. For example, in the case of the mid back rounded vowel, the feature [–Expanded] puts pressure on the vowel to become low. However, this cannot occur since the vowel is underlyingly specified as [–low] so, instead, a kind of accommodation takes place which surfaces as diphthongization. There are some problems with this analysis. For instance it is unclear why diphthongization appears to be more prevalent in resolving conflicts in the mid vowels than in the high vowels. In the second place, it is not clear whether this is merely a phonetic or a phonological adjustment.

Unlike in the case of [–Expanded], [+Expanded] is generally in agreement with the underlying vowel specifications of Khmer.

(20)	i:	ɨ:	u:	e:	ə̀:	ò:	ɛ:	ie	ɔ:
high	+	+	+						
low				–	–	–			
front	+			+			+		
round		–			–			–	
Expanded	+	+	+	+	+	+	+	+	+

In addition to the effect on feature representations, one might expect that there could be certain effects on the default values depending on what register the vowel has. The default values proposed here are perfectly compatible with the feature [–Expanded]. However, they are not perfectly compatible with [+Expanded]. With reference again to (18), the default values expected with [+Expanded] are [+high], [+front], and [–low]. The only case where it appears that [+Expanded] is exerting pressure on default values is in the case of the vowel [ìe]. This vowel is the [+Expanded] reflex of [a:]. Since the vowel is

unspecified except for rounding, it can take on values for [high], [front] and [low] which are more compatible to the value for [Expanded]. This also accounts for the fact that the low front vowel surfaces as somewhat phonetically closer to mid. This does not account for the fact, however, that this conflict does not occur in the case of the totally unspecified vowel. In addition, it is not clear why [i̬e] should diphthongize, unless, as noted earlier, it has an additional back specification in the form of a pharyngeal node. It might be noted at this point that there is something special about short and long [a] in Khmer. They occur very frequently in the language and very often in loanwords. A final syllable containing short [a] checked by a glottal stop is often subject to deletion and when in an initial syllable, short [a] often occurs variably as [ɒ]. This propensity to become the unspecified vowel coincides with the explanation that /a:/ and /a/ are specified for, at most, one feature and therefore have less to lose.

There are two vocalic nuclei that have not yet been dealt with. These are [ay/èy] and [aʊ/i̬ʊ]. As argued in Chapter Three, syllable structure constraints indicate that these are not vowel sequences but, in fact, sequences of vowel plus consonant. Therefore in these cases, an alternation between [a/è] and [a/i̬] takes place depending on the following consonant. The vowel is considered to belong to the short set for two reasons. In the first place, there is undoubtedly some interference taking place in the quality of the vowel as a result of the following consonant. As noted above, this is a common feature of the short vowel set. In addition, the above long diphthongs contrast with long vowels preceding a glide as is shown in (21).

(21)	[ca:ʊ]	'to break even'(H178)	[caʊ]	'grandchild'(H190)
	[ca:y]	'spend'(J42)	[cay]	'louse'(J45)
	[cì̬eʊ]	'to buy, to deal'(H243)	[cì̬ʊ]	'incompletely threshed rice'(H255)
	[cì̬ey]	'end part'(J56)	[kèy]	'embezzle'(H130)

Probably the same alternation is going on here as the one involving the short expanded register low vowel elsewhere. Where we would expect to get [èaʊ][12] and [òay], [i̬ʊ] and [èy] appear since neither [èa] nor [òa] occur prior to [y] and [w]. Some kind of phonetic adjustment is taking place which either fuses the short diphthong or prevents diphthongization prior to a glide. As previously noted, there are definitely cooccurrence restrictions operating with relation to the vocalic nuclei and glides. Interactions between

[12]In fact, it is unclear what to expect here. Recall that with nasal assimilation, /ʊ/ is a member of the back class of consonants triggering a velar place of articulation.

vowels and glides, as discussed above, may account for the fact that this vowel alternates differently before glides than in other environments.

The fact that the co-occurrence restrictions noted above for vowels and consonants occur across registers shows that, although the phonetic pressures behind the co-occurrence restrictions proposed by Archangeli and Pulleyblank (in prep) are in force for Khmer speakers, giving rise to diphthongization, these are phonetic rather than phonological adjustments. If these were phonologically active, it would be expected that the cooccurrence conditions might serve to change underlying values and therefore we would find restrictions that hold in one register and not the other. This gives Khmer a very marked status in that it appears that none of these conditions are phonologically active. However, diphthongization in the predicted direction also supports the hypothesis that register is very closely related, if only physically, to [ATR].

It remains to determine the distinctive values of register. Under the assumptions of a theory of radical underspecification, only one value for a feature is underlyingly specified, with the other value inserted by default. Generally, the underlying value is that which is shown to participate in cooccurrence restrictions, or to actively spread in rules such as assimilation or vowel harmony. A look at register harmony in Khmer is required to decide the underlying value for register in Khmer.

5.3 Vowel Harmony

5.3.1 Constricted Register Harmony

Register is a distinctive property of Khmer syllables and is generally not predictable except within the domain of a restricted disyllable where vowel harmony takes place. Vowel harmony in Khmer can be illustrated using the reciprocal prefix /prɒ – prɔ/.

(22) (a) Constricted Register Bases

[prɒʔaop]	'embrace each other'(H593)	[ʔaop]	'embrace'(H1492)
[prɒcak]	'stab each other'(H567)	[cak]	'stab, pierce'(H173)
[prɒhaek]	'tear or rip each other'(H591)	[haek]	'tear apart'(H1292)
[prɒkham]	'bite one another (dogs)'(H566)	[kham]	'bite'(H94)
[prɒsaːc]	'in a scattered manner'(H589)	[saːc]	'spray'(H1115)
[prɒtɒp]	'hit or pound each other'(H573)	[tɒp]	'box'(H314)
[prɒɓiət]	'press in tightly'(H580)	[ɓiət]	'put side by side'(H546)

(b) Expanded Register Bases - Obstruent Initial

[prɒcrùəh]	'bypassing each other'(H570)	[crùəh]	'exceed'(H262)
[prɒcùm]	'assemble, gather'(H570)	[cùm]	'gather around'(H255)
[prɒkɔ̀ŋ]	'pile up (many things)'(H566)	[kɔ̀ŋ]	'put on top of '(H115)
[prɒpùm]	'gather, assemble'(H580)	[pùm]	'crowd together'(H659)
[prɒtɔ̀əŋ]	'pull from both sides'(H577)	[tɔ̀əŋ]	'pull back and forth' (H363)

(c) Expanded Register Bases - Sonorant Initial

[prɒɲap]	'be in a hurry'(H570)	[ɲòap]	'hurriedly'(H274)
[prɒʋaːy]	'hit each other '(H587)	[ʋìey~ʋay]	'beat'(H982)
[prɒʋaeŋ]	'length'(H588)	[ʋèŋ]	'long, tall'(H1029)
[prɒmoːl]	'gather, assemble'(H584)	[mùːl]	'get together'(H755)
[prɒmaəl]	'survey'(H584)	[məːl]	'observe, look at'(H759)
[prɒloːk]	'get into a fight'(H586)	[lùːk]	'to extend a hand'(H927)
[prɒlaeŋ]	'to play (children)'(H587)	[lèŋ]	'to play'(H934)

As can be seen in the examples in (22a) and (22b), the reciprocal is straightforwardly prefixed onto a base word. However, when the initial consonant of the base word is a sonorant and the word is expanded register as in (22c), the vowel of the base word undergoes a change. In every case, the base vowel changes from [+Expanded] to [–Expanded].

In all examples but two found in any reference, the spreading of [–Expanded] is from left to right with the reciprocal prefix appearing in its citation form, with a [–Expanded] vowel. Huffman (1967) lists two examples which also appear in Headley et al. (1977), although they are not given as derivatives there. These are shown in (23).

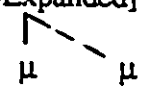
(23)	[prɔ̀n̄t]	'to encircle one another'	[n̄t]	'to bind tightly'
	[prɔ̀rùət]	'to embrace'	[rùət]	'to squeeze' (Huffman 1967:78)

The examples in (23) illustrate one of the main problems in dealing with Khmer. Due to the derivational nature of the morphology, it is often difficult, if not impossible, to be assured that counterexamples such as those in (23) are, in fact, counterexamples. It should be noted that there are no instances in the data, other than the cases cited in (23), of the reciprocal prefix being added to words beginning with /r/. If indeed this is the reciprocal prefix, it may be that the appearance of a [+Expanded] vowel in this context is related to /r/ rather

than to a rule of vowel harmony. The relationship of /r/ to the feature [+Expanded] will be discussed shortly.

Disregarding the examples in (23), the harmony process taking place in (22) can be formalized as follows. The feature [–Expanded] is underlyingly associated to the mora of the reciprocal prefix and spreads from left to right within the domain of the foot. This could be either an iterative or non-iterative spreading rule but since, as argued in Chapter Three, the word in Khmer is never more than two syllables long, there is no way to check this. As the examples in (22b) and (25b) show, the association and spreading of [–Expanded] is blocked by an intervening obstruent while an intervening sonorant is transparent to the harmony.

(24) [–Expanded]



:where an intervening sonorant (including h) is transparent to the rule and an intervening obstruent is opaque.[13]

In the examples in (25), where a causative prefix /p-/ is attached to a base form, there is no evidence at all of an underlying vowel in the prefix to which the register feature might be underlyingly attached.

(25) (a) Constricted Register Stems

[ca:l]	'to avoid repeating'(H177)	[pca:l]	'to deter from repeating' (H614)
[ʔaem]	'sweet'(H1436)	[pʔaem]	'sweet'(H626)

(b) Expanded Register Stems — beginning with an obstruent

[kòap]	'right, satisfied'(H123)	[pkòap]	'to satisfy'(H613)
[tùp]	'to stop, block'(H370)	[ptùp]	'to converge on'(H618)
[còap]	'to be attached'(H241)	[pcòap]	'to link together'(H701)

(c) Expanded Register Stems — beginning with a sonorant

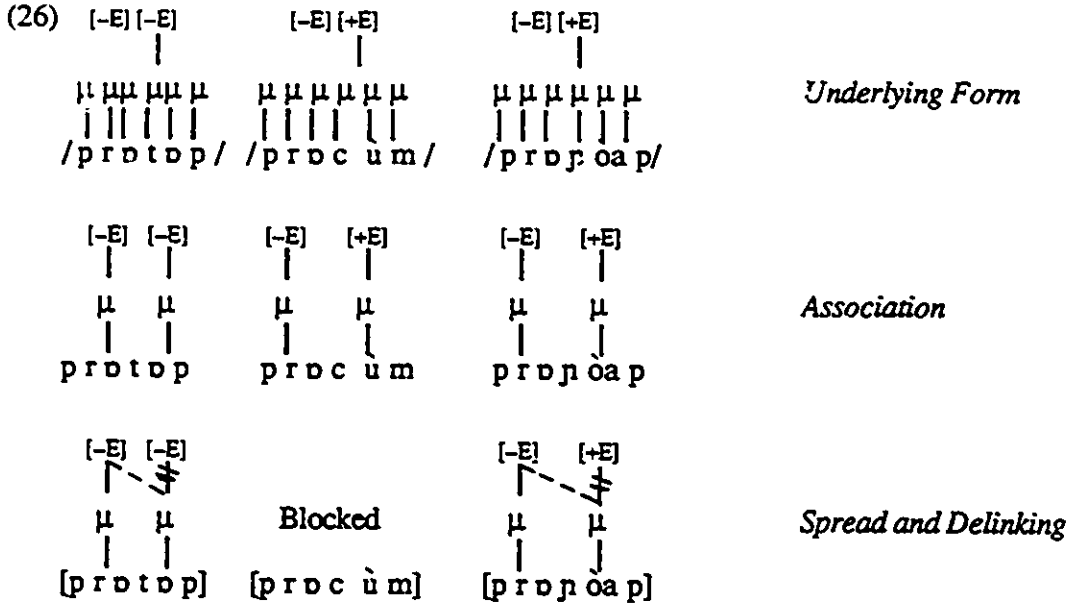
[rè:]	'turn frequently'(H884)	[prae]	'to turn'(H600)
[rìey]	'to scatter'(H864)	[pra:y]	'to scatter'(H595)
[ŋùːt]	'to wash oneself'(H156)	[pŋo:t]	'to bathe (someone)'(H614)

Therefore, it is more general to consider that, in both these cases, [–Expanded] is a floating feature of the morpheme which then spreads to the vowel. The process of [–Expanded]

[13]The representation of opaque/transparent segments will be discussed in Chapter Six.

association and spreading is shown in (26) with [–E] indicating [–Expanded] and [+E] indicating [+Expanded].

(26)



Although it was not stated, the same condition on the intervening segments holds for both association and spreading. All this indicates that [–Expanded] is the active underlying value for register in Khmer but a look at other examples shows that it is not the only active value.

5.3.2 Expanded Register Harmony

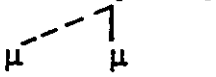
Additional properties of vowel harmony in Khmer can be discovered by a consideration of infixation. Consider the examples in (27a-e) with the -N- infix and (27f-g) with the -mn- infix.[14] When these infixes are added to a base word, if necessary, an epenthetic vowel results. This can be seen by comparing the examples in (27a) where, since no syllable structure conditions are violated, the affix merely appears following the initial consonant, to those in (27b) where infixation creates a non-allowable cluster. The epenthetic vowel takes on the existing register of the base word except in particular cases. If the base word is [+Expanded] and the epenthetic vowel is separated from it by an obstruent, as in (27d), the epenthetic vowel will not be [+Expanded], but will be [–Expanded].

[14]A partial list of derivations with the -mn- infix and a short characterization of its function can be found in Appendix III.

(27)	(a)	[knaət]	'period of waxing moon'(H100)	[kaət]	'day of waxing moon'(H42)
		[tnə̀:]	'a board or shelf'(H433)	[tə̀:]	'place on a shelf'(H400)
	(b)	[rɔnò:c]	'15 day period of the waning moon'(H817)	[rò:c]	'days of the month when moon is waning'(H889)
	(c)	[kɒŋʊa:]	'harpoon, hook'(H5)	[kʊa:]	'to catch with a hook'(H108)
		[sɒnlɒŋ]	'plug'(H1070)	[slɒŋ]	'to plug a hole'(H1263)
		[tɒŋkɒ:]	'fine weaving thread'(H312)	[tkɒ:]	'to weave'(H353)
		[tɒŋʊa:y]	'offer, offering'(H312)	[tʊa:y]	'to give, to offer'(H361)
		[cɒŋʔaə]	'grill (to cook food)'(H165)	[cʔaə]	'to grill'(H223)
	(d)	[cɒmpìem]	'any tweezer-like device'(H170)	[cpìem]	'to grasp with fingers'(H219)
		[sɒntù:c]	'fishing pole'(H1065)	[stù:c]	'to fish (with a pole)'(H1224)
		[kɒntɔ̀:p]	'belt'(H15)	[ktɔ̀:p]	'to hold together'(H97)
	(e)	[tɔ̀ənlèak]	'fall (of water)'(H369)	[tlèak]	'to fall down'(H434)
		[kɔ̀ərʊìel]	'guardian, keeper'(H116)	[kʊìel]	'to tend, to guard'(H151)
	(f)	[cɒmna:y]	'expenditure'(H192)	[ca:y]	'to spend'(H177)
		[cɒmnuəp]	'meeting'(H194)	[cuəp]	'to meet'(H248)
		[kɒmnao]	'person with a shaved head'(H50)	[kao]	'to shave'(H47)
		[ɗɒmnaol]	'action of poling (a boat)'(H298)	[ɗaol]	'to push, pole a boat'(H295)
		[ʔɒmna:c]	'power, authority'(H1438)	[ʔa:c]	'to dare to'(H1403)
	(g)	[cùmnò:]	'tide (of water)'(H257)	[cò:]	'to rise (tide)'(H255)
		[cùmnùəh]	'replacement'(H257)	[cùəh]	'to replace'(H248)
		[kùmnɔ̀:]	'pile, stack'(H133)	[kɔ̀:]	'to pile up'(H122)
		[cùmŋì:]	'disease, illness'(H230)	[chì:]	'to be sick, ill'(H266)

If the default value is [+Expanded] then, since the base form is [+Expanded] and assuming radical underspecification, the word must not carry a value for [Expanded] and its surface value must be supplied by default. Therefore, where does the [–Expanded] value that surfaces on the initial syllables in (27d) come from?

The best solution is that a second harmony rule is operating to spread [+Expanded] from right to left over the same set of transparent segments as noted with the spreading of [–Expanded].

(28) 

:where an intervening sonorant [15](including h) is transparent to the rule and an intervening obstruent is opaque.

It is also apparent from examples (27f) and (27g) that the diphthong /uɔ/ occurs as both constricted or expanded register since, in one case (27g), the presyllable contains expanded register, while in the other, it does not (27f). This would seem to contradict Huffman's (1976) claim that register is not phonologically distinctive in Khmer and, in particular, that this diphthong does not alternate for register since register plays a phonological role here.

The infix /-m-/ can also illustrate this second harmony rule in Khmer. Generally, this infix is considered to be non-productive but there are a great many examples of words derived, if only historically, with this affix and it seems apparent that vowel harmony is operating here.[16] In general, as shown by (29c), if expanded register cannot spread to the initial syllable, the constricted register is inserted. This implies that expanded register or [+Expanded] is underlyingly marked and that [–Expanded] is inserted by default. The register of this initial syllable can also be determined, however, by the type of initial consonant as is shown by (29e). As just noted, the initial syllable in (29e) should be constricted register. This is not the case, however, because the initial consonant of the presyllable is /l/ or /r/. In that case, the register of the initial syllable is always expanded register.

(29) Constricted Register

(a)	[cɒm?eh]	'noxious smell'(H199)	[c?eh]	'bad smelling'(H224)
	[kɒmla:c]	'fearful, afraid'(H56)	[kla:c]	'to fear'(H105)
	[kɒmɗau]	'heat, to warm up'(H49)	[kɗau]	'hot'(H61)
(b)	[cɒmhot]	' precision'(H197)	[chot]	'very accurate'(H213)
	[cɒmlak]	'sculpture,'(H171)	[clak]	'to carve'(H221)
	[kɒmreɛp]	'absorption, sip'(H56)	[kreɛp]	'to sip'(H80)
	[sɒmɲat]	'to quiet down'(H1088)	[sɲat]	'silent, quiet'(H1213)

[15]The categorization of /ʊ/ as a sonorant will be discussed in section 6.1.

[16]A list of words that can be shown as derivations utilizing the /-m-/ infix is provided in Appendix II.

	Expanded Register			
(c)	[sɒmkɔ̀ːm]	'thin'(H1191)	[skɔ̀ːm]	'thin'(H1212)
	[kɒmcə̀l]	'lazy person, lazy'(H49)	[kcə̀l]	'lazy, careless'(H95)
	[kɒmpɔ̀əh]	'height'(H53)	[kpɔ̀əh]	'high, tall'(H101)
(d)	[cùmhìen]	'step, pace'(H258)	[chìen]	'to take a step'(H265)
	[cùmlə̀ːy]	'oddity'(H232)	[clə̀ːy]	'odd, dissonant'(H271)
	[cùmnèah]	'to win, victory'(H257)	[cnèah]	'to win, vanquish'(H269)
	[kùmlìen]	'hunger'(H135)	[klìen]	'to be hungry'(H150)
	[kùmrɔ̀ːp]	'cover'(H121)	[krɔ̀ːp]	'to cover (over)'(H138)
	[tùmlòap]	'habit, custom'(H372)	[tlòap]	'be accustomed to'(H435)
	[tùmrɔ̀ːm]	'weakness'(H371)	[trɔ̀ːm]	'poor,weak'(H416)
	Constricted Register			
(e)	[lùmʔɒŋ]	'powder'(H948)	[lʔɒŋ]	'fine powdery dust'(H961)
	[rùmhaok]	'to cause to wear out' (H901)	[haok]	'to be worn out' (H1293)

It is possible that any consonant-vowel effects in Khmer relating to /r/ are a result of more general sonorant-vowel relationships such as have been shown between voicing and vowels than anything specific to /r/ or /l/. This example points out a property of Khmer register in relation to consonants. Some consonants are inherently more closely associated with a particular register. As noted previously, the implosives, glottal stop and /s/ are almost exclusively associated with constricted register while all sonorants are very closely associated with expanded register. Some consonants exert an effect on what value of [Expanded] may be inserted which is independent of the marked language specific values, in particular when the unspecified vowel is involved.

5.3.3 Ambiguous Harmony

The dual operation of register in restricted disyllables comes together with the causative prefix /BVN-/ where B is either [p] or [ɓ], V is the unspecified vowel and N is a nasal homorganic to the first consonant of the base word. The unspecified vowel contained in the prefix will generally be the same register as that in the base word. As can be seen in the examples in (30a), if the base word contains a constricted register vowel, the prefix will also contain a constricted register vowel. In (30b), notice that if the main syllable contains a expanded register vowel, the prefix will contain a expanded register vowel.The laryngeal features of the initial consonant are also interacting with harmony but only under certain restricted conditions. This is illustrated by the examples in (30c).

(30) Constricted Register Bases

(a)	[ɓɒmpah]	'cause to touch'(H555)	[pah]	'meet, touch'(H561)
	[ɓɒŋʔaon]	'bend sthg down'(H472)	[ʔaon]	'bend over'(H1492)
	[ɓɒŋhɒ:k]	'cause a relapse'(H468)	[hɒ:k]	'relapse'(H1276)
	[ɓɒnsaok]	'make miserable'(J106)	[saok]	'mourn'(J202)
	[ɓɒɲcam]	'pawn'(H477)	[cam]	'guard (keep)'(H199)
	[ɓɒnlɒp]	'confuse'(H496)	[lɒp]	'confused'(H1297)

Expanded Register

(b)	[pɔ̀ənlù:c]	'cause sthg to emerge'(H632)	[lù:c]	'stick out'(H927)
	[pɔ̀əŋrì:ŋ]	'cause to dry up'(H628)	[rì:ŋ]	'drying up'(H869)
	[pɔ̀əŋʊɔ̀ək]	'confuse'(J131)	[ʊɔ̀ək]	'confused'(J131)
	[pɔ̀ənyùl]	'cause to droop'(H631)	[yùl]	'drooping'(H786)
(c)	[ɓɒmphìt]	'scare'(H559)	[phìt]	'afraid'(H694)
	[ɓɒŋkàc]	'evade'(H466)	[kàc]	'avoid'(H130)
	[ɓɒnsì:]	'cause to eat'(H499)	[sì:]	'eat'(H1142)
	[ɓɒntɔ̀ən]	'soften'(H494)	[tɔ̀ən]	'soft, tender'(H368)
	[ɓɒɲchùp]	'cause to stop'(H481)	[chùp]	'stop'(H265)
(d)	[ɓɒŋʊaeŋ]	'make longer'(H467)	[ʊɛ̀ŋ]	'long, tall'(H1029)
	[ɓɒŋʊəl]	'force to turn round'(J100)	[ʊ̀l]	'turn round'(J180)
	[ɓɒnlaeŋ]	'play, amuse'(J105)	[lèŋ]	'amuse oneself'(J173)
	[ɓɒnlə:]	'echo'(H498)	[lì:]	'hear'(H1484)
	[ɓɒŋɟiən]	'teach'(H467)	[rìən]	'learn'(H882)

Register harmony depends on the segment intervening between the two syllables. If the intervening segment is one of the class of segments including [p, t, c, k, ʔ, ɛ, ɗ or s], then the first syllable is constricted register, and the second syllable is expanded register. In (30c) the expanded register is prevented from appearing on the presyllable by the presence of this class of segments intervening between syllables. The examples in (30d) reveal another possibility for register. In a few examples involving [ʊ] and [l], the prefix takes on constricted register and the base word matches it. Both [+Expanded] and [–Expanded] harmony are occurring with respect to what is ostensibly the same affix. Assuming radical underspecification, only one value for register should be able to be marked distinctively on Khmer words.

At this point the possibilities allowed by assuming radical underspecification can be reviewed assuming either constricted or expanded register as marked. The examples in (22)

and (25) indicate that constricted register could be the marked value. Under that assumption, there are several ways that the words in (30a) might be represented. In the first place, register could be a distinctive feature of the prefix which spreads to the base word. The examples in (30d) appear to support this. The causative prefix is underlyingly specified as constricted register and register spread takes place from left to right. In the case of the examples in (30c) the rightward spread of register is blocked by the intervening obstruent. In the case of the examples in (30a), the base word is also underlyingly constricted register so naturally both prefix and base surface as constricted register regardless of the intervening consonant. The derivation is shown in (31). The best argument against this analysis comes from the examples in (30b). If the prefix is underlyingly constricted register there is no clear reason why both syllables of these words should not surface as [–Expanded] as in the examples in (30d). Instead, they both are [+Expanded].

(31)

[–E]	[–E]	[–E]	*Underlying Representation*
/ɓɒnlɒp/	/ɓɒŋkàc/	/ɓɒnlaeŋ/	
[–E]	Blocked	[–E]	*Register Spread*
[ɓɒnlɒp]		[ɓɒnlàeŋ]	

The second way that register might be represented is that [–Expanded] is associated to the vowel of the base word which spreads leftward to the vowel of the prefix. In the case of the examples in (30b), since there is no register marked on the base word, the prefix vowel becomes [+Expanded] by default. This is shown in (32).

(32)

[–E]		*Underlying Representation*
/ɓɒnlɒp/	/pɔ̀ənyùl/	
[–E]		*Register Spread*
ɓɒnlɒp	pɔ̀ənyùl	
[–E] [+E]		*Default Insertion*
[ɓɒnlɒp]	[pɔ̀ənyùl]	

However, this does not account for the examples in (30c). Under this analysis, the vowel of the prefix in (30c) should surface as [+Expanded] but that is not the case. It is

[–Expanded]. In addition, there is no explanation as to why the base words in (30d) should surface as [+Expanded] when unsuffixed.

Finally, it is possible that [–Expanded] is a floating feature of the word which associates from left to right. However, this does not explain why the examples in (30c) and (30d) surface as [–Expanded] since the base form of the word is [+Expanded] and therefore arguably no feature exists underlyingly to associate. Changing the direction of association does not help. Assume for a moment that there is a prohibition on the association of [–Expanded] immediately to the right of a sonorant. The examples in (30b), containing no underlying value of [–Expanded], surface as [+Expanded] [+Expanded]. The examples in (30d) have an underlying value of [–Expanded] and therefore surface as [–Expanded] [–Expanded]. The base forms in (30d) surface as [+Expanded] due to a prohibition on associating the floating value of [–Expanded] adjacent to a sonorant. The spreading rule has no such prohibition. However, this does not explain the examples in (30c). If the appearance of [–Expanded] on the prefix is a result of the underlying value of the base word, it is unclear why the base word surfaces as [+Expanded] since there is no apparent restriction on [–Expanded] next to an obstruent. It appears that [–Expanded] as an underlying form does not account for the data.

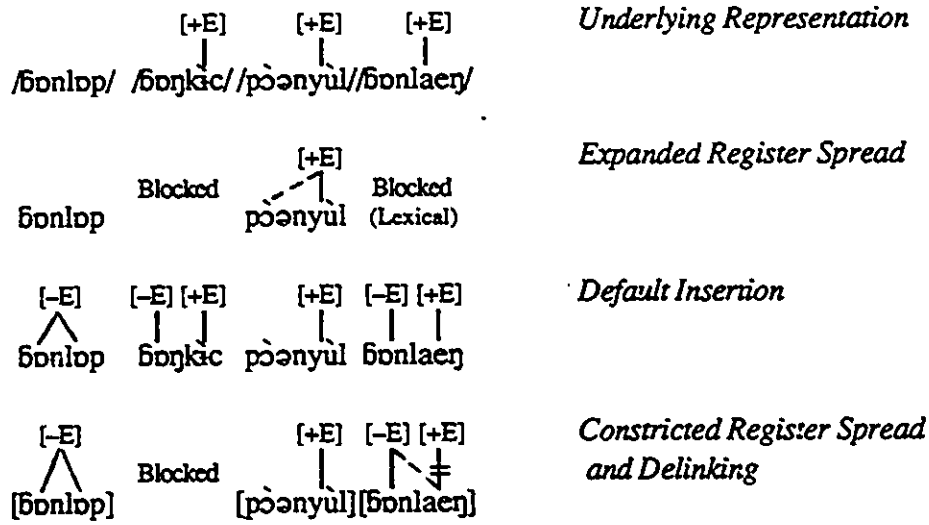
An alternative possibility is that [+Expanded] is the marked feature and [–Expanded] is filled in by default. Indeed, constricted register is often referred to as "normal" while expanded register is termed "abnormal" (Gregerson 1976). In addition, as noted above, the other marked features of the language are most compatible with the value [+Expanded]. This would indicate that the vowel system is stable in underlying form and only undergoes conflicts after the assignment of default values. Assuming that [+Expanded] is the marked value, the above representational possiblities can be reassessed.

First note that, as with the previous discussion of [–Expanded] as the marked feature, [+Expanded] cannot be a feature of the causative prefix as is evidenced by the examples in (30a). If [+Expanded] was a feature of the prefix, it should surface somewhere on the word. Secondly, consider the possibility that [+Expanded] may be a distinctive feature of the vowel of the base word. Register harmony then involves the spreading of [+Expanded] from right to left across an intervening transparent segment. An intervening obstruent blocks the harmony. This explanation accounts for all examples except those in (30d).

Making [+Expanded] a floating feature of the minimal word offers no benefits. Since there are opaque and transparent segments, a rule of spreading is still required and there is still

no explanation for why the examples in (30d) surface as entirely [–Expanded]. A derivation is shown in (33). The example from (30d) shows that, for some reason, the spread of expanded register harmony is blocked in just these cases.

(33)



One fact which may bear on the above problem is the number of examples. There are a total of two hundred and seventy-two words formed with the causative prefix in the data (Headley et al. 1977). Of those, there are forty-two examples of words with the pattern in (30b), or 18%, and only five, or 2%, with the pattern in (30d). Therefore, the blocking of expanded register harmony may be a lexical feature of these specific words. There is also a possibility that the different patterns may hinge on differences between the intervening consonant. In the case of (30d), all the intervening consonants are either /l/ or /ʊ/. In fact, there is only one instance of /ʊ/ occurring in a word of the pattern in (30b). A difference in the classes of transparent and opaque segments suggests again that there are two kinds of harmony here. In one case, [–Expanded] spreads from left to right across an intervening transparent segment, while in the other, [+Expanded] spreads from right to left.

A possibility that is suggested by this data and that would go along with radical underspecification is that there are two complementary features operating at the same time. One feature corresponds to [±constricted pharynx] while the other is [±expanded pharynx]. In fact, Perkell (1971) describes [+constricted pharynx] as a feature articulated with the pharyngeal constrictors in the throat while [expanded] involves the genioglossus. However, if this were true, at least one more class of words in Khmer is expected since one class should be [Expanded], one [Constricted] and the other neutral. So far as can be ascertained, this is not the case. All words in Khmer are either constricted or expanded

register. Alternatively, there may be only one feature operating in Khmer but it is not underspecified. In other words, all words are underlyingly specified as either constricted or expanded register.

A solution depending on levels of representation may also be indicated. As a result of the sur. .y above, the best solution that can be offered at this time is that underlyingly [+Expanded] is the marked feature. Words in Khmer are either specified as [+Expanded] or are unspecified. Less productive affixes are subject to expanded register harmony. As noted above, some exceptions occur as in the case of those examples in (30d). Later in the derivation, some affixes, lexically specified as [–Expanded], occur. Where this happens, constricted register harmony takes place. There is one major problem with this explanation. If these two kind of harmonies are a result of different levels of the grammar, then how can the same affix be in two different levels. This is partially explained by the fact that the causative is apparently a somewhat schizophrenic affix. Jenner and Pou (1982) assert that although all examples of the causative affix look the same, they may be derived differently. Older formations were apparently a result of -N- infixation. They hypothesize that the general productivity of this affix is a result of a newer secondary prefix /ɓVN-/ being introduced into the language which is analogically derived from the previous one. If that is true, then the apparent confusion between levels here may actually be a result of confusion between two different affixes.

Whichever value of register is determined to be basic in Khmer, two things are apparent. In the first place, since the harmonic processes involved with both values are subject to roughly the same sets of transparent and opaque segments, they are undoubtedly either two values of the same feature or at least subject to the same feature dependency relations. It also seems likely that, since the set of opaque segments are obstruents as opposed to sonorants, a laryngeal relation is indicated. In the next chapter, the characterization of register will be related to the specifications of these two classes of consonants. In particular, several feature geometry theories will be looked at for their specific capability to handle this problem in Khmer.

Chapter Six
The Specification of Register

6.0 Introduction

In the previous two chapters, it has been claimed that register is a feature realized on vowels but licensed by morae. In this chapter, the precise specification of register will be discussed with particular reference to how it figures in the universal hierarchy of features. It will be argued that Khmer register, despite its phonetic resemblance to the place of articulation feature [ATR], is phonologically a laryngeal feature. While such considerations as the shape of the vocal tract and intermuscular connections may be relevant to a universal feature hierarchy, it is the phonological considerations which are important. The fact that one feature can be a result of a complex of articulatory mechanisms indicates that it may not always be clear how that feature may interact phonologically and where it should be represented on a feature hierarchy. Alternatively, register, although phonetically similar to [ATR] may, in fact, be the manifestation of an entirely different feature.

6.1 Transparent and Opaque Classes of Consonants

There are two classes of consonants that must be represented in Khmer. These are the class of consonants that are opaque to register spreading, and the class of consonants that are transparent to register spreading. The organization of Khmer consonants into the corresponding classes is illustrated by the examples in (1) and (2). The examples in (1) show the class of opaque and transparent segments in the right-to-left rule of expanded register spreading.

(1) Transparent and Opaque Segments in right to left Expanded Register Harmony

(a) Opaque segments

/p/	[kɔmpùəh]	'height'(J5)	[kpùəh]	'high'(J27)
/t/	[kɔmt̀ɔc]	'crush to bits'(J5)	[kht̀ɔc]	'in small bits'(J26)
/c/	[kɔmcàl]	'lazy'(J5)	[kcàl]	'lazy, unwilling'(J25)
/k/	[ɓɑŋkrùp]	'make complete'(H466)	[krùp]	'complete'(H138)
/s/	[ɓɑnsì:]	'to cause to eat'(H499)	[sì:]	'to eat'(H1142)[1]

[1]This is the only example of /s/ as an opaque segment. There are no examples of /s/ as transparent. In the large majority of cases, a word beginning with /s/ is first register. In fact, Jenner (1969) reported that in his data, out of forty primary base words, only 2 or 5% are second register. Therefore, there are very few instances where the environment for vowel harmony could occur. Since the one example found in this data gives /s/ as opaque, it is included here. Note that while /h/ is also primarily associated with first register (only 15% of the primary words beginning with /h/ are second register, there are no instances where /h/ is opaque. All examples involving /h/ show it to be transparent.

(b) Transparent segments

/h/	[cùmhìen]	'step'(J59)	[chìen]	'take a step'(J61)
/l/	[cùmlɔ̀əh]	'quarrel'(J55)	[chlɔ̀əh]	'quarrel'(J62)
/r/	[cùmrùh]	'shed'(J54)	[crùh]	'fall off, be shed'(J60)
/y/	[pɔ̀ənyì:n]	'to delay'(H631)	[yì:n]	'taking a long time'(H784)
/ʊ/	[pɔ̀əŋʊɔ̀ək]	'confuse'(J131)	[ʊɔ̀ək]	'confused'(J131)
/m, ŋ, n/	[cùmnò:]	'flood'(J58)	[cò:]	'flood, flow'(J58)
/ɲ/	[pɔ̀əɲɲeak]	'to stun, stupefy'(H629)	[ɲɲèak]	'to be startled'(H702)

In the case of the rule spreading [+Expanded] from right to left, obstruents are clearly characteristic of the opaque segments while transparent segments are sonorants. Some comments need to be made on the examples in (1). In the first place, the examples were chosen to show all possible intervening elements in the data. Since expanded register harmony is initiated from the vowel of the base word and base words beginning with implosives and glottal stops are almost never expanded register, it follows that examples of expanded register harmony involving an intervening implosive or glottal stop should be rare. In fact, there were none. Therefore, there is no clear evidence one way or another as to what effect an implosive or glottal stop would have on the spreading of register. Given that some kind of cooccurrence restriction appears to be at work with respect to implosives and glottal stops with respect to register, it seems likely that these segments are distinctively specified with either the same feature or a feature closely related to that involved with register and therefore, given the theory of harmony processes assumed here (Cole 1987 and others), it is predicted that a blocking effect would occur.

As for the examples involving transparent elements, it should be noted that, except in the case of the infix -mn-, examples involving nasals are rare. Since an examination of cluster occurrences in Table 4 in Chapter Four shows that all four nasals occur fairly frequently in second position, this is probably due to the fact that almost all clusters are a result of affixation. Most likely, nasals appearing in second position are largely a result of infixation and further nasal infixation cannot take place to produce the epenthetic vowels that serve as targets for the rule. Of the other transparent segments, all occur relatively frequently with the exception of /ʊ/ for which the word in (1b) is the only example of its transparency in this rule.[2] The properties of /ʊ/ with regard to register harmony will be further discussed after an examination of the transparent/opaque segments involved in the constricted register harmony rule.

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[2]This word was not cited by Headley et al. (1977).

Examples illustrating the transparent/opaque classes of segments in the constricted register harmony rule are shown in (2).

(2) Transparent and Opaque segments in left-to-right Constricted Register Harmony

(a) Opaque Segments

/p/	[prɑpù:n]	'to gather, assemble'(H580)	[pù:n]	'to crowd together'(H659)
/t/	[prɑtɔ̀ɔŋ]	'pull from both sides'(H577)	[tɔ̀ɔŋ]	'pull back and forth'(H363)
/c/	[prɑcùm]	'to assemble, gather'(H570)	[cùm]	'to gather around'(H255)
/k/	[prɑkɔ̀:ŋ]	'to pile up'(H566)	[kɔ̀:ŋ]	'to put on top of'(H115)

(b) Transparent Segments

/l/	[prɒlaom]	'to convince'(H587)	[lò:m]	'cajole'(J174)
/y/	[prɒyaol]	'plumbline'(H586)	[yò:l]	'to oscillate'(H791)
/ʊ/	[prɑʊaeŋ]	'length'(H588)	[ʊɛ̀:ŋ]	'long, tall'(H1029)
/ɲ/	[prɑɲap]	'to press s.o. to hurry'(H570)	[ɲòap]	'hurriedly'(H274)
/m/	[prɒmo:l]	'to gather together'(J121)	[mù:l]	'to get together'(H755)

As in expanded register harmony, the class of obstruents act as opaque to harmony while sonorants are transparent. Unlike the expanded register harmony rule, there are many examples of /ʊ/ acting as a transparent element in constricted register harmony. Only one is illustrated here although more were seen in Chapter Five.

At this point, a discussion of the glides, which comprise /ʊ/ and /y/ (and possibly /h/), is warranted. In the last chapter, it was suggested that, in a few exceptional cases, expanded register harmony is lexically blocked. Later on in the derivation, those presyllables not filled in by expanded register spread are filled with constricted register by default. Morphemes specified for constricted register and these newly specified presyllables serve as the triggers for constricted register spread. As a possible alternative to lexical blocking, it might be suggested that the glides are blocking expanded register harmony but are transparent to constricted register harmony.

It should be recognized that, phonologically, /ʊ/ is somewhat of a chameleon element. Recall that, while for the purposes of cluster cooccurrence restrictions, /ʊ/ is labial, for nasal assimilation, it is dorso-pharyngeal. In the case of register, for expanded register harmony, it patterns with the obstruents, while with constricted register harmony, it acts like a sonorant. Phonetically, /ʊ/ also varies quite a bit. According to Headley et al. (1977) it is more consonantal word-initially than word-finally and in word-final position, it tends

to de-labialize. There is also a possibility that the same kind of ambiguity noted with /ʊ/ could be a property of /y/. There are very few examples of /y/ participating in any kind of harmony so it is possible that /y/ could also be ambiguous in the same way as /ʊ/.

One difficulty with this explanation is that it requires that constricted and expanded register be two different features because otherwise glides would need to be specified for register at one point and then not specified later. Also, it does not account for the fact that sometimes glides are transparent to expanded register. A final difficulty with this account of the exceptional cases of expanded register blocking is the fact that, besides /ʊ/, the most common intervening element is /l/. There is no phonological evidence that /l/ is specified for any pharyngeal expansion feature. In fact, it was indicated in Chapter Three that [l] is the result when /r/ loses its pharyngeal expansion element.

It is also unclear from the data what, exactly, is the case with regard to /h/ and constricted register harmony. In the first place, the vast majority of base words starting with /h/ are constricted register and therefore, do not reveal anything with regard to the theory advanced here. Jenner (1969) offers only one example of /h/ as transparent to constricted register harmony, shown in (3) but even this one example is not conclusive.

(3) [trɔhəŋ] 'deafening' [hìŋ] 'to be momentarily deaf' (Jenner 1969: 132)

In Headley et al. (1977) the derived form of this word is given as [trɔhiŋ] 'loud, noisy'(H418) where expanded register harmony has taken place. The indication is that /h/ would be transparent to constricted register harmony but, without clearer data, the question of constricted register harmony with respect to /h/ remains unresolved.

There is a great similarity between the two register harmony rules with regard to transparent and opaque segments. Opaque segments are all the obstruents while transparent segments are all sonorants and /h/. This is consistent with the analysis of Chomsky and Halle (1968), where /h/ was classed as a sonorant. This property of /h/ may provide an important clue to the exact nature of the sonorant/obstruent distinction in Khmer. Inconsistency does occur with respect to the rule of expanded register [+Expanded] spreading since, on a few occasions, expanded register harmony has not taken place or, in the case of the two examples involving /r/, taken place unexpectedly. Expanded register harmony probably takes place as a lexical rule during the derivation since it applies prior to default insertion. Since one property of lexical rules is that they contain exceptions, this is not necessarily a problem for the assertion that obstruents are opaque and sonorants are transparent.

Within the two larger classes of consonants which comprise the transparent and opaque segments are found the class of consonants that are predisposed to occur with constricted register along with the consonants which are commonly associated with expanded register. Those most commonly associated with constricted register are the implosives, /s/ and the glottal stop. In Jacob (1968), out of thirty one word listings beginning with [ɗ], only three, or 9% contained a sequence of [ɗ] + 2nd register vowel. In the case of [ɓ], there were no examples containing an immediately adjacent 2nd register vowel. This compares to 337 occurrences (59%) of /p/ + 2nd register out of all words beginning with /p/ and 288 out of 501 occurrences of /t/ with 2nd register (57%). In addition, in all instances where the vowel following an implosive, /s/ or a glottal stop might be argued to be epenthetic, it occurs as constricted register. With regard to expanded register, it occurs very frequently after sonorants. In fact, in the examples in (4), where constricted register should be expected by default, expanded register occurs. In all cases, the initial segment is a sonorant.

(4) [+Expanded] Default Insertion

[lùmʔaːn]	'trace'(J175)	[lʔaːn]	'leaving a trace'(J176)
[lùmhae]	'cause to be at leisure'(J171)	[lhae]	'relax'(J176)
[rùmsaːy]	'spread out, scatter'(J161)	[rɔ̀saːy]	'come untied'(H842)
[rùmdɒh]	'free'(J169)	[rɔ̀dɒh]	'freed, free from'(H806)

The only examples in the data of sonorants occurring in this position is /ɾ/ or /l/. Therefore, it is unclear whether the affinity for expanded register exhibited here is a result of some more global feature such as [sonorant] or some particular characteristic of /ɾ/ and /l/. Since, according to Jenner, the overwhelming majority of base words beginning with sonorant elements, /ʊ/, /ɾ/, /l/ and /y/, are expanded register, the inclination here is to treat the affinity for inserting expanded register next to /ɾ/ and /l/ as a general property of the transparent class of consonants rather than just /ɾ/ and /l/. Neither possibility is eliminated by the data. The different classes of consonants are summarized in (5).

(5)

Mostly Constricted Register	/ʔ/, /ɓ/, /ɗ/, /s/, /h/
Mostly Expanded Register	/ɾ/, /l/, /y/, /ʊ/, /m/, /n/, /ɲ/, /ŋ/
Ambivalent (not overwhelmingly associated with one or the other)	/p/, /t/, /c/, /k/
Opaque	/p/, /t/, /c/, /k/, /s/
Transparent	/ɾ/, /l/, /ʊ/, /y/, /h/, /m/, /n/, /ɲ/, /ŋ/

In the next section of this chapter, the specification of register will be discussed and three proposals for hierarchical feature arrangement will be assessed as to how well they account for the harmony facts of Khmer.

6.2 The Register Feature

On the basis of its phonetic implementation and historical relationship with voicing, the closest feature to the phonetic and phonological facts of register which has been proposed up to the present point is [Expanded]. There are two other independent clues for determining the correct feature specification for register as it operates in the phonological system of Khmer. The first clue has already been discussed in Chapter Five in relation to the Khmer vowel system. Khmer has at least a nine vowel system, without the complicating factor of register and how these vowels alternate along the dimension of register is an important clue to its representation. The fact that register triggers phonetic adjustments in vowel height and backness which correspond to the feature interactions proposed for [ATR] indicates that either it is [ATR] or it is articulatorily similar to it. However, up to now, there is no clear indication that [Expanded] is phonologically the same feature as [ATR] or that it must be represented in the same place on a feature hierarchy.

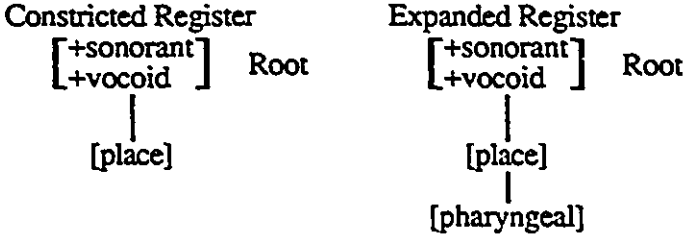
The second clue to the specification of Khmer register is found by the examination of register harmony and in particular, the sets of transparent and opaque segments. As Cole (1987) points out, opaque elements in harmony processes, particularly those which are not possible undergoers of the harmony, are best characterized as being specified for the element which is spreading. Therefore, the blocking of harmony can be seen to be merely a result of the statement in the Wellformedness Condition which forbids crossed association lines (Goldsmith 1979, 1990). In the first part of this chapter, a characterization of the Khmer vowel system will be proposed in terms of three possible feature hierarchies. One possibility is along the lines of the feature hierarchies proposed by Cole (1987), Sagey (1988), Maddieson and Ladefoged (1988) and McCarthy (1989a,b) whereby [Expanded] is a place feature. Another possibility is that it corresponds to the gesture required for spontaneous voicing and hence is associated to the spontaneous voicing node (Avery and Rice 1989b). Finally, it is possible that [Expanded] is a feature of the larynx (Kingston 1986, Yip 1990). The harmony processes of Khmer will be discussed and the predictions made by each of the above theories will be checked against consonant-vowel interaction involved in those processes. In particular the classes of transparent and opaque segments will be discussed. The special relationship of each register to subclasses of these segments

will also be discussed. Study of these two kinds of relationships, harmony and cooccurrence restrictions, will provide clues as to how Khmer register should be specified.

6.2.1 Register as a Place Feature

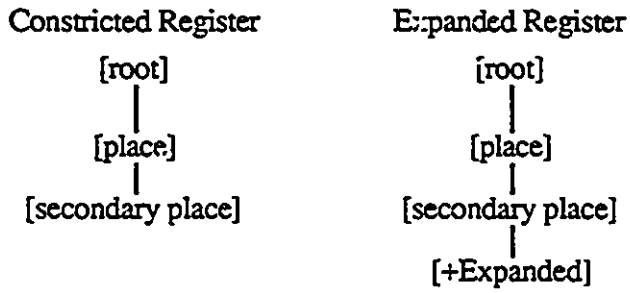
Assuming that register is a place feature, the two registers of Khmer can be represented as in (6). According to McCarthy, the implementation of the feature node [Pharyngeal] would be a language specific stipulation. In the case of Khmer, since, as argued in Chapter Five, the expanded pharynx is distinctive, [Pharyngeal] would be phonetically implemented as [+Expanded].

(6)



Individual vowels would also be represented for other place features. An alternate but related option is that proposed by Maddieson and Ladefoged (1988) and Clements (1989) whereby the vowels of Khmer would be represented as in (7). No class features need be represented at the root node since sonority features are derived from other manner and place features in Clements's hierarchy. The appearance of the secondary place node without the primary node indicates that the segment in question is a vowel.

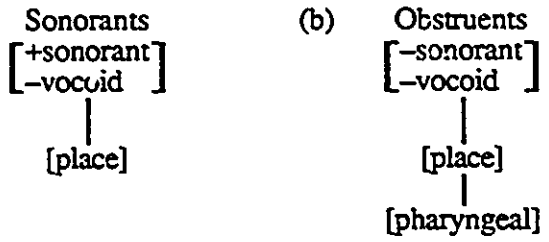
(7)



Therefore, if register is a place of articulation feature, two possible ways of representing it in current feature theory are shown in (6) and (7). McCarthy (1989a,b) and Cole (1987) predict that consonants specified for pharyngeal will interfere with harmony processes. Maddieson and Ladefoged (1988) and Clements (1989) predict that only consonants associated with this feature as a secondary articulation will do so.

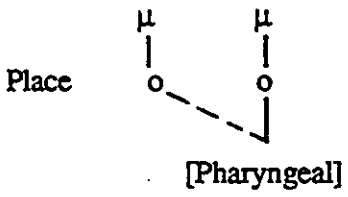
The first of these two proposals will be discussed first because it makes a stronger claim about which consonants and vowels will interact. In order to account for the fact that some consonants block the spreading of register in Khmer, it is necessary that they be specified for the feature in question. Therefore, since the sonorants are transparent to harmony, they would be specified as in (8a). Obstruents, being opaque are specified as in (8b).

(8)



While it may seem somewhat counterintuitive to specify the difference between sonorants and obstruents in terms of place features, the general idea is not completely without precedent. In fact, McCarthy (1989a) suggests that ejectives, implosives, or other classes of segments characterized by what might be considered a phonation distinction are, in fact, complex segments carrying both a more conventional place feature such as [labial] or [coronal] and a [pharyngeal] node with the further possibility of carrying [glottal] as a dependent feature for implosives. To use this analysis for Khmer would require that all obstruents, including the plain voiceless ones be specified as [pharyngeal]. The phonetic implementation of the [pharyngeal] node would need to be [–Expanded] for consonants and [+Expanded] for vowels under the assumption that one of the articulatory mechanisms of voiceless consonants involves the constriction of the pharyngeal tract to inhibit voicing and its expansion to allow it. Under this analysis, expanded register harmony might be formalized as in (9).

(9)



Recall that one property of /ʊ/ was the fact that it classes with the set of consonants termed Dorso-Pharyngeal in that they all trigger nasals to become velars. If the class of opaque consonants should be specified as [pharyngeal], then it follows that /ʊ/ and all other [pharyngeally] specified consonants should be opaque to register harmony. This is an

outside possibility with respect to expanded register harmony but is clearly not the case with constricted register harmony.

There are several other problems with this analysis. One problem, which relates to its universality, is the characterization of the distinction between sonorants and obstruents as a place feature. With the exception of McCarthy (1989a), phonatory distinctions have not been characterized as place features and even McCarthy does not try to characterize the difference between sonorants and obstruents as a place distinction. Further research into consonant systems without voicing distinctions would be required to support this analysis. Secondly, the characterization of the register feature as the monovalent feature [pharyngeal] causes problems because, as argued in Chapter Five, both values of register spread. This requires that register be a binary feature. However, assuming that register is really [ATR] suspended from [Pharyngeal], this is not a problem. Finally, in the process of nasal assimilation, nasals become velar before a set of consonants characterized here as dorso-pharyngeal. If all obstruents were specified with a pharyngeal node, then it might be expected that nasals would always become velar before obstruents. This is not the case.

It might still be possible to characterize register as a place feature utilizing the ideas of Clements (1989) whereby most obstruents would be specified as [pharyngeal] as a secondary articulation. Since expanded register harmony spreads from vowels to vowels, as is evidenced by the lack of effects on intervening consonants, it should only be blocked by consonants bearing pharyngeal as a secondary articulation. This might also provide a clue to the ambiguity of /ʊ/ with respect to place features. It would have to be specified as a pharyngeal segment primarily and possibly a labial segment secondarily.[3] Nasal assimilation would involve only consonantal features and therefore, only before those consonants with a primary pharyngeal specification would nasals become velar.

This still does not account for constricted register harmony. Since constricted and expanded register harmony involve two values of the same feature, there should still be no reason why /ʊ/ should block harmony in one direction and not in the other. In addition, it has the

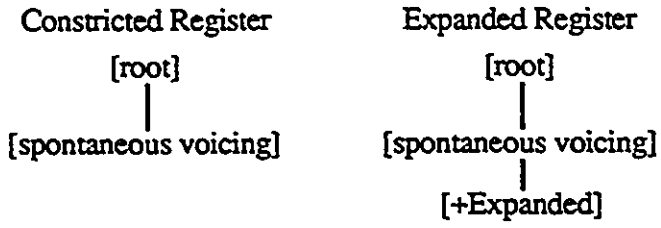
[3]The lack of restrictions between onset labial consonants and labial vowels tends to make this unlikely although this result may be an artifact of the notation for vowels. For example, current feature theory permits only two values along the front/back dimension. Additional degrees of backness are considered to be alternating for roundness as has been assumed here. Recall, though, that before a labial consonant, the unspecified vowel, which should, by default be considered round, becomes more round. This indicates that what appears to be roundness or labiality in the general system may be a further value of back. If roundness is not a distinctive value of vowels, then no cooccurrence restrictions between consonants and vowels on the basis of [round] would be expected.

counterintuitive requirement that all obstruents carry a secondary articulation as [pharyngeal].

6.2.2 Register as a Spontaneous Voicing Feature

Another possibility is that register is related to spontaneous voicing. In that case register will be specified at the spontaneous voicing node. This is shown in (10). Register harmony can be either the spread of the spontaneous voicing node or the spread of the feature [+Expanded]. If it is the spontaneous voicing node which is spreading, one would expect that obstruents, which are not specified for that node, would be transparent to harmony while sonorants would be opaque.

(10)

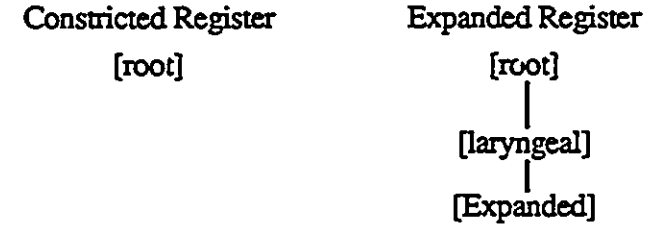


It is obvious that the facts of Khmer do not support the analysis of register as a feature corresponding to spontaneous voice. Given the two sets of consonants in Khmer, obstruents and sonorants, it is the sonorants which would be expected to carry the distinctive feature if it is spontaneous voice. If register is determined to be spontaneous voice, or some feature of spontaneous voice, then it is the sonorants which would be expected to block the spread of register. This is clearly not the case. The only way that register as a spontaneous voicing feature can work is to reanalyze assumptions about blocking segments in harmony processes. In fact, this is a feature of Avery and Rice's approach, although not one which is adopted here.

6.2.3 Register as a Laryngeal Feature

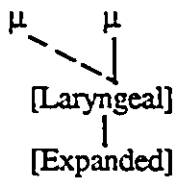
A third option, and the one that will be defended here is that [Expanded] is a feature of the larynx. Under that assumption, the vowels of Khmer are represented as in (11).

(11)



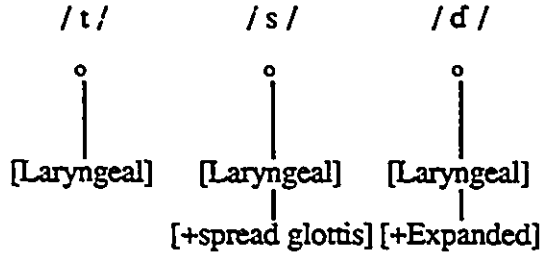
The prediction made by this final possibility is that a harmony rule spreading expanded register would be blocked only by segments specified by laryngeal features.

(12)



Under the assumption that register is a laryngeal feature, the laryngeal node of expanded register vowels spreads from right to left to an adjacent mora when affixation takes place. Obstruents are opaque to this rule since they are specified as in (13) and, in order for the laryngeal node to associate across these consonants, the no line-crossing constraint would have to be violated (Goldsmith 1979, 1990).

(13)



Given that, in most formulations of feature geometry, /h/ is a laryngeally specified segment, it would appear to pose a problem here since it is transparent to register harmony. If, however, the notation of McCarthy (1989b) is adopted whereby back consonants can all be specified under the pharyngeal node, /h/ can be specified as in (14).

(14)

Since /h/ is one of the class of segments triggering nasal assimilation to the Dorso-Pharyngeal place of articulation, this is otherwise motivated.

The problem with making /h/ a non-laryngeally specified consonant relates to the fact that word final /s/ in Khmer reduces to [h]. If [h] is specified as pharyngeal, this rule becomes

very complex. This is a highly undesirable result given that these types of rules are well-known historically (Lass 1976). The solution lies with the feature hierarchy designed by McCarthy (1989a, b) whereby articulation at the glottis can be specified as either a laryngeal or a pharyngeal feature. In word-final position in Khmer, there are actually two kinds of [h]. One kind is pharyngeally specified and the other is laryngeally specified. In order to constrain the tree, McCarthy suggests that this type of situation should not be permitted to occur within the description of one language but there is some justification for saying that two kinds of [h] occur on the surface word-finally in Khmer.

Jacob (1968) reports that in a word spelled with final /h/, the vowel must be short. Since words written with final /s/ are pronounced with a final [h], a contrast between long and short vowels before [h] occurs in the spoken language rather than a contrast of /h/ versus /s/. There are several arguments to support distinctive final consonants rather than distinctive vowels. In the first place, if all the final [h]s are considered as underlyingly /h/, then there is a gap in the distribution of /s/. Recall that /r/, /ɓ/ and /ɗ/ are also prohibited in syllable final position but, these three consonants share other distributional constraints since, as was discussed earlier, /r/, /ɓ/ or /ɗ/ also may not occur unless followed by a vowel.

However, /s/ has no such restriction so its non-occurrence in coda position must be otherwise motivated. Other than word finally, there are no restrictions on /s/. In fact, not only is /s/ perfectly free to occur as both the initial and second member of a two consonant cluster, it can also occur as the initial member of a three consonant cluster. It is more likely that /s/ in coda position is a result of some general weakening process serving to delink supralaryngeal properties leaving only the laryngeal features (c.f. Lass 1976) or, if coronal is the default place node, a constraint preventing default place specification of laryngeally specified segments in syllable final position.

Finally, both Jacobs (1968, 1974) and Huffman (1967) report that in a very careful reading style of speech, syllable final [s] will still sometimes occur since the distinction between /s/ and /h/ is available to the native speaker through the spelling system. Since native speakers can make this distinction, it is preferable that this be considered an underlying distinction between /h/ and /s/ that is neutralized word finally. Therefore, it is not necessary that both underlying /h/ and [h] from /s/ be specified identically since they are phonologically, if not phonetically, distinct.

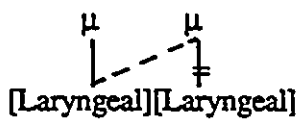
The specification of /h/ as sometimes pharyngeal is also indicated by a variable process referred to by Huffman (1967) where /ʊ/ → [h] when it occurs in second position of an initial cluster. Huffman gives one example shown in (15).

(15) /tʊəː/ → [thəː] 'to make, do' (Huffman 1967:52)

This process is simply expressed by the loss of the labial node of /ʊ/, leaving only the pharyngeal node.

The Constricted Register Harmony rule is similar to Expanded Register Harmony except for its direction and the fact that it must also involve delinking. When the laryngeal node spreads from left to right, it causes the existing laryngeal node to delink.

(16)



The above characterization accounts for the fact that obstruents are generally opaque and sonorants are generally transparent to register harmony rules.

6.3 Choosing Between the Above Three Theories

Only the specification of register as a place feature and its specification as a laryngeal feature can be considered for the representation of Khmer register. Between these two, the specification of register as a laryngeal feature is preferable since it allows a specification of consonants that is compatible with other assimilatory rules of the language without arbitrarily designating the opaque set of consonants as secondarily articulated at the pharynx. There is no evidence, phonetic or phonological that these consonants are pharyngeally specified at any other place than the glottis and the glottal specification would already be required under that analysis to account for implosives so it allows no way to distinguish plosives from implosives.

It was hoped that a closer examination of these theories would reveal that one of them can also provide a good reason why implosives pattern with constricted register and sonorants pattern with expanded register. There are two possibilities. In one case, implosives and sonorants carry some feature which then spreads onto the adjacent vowel. In the case of implosives, this would have to be [–Expanded] and in sonorants, [+Expanded]. The phonetic evidence on laryngeal lowering or pharyngeal expansion in the case of sonorants is not clear but some researchers have discovered laryngeal lowering in some cases. As for

implosives, they are most definitely not [–Expanded], since their most distinctive articulatory feature is laryngeal lowering. Another, more fertile possibility, is related to underspecification. Since implosives are distinctive, they must be specified for the feature that distinguishes them. This is [+Expanded]. In that case, a default specification for [–Expanded] on the adjacent vowel is required in order to avoid a violation of the OCP. In the case of expanded register spreading, the spread of [+Expanded] onto the vowel also causes an OCP violation and bumps the [+Expanded] specification off the implosive. However, this explanation leaves us in the dark with regards to why [+Expanded] occurs exclusively next to sonorants when harmony cannot supply the epenthetic vowel with a register specification. It should be expected that vowels adjacent to sonorants are receiving the default specification of [+Expanded] from the sonorant, but this cannot be the case if that specification is required for implosives. More research into these patterns including the entire range of possible laryngeal specifications is required to make any coherent statement. In addition, it would be nice to be a little more clear on the exact phonetic facts involved in the difference between sonorants, voiced obstruents and implosives.

6.4 The Accommodation of Register on a Laryngeal Tier

It remains to account for how a feature like [Expanded] fits in with previous theories of laryngeal features. If an existing feature can be used in its place, it would be preferable. Recall that Sagey (1986) proposed a laryngeal tier using the laryngeal features of Halle and Stevens (1971). The vowels and consonants of Khmer could be classified according to that system in Table 7.

Features	[ɓ],[ɗ],[ʔ]	[s]	[p],[t],[c],[k]	Constricted Vowels	Nasals and [r],[l],[ʋ],[h]	Expanded Vowels
constricted glottis	+	–	–	–	–	–
spread glottis	–	+	–	–	–	–
stiff vocal cords	+	+	+	+	–	–
slack vocal cords	–	–	–	–	–	–

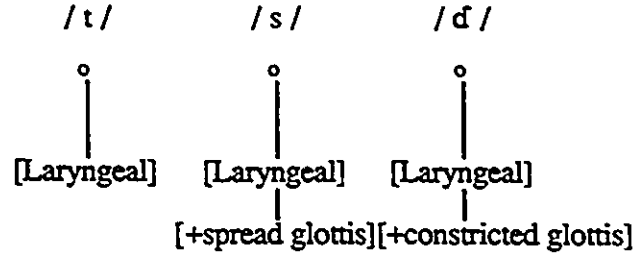
Table 7: Classification of Khmer vowel and consonant classes

Under this system, constricted register vowels pattern with consonants having the feature [stiff v.c.] while expanded register vowels pattern with all other segments. This characterization of register gives the right result but entails representing variation in larynx height as variation in vocal cord tension. This may be a result of implementation given that

the raising of the larynx does tend to tighten the vocal cords while lowering it slackens them. It may just be that in Khmer, the implementation of vocal cord stiffness is a result of laryngeal raising/lowering. This would also account for the predilection of sonorants to pattern with expanded register (lowered larynx, slack vocal cords) since sonorants also characteristically have lax vocal cords. In other words, the relevant distinction is not expansion of the larynx but, rather, vocal cord stiffness. Again, however, this does not account for implosives, /s/ and glottal stop. The only difference between plain voiceless stops and this class is glottal features. There is no clue as to why glottal features should not cooccur with vocal cord features.

Kingston (1986) suggests that the relevant difference in Khmer register is breathy versus modal phonation and characterizes the difference as [±spread glottis]. Consider a possibly distinctive representation of Khmer obstruents.

(17)



This has the advantage of accounting for register patterns in the vicinity of /s/ since it might be argued that the fact that expanded register tends not to occur next to /s/ is a result of the OCP. The difficulty with Kingston's analysis is that it does not account for the fact that implosives are so closely connected to constricted register since there is no formal reason why a laryngeal node specified as [spread glottis] should be restricted from occurring next to one specified as [constricted glottis]. Another possibility using the features of Halle and Stevens (1971), since constricted register vowels are characterized as "creaky", is that the opposition is between [+constricted glottis] vowels and [–constricted glottis] vowels. This allows both implosives and glottal stops to naturally pattern with constricted register vowels but it does not account for the predilection for /s/ and constricted register.

In Halle and Stevens's (1971) formulation, the four laryngeal features are supposed to be able to combine together to form a wide variety of phonation types, voicing and tone. Voicing is represented as slack vocal cords along with low tone. In more recent versions of the feature tree, tone has appeared on its own tier directly associated to the mora tier and somewhat independent of other features including laryngeal ones. Since, without the

necessity of specifying tone, [stiff] and [slack] are only required to represent voicing, more recent proposals have replaced these two features with the binary feature of [voice] (Clements 1985).

Kingston (1986), in an attempt to conserve tone on a laryngeal tier, includes all four of Halle and Stevens's (1971) original features and adds [voice]. The addition of [voice] to these original features is to allow the representation of the type of tone splits, attested to have occurred in Tai languages, for which Halle and Stevens (1971) could not account (Gandour 1975). Kingston (1986) also proposes that both consonants and vowels are specified for tonal and non-tonal features.

A consonant tree is shown in Figure 9: (a) while a vowel tree appears in Figure 9: (b).

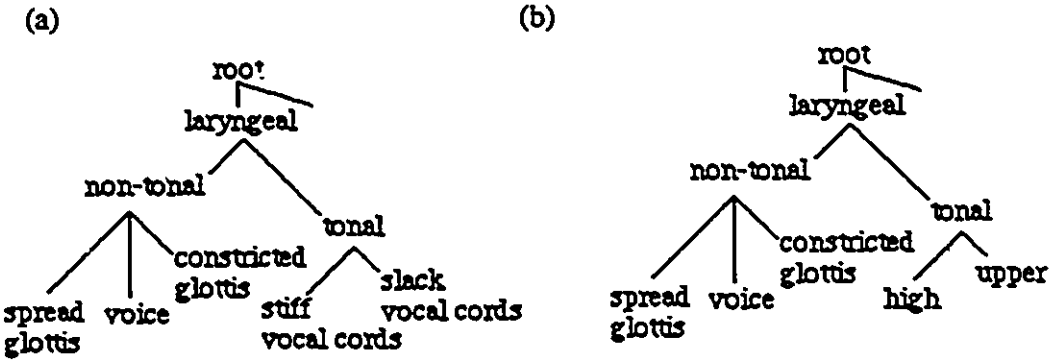


Figure 9: Consonant (a) and Vowel (b) Feature Hierarchies proposed by Kingston (1986)

Kingston characterizes consonantal effects on tone as the spreading of tonal node features from the consonant to the vowel. Since consonant tone features are different from vowel tone features, they must undergo a sort of transformation when they reach the vowel. For example, [+slack] spreading onto the tonal node of a vowel yields [–upper]. A possible modification to the above system which would account for the register harmony in Khmer is to claim that [voice] is not a relevant feature for vowels. In its place would be [Expanded]. If [+Voice] spreads to a following vowel, it appears on the vowel as [+Expanded].

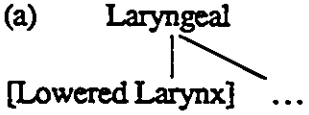
The problem with the feature specifications on the trees in Figure 9 is that it is not clear what is being gained. Feature cooccurrence constraints do not necessarily need to be expressed through feature geometry. For example, Kingston himself argues that, in Khmer, the feature corresponding to expanded register is [+spread glottis] and that the

correlation between high vowels and expanded register and low vowels and constricted register can be expressed by redundancy rules.[4] It is not clear why this same kind of accommodation cannot be made for those occasions where tone and consonants interact. Since Khmer does not have tone, and the vowel features are only phonetically important, it does not pose a serious problem for the universality of the feature tree with respect to tone. Register is a laryngeal feature and interacts only with laryngeal features with regards to harmony.

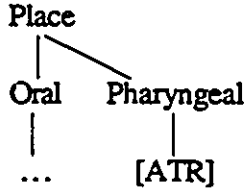
Yip (1990) notes that [murmur], found in many Southeast Asian languages, shows interdependencies with both the tonal and the laryngeal node. In Shanghai, for example, she argues that [murmur] must be a laryngeal feature since it induces voicing of the obstruent preceding it in a syllable, but that it also must be a tonal feature since it deletes along with the tone in a rule deleting all but the initial tone in polysyllabic words. In Tibetan, she argues that the opposite occurs whereby, when laryngeal features are deleted, [murmur] deletes. In order to account for this, Yip argues that [murmur] is universally required to be dependent on both the laryngeal and the tonal tier to be realized. Although Yip does not give an explicit phonetic description of this feature, it sounds very much like register. If that is the case, Khmer would appear to pose a problem for an analysis requiring the universal double dependency of [murmur] on a laryngeal tier and a tonal tier since there is no tonal tier in Khmer.

A final possibility is that none of the above proposals is tenable and that a new feature, or, at least a new feature definition, is required under the laryngeal node. This feature may be described as [± Lowered Larynx] (Denning 1989, Trigo 1991), although it may actually best correspond to [Voice], and can be defined as the extension or expansion of the pharyngeal tract by means of the raising or lowering of the larynx. Unlike [ATR], which has a similar acoustic effect and is depended from the Place Tier as in (18b), [Lowered Larynx] depends from the laryngeal tier as in (18a).

(18) (a)



(b)



[4]In fact, as has been stated previously, register in Khmer, although acoustically significant as far as vowel height is concerned, is not phonologically significant.

Bor Dinka (Hall et al. 1982 cited in Denning 1989) may provide evidence for the requirement for these two independent features. In Bor Dinka there are four separate series of vowels described as "hollow", "breathy", "normal" and "harsh". According to Denning (1989), "breathy" versus "normal" voice is implemented by advancement and retraction of the tongue root. To implement the "hollow" voice, the larynx is "dramatically" lowered while with the "harsh" voice, it is retracted. With a feature such as [Lowered Larynx] (Henceforth [LL]), these four sets of vowels can be distinguished as in (19).

(19)

"Hollow"	"Breathy"	"Normal"	"Harsh"
[+ATR, +L L]	[+ATR, –L L]	[–ATR, +L L]	[–ATR, –L L]

While in some languages like Coeur d'Alene, the feature [ATR] is active, as revealed by place of articulation interaction in harmony rules, in other languages such as Khmer, only the feature [lowered larynx] is operating. This is shown by the fact that it is laryngeal features which interact with Khmer register.

In this chapter, it has been argued that [Expanded] is a laryngeal feature in Khmer and some previous proposals for the laryngeal representation of register have been reviewed. Since the register is characterized by pharyngeal expansion, a feature which is representative of this is preferred. None of the previous proposals utilize such a feature. The only other available feature in current use which matches this phonetic description is [ATR]. The central question is whether or not the laryngeal articulation of pharyngeal expansion needs to be phonologically invoked independently of [ATR]. I suggest that if pharyngeal expansion is operating in different ways in different languages, it needs to be two features.

Chapter Seven
Conclusion

By examining phonetic and phonological properties associated with Khmer register, this thesis has investigated the hypothesis that register is a laryngeal feature. These properties have been found to support this in two ways. In the first place, all the acoustic properties of Khmer register can be accounted for by laryngeal height. In the second place, interactions between laryngeally specified segments and Khmer register harmony argue for a laryngeal solution. From this, it has been concluded that register is a laryngeal feature.

7.1 Phonetics

An examination of the phonetic literature revealed that the manipulation of laryngeal height can have a wide range of acoustic consequences. These consequences include pitch variation, phonation differences and vowel height/tenseness variation. Remarkably, all these acoustic properties have been associated with Khmer register. Unfortunately, due to the fact that there is still very little that is uncontroversial with respect to speculations on laryngeal function, it cannot be positively stated that all these acoustic consequences are definitely and without a doubt a result of the larynx height factor. However, the indications from phonetics are strong and hopefully, new results can clear up what is, at this point, a murky area. In particular, the details and consequences of implosives is an area where much more research could be done.

7.2 Phonology

As for the phonological literature, there are many conflicting proposals for the laryngeal area. Within most theories of phonological feature dependence, it has been commonly held that the laryngeal node is an indisputable requirement for the organization of laryngeal features. However, the picture is not all that clear. In the first place, there are a great many proposals for features involving the larynx. Disregarding feature proposals made before Halle and Stevens (1971), there are still a wide variety of combinations available. Agreement has not been reached as to what, exactly, the inventory of laryngeal features should be. In addition, while there have been many proposals, one which advocates larynx height alone as a possible feature has not yet been phonologically motivated (although see Denning 1989, Trigo 1991). Among the proposals that have been reviewed here are those of Halle and Stevens (1971), Lindau (1979) Clements (1985), Kingston (1986), McCarthy (1989a,b) and Yip (1990). Although feature proposals like Ladefoged (1973) where the set of laryngeal features operates on a scaled continuum have been reviewed, given the way

that register appears to "flop" from one value to another, these kinds of proposals do not seem to provide a good solution to the discussion of register.

In addition to how laryngeal features should be represented, there is also the question of where they should be placed in a feature hierarchy. The theories of McCarthy (1989a,b), Sagey (1986), Kingston (1986) and Yip (1990) have all been reviewed in order to determine what kind of variety exists in the theory. There is a great deal. Sagey (1986), represents a somewhat traditional view with all laryngeal features occurring under a laryngeal node. In McCarthy (1989a,b), there is a laryngeal node, but a feature relating to the larynx also appears under the place node. In Kingston (1986), all laryngeal features remain under the laryngeal node, but they separate into two sub-nodes of tonal and non-tonal features. Yip (1990) claims that, to account for properties of other South-East Asian languages, laryngeal features must sometimes be multiply dependent, in that they must be dependent on both the laryngeal node and some other.

In order to determine the contribution of Khmer phonology to any debate on laryngeal representation, it was necessary to analyze it in terms of non-linear phonological theory. The most prevalent synchronic phonological process involving register is the harmony rule. In order to determine the nature of harmony, the phonological nature of the target elements, the vowels, needed to be researched. It was necessary to be clear on how much of the register phenomenon was truly due to registral variation and how much was not.

7.3 Khmer Register Harmony

7.3.1 Word Structure

A moraic analysis of Khmer words was used. It was assumed that syllables are constructed following the principles outlined by Hyman (1985) whereby syllabification is an automatic process which groups melodic segments into syllables with a layer of structure occupied by morae mediating between the syllabic and melodic level. The restricted shape of Khmer words and the reported "continuum" between the monosyllable and the disyllable was determined to result from differing processes operating to keep Khmer word structure at an optimal shape. Khmer, being a language with what McCarthy and Prince (to appear) call iambic rhythm, favors either a bimoraic foot or an iambic foot consisting of a monomoraic syllable followed by a bimoraic syllable. When the incorporation of melodic material requires the construction of this structure over a melodic sequence containing only one underlying vowel, epenthesis occurs and register harmony takes place. The insertion of additional vowels triggers a need for register specification which does not occur when all the vowels of a disyllable are present from the beginning of the derivation.

The foot operates as the domain for nasal assimilation. Assimilation of nasals to a following point of articulation can only take place within a restricted disyllable. The nasal assimilation rule also reveals an unusual class of consonants in Khmer which comprises all consonants articulated from the velum to the glottis. This class supports the proposal of McCarthy (1989b) whereby all these consonants can be accommodated under a pharyngeal node. The reality of this class is also supported by the cooccurrence restrictions between this "back" class of consonants and back vowels. Between nasal assimilation and vowel-consonant cooccurrence patterns, it can be established that backness is a relevant dimension in the specification of both vowels and consonants in Khmer.

7.3.2 Vowel Specification

There are two important facts relating to the specification of vowels in Khmer. In the first place, the basic vowel specifications, that is, those which are traditionally cited in vowel systems, height, backness and rounding, can be roughly ascertained by examining the vowel-consonant coocurrence patterns described above. From this examination, it was determined that, not considering register, there are two systems of vowels operating in Khmer. The "full" vowel system contains the long vowels, or those associated to two morae, while the "reduced" system contains the short vowels, or those associated only to one mora. The "reduced" system is hypothsized to result from licensing properties of suprasegmental structure. The vowel features [high] and [front] can only be licensed by the second mora and, since the short vowels are unassociated with that mora, they are "reduced" to the set of vowels which can be distinctively specified using only the features [low] and [round]. The lack of the features [high] and [front] in the "reduced" system is shown by the fact that the cooccurrence restrictions between [high] and [front] vowels and [high] and [front] glides are not operating in that system. Therefore, ostensibly high or front short vowels are receiving their values for those features from another source, namely the adjacent consonants, and are not distinctive on those dimensions.

If register is considered, two more vowel systems, corresponding to constricted and expanded register, also operate in Khmer. The alternations between vowels resemble the alternations noted in languages where the relevant distinctive feature has been argued to be [ATR]. In fact, Gregerson (1976) has argued extensively that [ATR] is relevant throughout the languages of Southeast Asia. While the [ATR] argument appears phonetically strong, it is proposed here that, as indicated by phonetic studies, laryngeal height can create the same effect as [ATR]. If register is not a place of articulation feature, as has been suggested for [ATR], but, as has been hypothesized, a laryngeal feature, then larynx height is the

strongest explanation for the way the register systems alternate. This vowel quality alternation cannot be directly explained by vocal cord stiffness or voicing. There is no good phonetic reason why these articulations should lead to the kinds of vowel quality alternations observed. As for other possible feature specifications, [murmur] and [tense], these features are either vaguely defined or have been redefined differently so many times that it is difficult to tell if they offer any explanation. The feature used in the analysis is that proposed by Lindau (1979), [Expanded], since it offers the least misleading representation of register as laryngeal height because laryngeal height is explicitly designated as one possible phonetic implementation of it along with advancing the tongue root. This has the added advantage of predicting that the alternation of larynx height should resemble the advancement and retraction of the tongue root.

7.3.3 Register Harmony

An examination of the processes of register harmony revealed that there are actually two harmony processes operating in the language. Each rule spreads a different value of [Expanded] indicating that, in Khmer, both values of this feature must be active. In the analysis offered here, it is suggested that at underlying form, only one value of register is present, with the other value introduced sometime during the derivation. In addition, these rules operate in opposite directions, with [–Expanded] spreading from left to right while [+Expanded] spreads from right to left.

Since the sets of transparent and opaque segments include the sonorants and obstruents respectively, three feature possibilities were selected to be evaluated against the facts of Khmer. It was determined quite quickly that spontaneous voicing could not be the relevant feature nor could register be dependent in any way on that node. The possibility that register is a place feature in the sense of McCarthy (1989a,b) and Maddieson and Ladefoged (1988) was also investigated but it was determined that the rule of nasal assimilation showed that the set of segments which should have comprised the opaque sets did not correlate with it in any systematic fashion. This leaves the possibility that [Expanded] is a laryngeal feature. The characterization that [Expanded] is a laryngeal feature is found to be very explanatory. The difference between opaque and transparent segments is designated by giving the opaque obstruents a laryngeal node. These segments require a laryngeal node in any case to distinguish implosives from plosives provided the amended view of radical underspecification outlined by Avery and Rice (1989a) is adopted.

7.4 Register and the Feature Hierarchy

The main difficulty with the laryngeal analysis with respect to this thesis is how to incorporate the feature [Expanded] as a laryngeal feature. Phonetically, it is similar to [ATR] but phonologically it corresponds best to a feature like [Voice]. This implies that features and processes that are phonetically similar may be represented in two quite different ways on the feature tree.

Despite these difficulties, the study of register harmony shows that a feature like [Expanded] must, at least in some languages, be dependent on the laryngeal tier in spite of its phonetic similarity to the feature [ATR]. This indicates that phonological phenomena may be phonetically very similar while differing phonologically. Is [Expanded] representative of one feature category or two? Following McCarthy's placement of [constricted glottis] on the laryngeal tier and [glottal] under a pharyngeal tier, it is stated here that if [Expanded] is operating in different ways in different languages, it must be two features. The feature [Expanded] should be divided into the two features [ATR] and [Lowered Larynx]. This is tentatively supported by the independent requirement for these two features in Bor Dinka (Hall et al. 1982 cited in Denning 1989). In most languages, however, only one of these features is active. The other has an enhancement relationship with it, such as that described by Stevens and Keyser (1989) for other features.

In order to support the proposition brought forward in this thesis, much further research is required. In the first place, the phonetic implications of the feature [Lowered Larynx] must be more fully investigated. Much of the phonetic evidence is still highly speculative. In addition, the structures and rules of Khmer could be looked at in much more detail. More study of the complex interaction between register and pharyngeal/laryngeal features is required. Finally, in order to justify the addition of a new feature, hard phonological evidence is required. In particular, a language which unmistakably requires both [ATR] and [Lowered Larynx] must be investigated. The most likely candidate for this is Bor Dinka, as suggested by Denning (1989). However, as noted by Yip (1991), there may be other candidates among the indigenous languages of Southeast Asia, many of which have only been partially described. The positive identification of a new feature awaits these investigations.

Appendix I
A Complete Description of Khmer Vowels

Various authors have discussed the vowels of standard Khmer. Working from descriptions in Jenner (1969) along with additional information from Martini (1946), Henderson (1952) and Jacob (1974), the vowels are described below. All these writers purport to represent the standard language. Each vowel is accompanied by a phonetic interpretation and some examples. Phonetic descriptions are relatively transparent although one term in particular should be clarified. Jenner describes vowels as alternatively "tense" and "lax". Although Jenner does not explicitly define these terms, it is assumed here that he is referring to them in the sense of Hockett (1955) given that it is cited in his bibliography. According to Hockett, tense vowels are characterized by a "bunching and tension" of the muscles immediately above and in front of the glottis as characterized by the alternation in vowels between the English words *beat* and *bit*. Lax vowels presumably do not have this tension. Note that although tenseness has been associated with the feature [Advanced Tongue Root] in English (Perkell 1971, Lindau 1974, MacKay 1977) and is a possible candidate for the representation of register, it does not appear to correlate with register as is evidenced by comparing constricted register [eɛ] and expanded register [è:] which are both described by Jenner as "tense".

The symbols used below are taken from Jenner (1969). Two symbols which require further comment are ˘ and ˆ. Jenner uses these symbols to represent "microtones". He claims that there are "microtonic contrasts of openness" (Jenner 1969:23) between vowels in Khmer. So, for example, the vowel [e˘] is considered to be one microtone more open than [e] which is again, one microtone more open than [eˆ]. To illustrate the size of a microtone, Jenner states that the difference between the vowels [i̝] and [ɪ] would represent a semitone and microtones are smaller than that.Where vowel symbols are ambiguous as to register, expanded register is indicated with an acute accent.

The Long Vowels

/ ìː / [iː]	kìː cìːk cìːp ùːʊ	salt-water shrimp to dig to pleat a bamboo counting device	H125 H244 H245 H389	High, front, tense, unrounded vowel. It appears only in the expanded register.
/ əy / [ʌy]	kəy ɗəy ɓəy pəy	loom earth three quickly	H37 H284 H531 H531	Central-back, unrounded, lower mid, tense vowel followed by a high front glide. It is constricted register and occurs only in open syllables. Jenner claims the glide is dropped in closed syllables.[1]
/ èː / [e^]	kèː kèːŋ cèːh tèːp	owner of a house to lie down, sleep the seventh month deity	H130 H130 H254 H402	High-mid, front, tense, unrounded vowel. It occurs in expanded register.
/ eɛ / [eːˇ]	keɛŋ keɛ keɛl keɛʊ	to guess story, gossip to kick with the side of the toe funnel shaped container	H43 H44 H44 H44	Front, unrounded, mid, tense vowel. It occurs in constricted register.
/ èː / [ɛː]	kèː kèːn kèːp cèːk	crop (of a bird) panpipe saddle to move things apart	H130 H130 H130 H254	Front, unrounded, low-mid, tense vowel. It occurs in expanded register.
/ ae / [ɐːɛ]	kae kaeŋ kaep kaeʊ	to correct carpenter's angle iron pillow glass	H45 H45 H45 H45	Diphthong with a low, front, unrounded, tense, long vowel preceding a low-mid, somewhat front, unrounded, lax, short vowel. It occurs in constricted register.
/ aː / [æː]	kaːŋ kaː kaːp kaːʊ	bloated ewer (Th) frame to crochet	H25 H24 H28 H35	Somewhat front, unrounded, low, tense vowel. It occurs in constricted register.
/ ìe / [iːə]	kìeŋ kìeʊ cìe pìek	hair on the side of the head sledge equal to word	H122 H124 H237 H641	Falling diphthong with a high, front, unrounded, tense vowel preceding a mid, central unrounded, lax, short vowel. It occurs in expanded register.

[1]A possible example of this occurs in the alternate pronunciations of the word meaning 'destruction' which can occur as either [ksəynaʔ] or [ksən]. When the word is truncated, the /n/, originally the onset of the second syllable, assumes the coda position. At this point, as Jenner claims, the /y/ is dropped.

/ ɨ̀ː / [ɯː]	kɨ̀ː yɨ̀ːt pɨ̀ːt	to be slow to try hard	H125 H784 H654	Somewhat back, unrounded, tense vowel. It occurs in expanded register.
/ ɔː / [ɯ̆ː]	cɔːn ɗɔː tɔːŋ pɔːp ɓɔːt	quiet, silent infertile land. furiously bellowing to absorb	H181 H286 H322 H532 H532	Somewhat back, somewhat high, unrounded tense vowel. It occurs in constricted register
/ ɔ̀ː / [ʏ̆ː]	cɔ̀ː cɔ̀ːŋ cɔ̀ːt cɔ̀ːy	exclamation of surprise left, foot, base, support kind of music lackadaisical	H249 H249 H252 H253	Back (somewhat centralized), somewhat lowered high mid, unrounded, tense vowel. It is expanded register.
/ aɔ / [aːɔ]	kaɔt kaɔy kaɔ kaɔŋ	be born lean one's head upon flag to run fast	H42 H43 H42 H42	Falling diphthong with a low, central, unrounded, tense, long vowel preceding a mid, central unrounded, lax, short vowel. It occurs in constricted register.
/ ù: / [uː]	kù:k kù: kù:t kù:h	large owl pair buttocks to draw, scribble	H128 H128 H128 H129	Back, rounded, high, tense vowel. It occurs in expanded register.
/ oː / [oːˆ]	koːk koːt koːn koː	"here I am!" scrape, scratch child to stir	H40 H40 H40 H42	Back, slightly raised high-mid, rounded, tense vowel. It occurs in constricted register.
/ ò: / [oːˇ]	kò:l kò: kò:ŋ kò:t	post to mark boundary ox, cow bumpy, uneven male elephant without tusks	H133 H130 H131 H131	Back, slightly lowered high-mid, rounded, tense vowel. It occurs in expanded register.
/ ao / [aːo)	kao kaoŋ kaot kaoy	Year of the Pig curved, warped amazed game played with a top & nuts	H39 H46 H46 H47	Falling diphthong with a low, central, unrounded, tense, long vowel preceding a high-mid, back, rounded, lax, short vowel. It is constricted register.
/ ɔ̀: / [ɔː]	kɔ̀:ŋ kɔ̀: kɔ̀:n kɔ̀:y	lean with full length upon muffled, hollow part of an elephant's back customs office	H115 H113 H119 H121	Back, somewhat rounded, low-mid, tense vowel. It occurs in expanded register.
/ ɒ· / [ɒː]	kɒ:ŋ-kon kɒ:n kɒ:p kɒ:	echoing, (figure in pyre) group agreeable, in harmony neck, begin to build	H4 H13 H20 H1	Back, somewhat rounded, low, tense vowel. It is constricted register.

The Short Vowels

/ ɨ / [ɯ]	kɨ̀t-kɨ̀t kɨ̀l kɨ̀ŋ kɨ̀c	think, consider fluttering sound detective avoid	H124 H125 H124 H130	Somewhat back, unrounded, high, tense vowel. It is expanded register. It tends to alternate between front and back becoming more front in the environment of a palatal.
/ ə / [ʌ]	kəŋ kət kəl-kel kəp-kep	roof (of a boat) get close to shuffle along on one's seat to keep back sthg	H36 H36 H37 H37	Central-back, unrounded, low-mid, tense vowel. It is constricted register. It alternates between front and back becoming fronted in the environment of a palatal consonant.
/ òa, èa / .[ɲə] .[ɜə]	kòap kòat kèak kòah kò:a (ŋph) cò:a(r) pò:a(r)	right, satisfied 3rd person singular be interrupted dig up sthg embryo resin, plastic the Pear - a Mon-Khmer tribe	H123 H123 H122 H124 H120 H233 H637	1. Falling diphthong with a mid, back, somewhat rounded, lax short vowel preceding a shwa. 2. Falling diphthong with a mid, front, unrounded, lax, short vowel preceding a schwa.
/ a / [æ]	kat kan kap kaĺ	cut hold to chop to chase a female (animal)	H26 H27 H28 H34	Somewhat front, unrounded, low, tense vowel. It occurs in the constricted register.
/ ù / [ɷ]	kùk kùn kùt kùy	furnace, oven good deed kill kind of wine	H125 H125 H127 H127	Back, somewhat rounded, mid-high, lax vowel. It is expanded register.
/ o / [ɲ]	kok koŋ kon-kɒŋ kot	doze, daydream curved, twisted human figure in pyre house where monks live	H38 H38 H38 H38	Back, somewhat rounded, mid, lax vowel. It is constricted register.
/ òə / [ɷə] [ɔ] [u]	kòəŋ kòəc kòən kòəl	well kept, safe pebble, pearl to watch for crocodile	H115 H116 H119 H122	Falling diphthong with a high-mid, back, somewhat rounded, lax, short vowel preceding a schwa. It is expanded register.
/ ɒ / [ɒ]	kɒŋ kɒl kɒp kɒh	wheel support from underneath bury scrape, grate	H5 H23 H20 H47	Back, somewhat rounded, low, tense vowel. It is constricted register.

[2]Jenner (1969:28) for verification that this diphthong lengthens in open syllables.

The Diphthongs

/ iə / [i:˘ə] or [i:ə]	kiək kiəp kiəu kiə ciəh ciən kiəc kiəŋ	put an arm around nip, pinch to wrap one's leg around to grasp, gather to avoid to fry to resist to chase, drive animals	H43 H43 H43 H43 H185 H184 H43 H43	Falling diphthong with a slightly lower version of [i:] preceding a mid, central, unrounded, lax, short vowel. This is constricted register
/ ìə / [i:˘ə]	kìəŋ cìən cìəu cìəh pìə	to round up (cattle) to fry noisily to avoid vindictiveness	H129 H253 H253 H253 H661	This is the same diphthong as the one immediately preceding except this is expanded register.
/ uə / [u˘ɔ]	kuəc kuet kuəy kuə	to make a knot to alter or improve the Kuy - a Mon-Khmer tribe cluster, bunch	H42 H42 H42 H42	Falling diphthong with a lowered high, back, somewhat rounded, tense, long vowel preceding a mid, central, unrounded, lax, short vowel, It is constricted register.
/ ùə / [u:ə]	kùə kùəp kùəy cùəŋ	proper, suitable to put together, braid the Kuy -Mon-Khmer tribe gong, bell	H129 H129 H129 H248	Falling diphthong with a high, back, somewhat rounded, tense, long vowel preceding a mid, central, unrounded, lax, short vowel. It is expanded register.
/ iə / [ɯ:˘]	kiəŋ tiə tiən	to run aground small and short to urge, hurry s.o.	H43 H325 H325	Falling diphthong with a lowered high, back, unrounded, tense, long vowel preceding a mid, central, unrounded, lax, short vowel. It is expanded register.
/ɨə / [ɯ:ə]	cɨə cɨən	to trust progressively	H253 H253	Falling diphthong with a high, back, unrounded, tense, long vowel preceding a mid, central, unrounded, lax, short vowel. It is expanded register.

Appendix II
The -m- Infix

Examples of word derivations involving register differentiation with the infix *-m-*

According to Jenner and Pou (1982) this infix has an iterative meaning. Depending on the base word, it can merely intensify the meaning or change it to an agentive or more nominal form. Jacob (1974) also attributes a causative meaning to some of these cases.
Page listings are from either Headley et al. (1977) designated as H or Jacob (1968) designated as J.

-m- + base word	gloss	page #	base word	gloss	page #
cmaɲ	guard	J52	caɲ	remember, wait for	H48
cmùəŋ	businessman	J62	cùəŋ	do business	J57
cumhìen	step	J59	chìen	take a step	J61
cumlɔ̀əh	quarrel	J55	clɔ̀əh	quarrel	J62
cumlə̀ːy	uncouth	J55	clə̀ːy	uncouth	J62
cumnèah	victory	J54	cnèah	win	J62
cumrèah	make clean; judge	J55	crèah	clean, pure	J61
cumrìel	make sloping	J54	crìel	sloping	J60
cumrìep	inform	J54	crìep	be learned by	J60
cumrɨ̀ʊ	depth	J54	crɨ̀ʊ	deep	J60
cumrùh	shed	J54	crùh	fall off, be shed	J60
cùmrùŋ	push	J54	rùŋ	push	J166
cùmrə̀ːh	choice	J54	crə̀ːh	take one's choice	J60
cɒmʔaːp	non-sweet foods	J41	cʔaːp	revolting(of food smell)	J52
cɒmʔən	cook	J42	cʔən	cooked	J53
cɒmɓaŋ	war	J41	cɓaŋ	fight	J48
cɒmɓɒːŋ	older, exceeding	J41	cɓɒːŋ	elder	J48
cɒmhiəŋ	part *(classifier)*	J47	chiəŋ	inclining to one side	J51
cɒmkaː	market garden	J41	ckaː	to clear vegetation	J51
cɒmkuət	foolishness	J41	ckuət	mad	J51
cɒmlak	carved picture or statuette	J41	clak	carve, sculpt	J52

cɒmlaɔy	answer	J41	claɔy	reply	J52
cɒmlɒŋ	cause to cross; copy	J41	clɒŋ	cross	J52
cɒmŋa:y	distance	J41	cŋa:y	distant	J51
cɒmpɔ̀ɔh	towards	J47	cpɔ̀ɔh	towards	J52
cɒmraɔn	increase	J41	craɔn	many, much	J49
cɒmriɔk	lengthwise section, strip	J41	criɔk	split into lengthwise sections	J49
cɒmriɔŋ	song	J41	criɔŋ	sing	49
cɒmro:t	harvest	J41	cro:t	cut down with a scythe	49
cɒmrɒŋ	act of reforging	H171	crɒŋ	to reforge	H207
cɒmrɒ:k	filling, full	H170	crɒ:k	to fill, to stuff	H202
ɗɒmra:y/ tɒmra:y	prepared way	J68/ 71	tra:y	make a way	J77
ɗɒmreɛk/ tɒmreɛk	sensual pleasure	J71	treɛk	be delighted, pleased	J78
ɗɒmrɔ:ʊ/ ɗɒmrəʊ tɒmrəʊ	require	J68	trɔ:ʊ	necessary	J77
kma:h	shy, timid	H101	ka:h	to pull away from	H35
kman	one who carries	H101	kan	to hold something	H27
kmɔ̀ɔh	gong	H149	kɔ̀ɔh	to beat, to knock	H136
kùmlùəŋ	leprous	J31	klùəŋ	leprosy	J37
kùmrù:	model	J31	krù:	teacher	J35
kùmrùp	complete	J31	krùp	complete	J35
kɒmʔael	dirt, filth	J14	kʔael	dirt	J23
kɒmcàl	lazy	J5	kcàl	lazy, unwilling	J25
kɒmɗaʊ	warm up/heat	J5/12	kɗaʊ	hot ; angry	J15
kɒmhoh	fault, wrong	J14	khoh	wrong, different	J24
kɒmhəŋ	anger	J14	khəŋ	angry	J24
kɒmla:	behave bravely	J6	kla:	bold, powerful	J22
kɒmla:c	afraid, fearful/timid	J6/14	kla:c	fear	J27
kɒmlaŋ	force, strength	J6	klaŋ	strong, loud	J28
kɒmlaoc	burnt things	J6	klaoc	burn, feel strongly	J28
kɒmlaʊ	ignorant, foolish	J6	klaʊ	ignorant	J28
kɒmpùəh	height	J5	kpùəh	high	J27

kɒmra:l	cover, cloth, tablecloth	J5	kra:l	spread out	J20
kɒmra:p	lay low, defeat	J5	kra:p	prostrate onself	J20
kɒmrah	thickness	J5	krah	thick	J20
kɒmriəm	crust	J5	kriəm	dried up	J21
kɒmriəv	castrated	J5	kriəv	castrate	J21
kɒmrɒ:	scarcity	J5	krɒ:	hard to find, rare	J16
kɒmrɒ:ŋ	garland	J5	krɒ:ŋ	weave in together	J16
kɒmrət	limit	J5	krət	decree	J20
kɒmsa:n	relax, be at leisure	J6	ksa:n	peaceful, tranquil	J22
kɒmsaoy	weak, feeble	J6	ksaoy	weak	J29
kɒmt̀c	crush to bits; destroy; bits	J5	kt̀c	in small bits; in detail	J26
lmò:p	greedy	J176	lò:p	greed	J174
lmə̀:h	to go against the law	J175	lə̀:h	go beyond, exceed	J173
lmù:əc	stealing	H956	lù:əc	to steal, pilfer	H928
lùm?a:n	trace	J175	l?a:n	leaving a trace	J176
lùm?iəŋ	incline to one side	J171	l?iəŋ	go to one side, slope,	J176
lùm?ɒ:	embellishment	J171	l?ɒ:	beautiful, good, nice	J176
lùm?ɒ:ŋ	fine dust, pollen	J171	l?ɒ:ŋ	dust	J176
lùmhae	cause to be at leisure, amuse	J171	lhae	relax	J176
lùmhaəy	relax; fresh (of air)	J171	lhaəy	fresh	J176
rùmdɒh	free	J169	rɔdɒh	freed, free from	H806
rùmlì:ŋ	dig out and clear away(especially trees)	J169	rɔlì:ŋ	clean and smooth	H834
rùmlìek	burn on flesh	J161	rɔlìek	scorched(of skin)	H832
rùmlìey	melt; abolish	J169	rɔlìey	melt	H833
rùmlìk	think of (particularly of an absent person or past occasion) miss, remember, commemorate	J169	rɔlìk	be aware, wake up, turn one's thoughts towards, miss (an absent person), be sad without	H834
rùmlù:t	abort	J161	rɔlù:t	come loose, miscarry	H835
rùmlɔ̀ət	extinguish	J169	rɔlɔ̀ət	extinguished	H832
rùmlə̀:ŋ	uproot, unearth, upend (tree, pillar)	J169	rɔlə̀:ŋ	uproot, overturn	H835
rùmŋòap	kill	H893	rɔŋòap	to die out	H797

rùmsa:y	spread out, scatter	J161	rɔsa:y	come untied	H842
smo:m	beggar	J210	so:m	to ask for	J200
sɒm?a:t	clean	J192	s?a:t	cleaned, nice looking	J216
sɒm?oy	bad smell, stink	J192	s?oy	smelling putrid	J216
sɒmɓɒt	oath	J190	sɓɒt	swear	J209
sɒmɗac	prince, lord	J190	sɗac	prince	J207
sɒmɗaeŋ	show, explain	J190	sɗaeŋ	clear	J207
sɒmɗəy	speech	J203	sɗəy	speak	J207
sɒmkɔ̀:m	thin	J189	skɔ̀:m	having not much flesh	J206
sɒmkɔ̀al	observe	J189	skɔ̀al	recognize	J206
sɒmliək-ɓɒmpɛ̀ak	lower and upper garments	J192	sliək-pɛ̀ak	wear below and above the waist	J215
sɒmlot	give (someone) a nasty shock, threaten, intimidate	J192	slot	be suddenly shocked, stunned, go limp	J215
sɒmloy	wear the sarong with the hem lowered at one side	J192	sloy	drag, trail because of having slipped down	J215
sɒmlɒ:	culinary dish	J192	slɒ:	prepare sɒmlɒ:	J214
sɒmɲa:c	make clear	J189	sɲa:c	gleaming white	J206
sɒmɲat	secret, keeping secret	J189	sɲat	quiet	J206
sɒmpìey	that which is carried in a bag or cloth slung over one shoulder	J190	spìet	carry slung over one shoulder and under the other arm in a cloth	J209
sɒmra:k	rest, relax	J191	sra:k	abate, go down	J213
sɒmra:l	make light (in weight)	J191	sra:l	light in weight	J213
sɒmra:t	remove clothes (transitive)	J191	sra:t	take off clothes	J213
sɒmrac	finish, achieve, be successful, decide	J192	srac	finish, complete	J214
sɒmraek	cry	J192	sraek	shriek, cry out	J214
sɒmrah	branches used to bar the way	J191	srah	close across an opening using branches	J213
sɒmraəp	excite, excitement	J191	sraəp	pleasantly excited	J214
sɒmreɛk	thirst	J191	sreɛk	be thirsty	J214
sɒmro:t	slither down (a pole, tree, etc.)	J191	sro:t	swiftly and directly	J214
sɒmroŋ	let down part of the sarong, right down, completely	J191	sroŋ	right down, completely down, completely	J214

sɒmruəl	make easy, emend/ laugh (royal vocabulary)	J191	sruəl	easy, comfortable	J214
sɒmrɒh	freshness, prettiness	J191	srɒh	fresh, not dried up,	J212
sɒmrɒk	let drip, let flow	J191	srɒk	fall (of liquids), drip	J210
sɒmrɒp	branches, etc. made to form a shade	J191	srɒp	stay in the shade	J211
sɒmɲeɲ	bare one's teeth	J189	sɲeɲ	gaping open	J207
tmaə	time	J80	ɗaə	walk, travel	J66
tùmhùm	size	J89	thom	be big, important	J93
tùmlèak	drop	J83	tlèak	fall from a height	J93
tùmlìey	pierce, make a hole through	J83	tlìey	have a hole through, be broke, pierced	J94
tùmlòap	habit, custom	J83	tlòap	used to, accustomed to	J94
tùmlùh	pierce	J83	tlùh	be pierced	J94
tùmɲòən	weight	J83	tɲòən	heavy, serious	J93
tùmpòək/ tɒmpòək	hook, crook	J83/ H315	tpòək	hook	J80
tùmrèːt	cause to bend so it leans	J83	trèːt	slope, lean, incline	J91
tùmrɔ̀əŋ	appearance, shape, form	J83	trɔ̀əŋ	support, hold	J89
tɒmʔoːɲ/ ɗɒmʔoːɲ	complaint, grumbling	J71	tʔoːɲ-tʔae	grumble	J78
tɒmɓot	small skewer	H315	tɓot	skewer	H331
tɒmkat/ ɗɒmkat	minor illness	J70	tkat	(with chìʊ-) ill	J79
tɒmkaəŋ	elevate	H314	tkaəŋ	be noble, glorious	H353
tɒmkɒl/ ɗɒmkɒl	place, store; resting, place	J70	tkɒl	be still, unmoving	J79
tɒmlay/ ɗɒmlay	cost, value	J71	tlay	be dear, expensive; cost	J81
tɒmləŋ/ ɗɒmləŋ	ounce	J71	tləŋ	weigh	J81
tɒmpòək	hook for picking fruit, fruit picker	J70	tpòək	hook	J80
tɒmraː/ ɗɒmraː	that which has been noted down in brief form	J70	traː	write down	J76
tɒmrah/ ɗɒmrah	order, speech (royal vocabulary)	J71	trah	be enlightened, explain (royal vocabulary)	J77

tɒmɾap/ ʤɒmɾap	example	J70	trap	imitate	J77
tɒmɾoŋ/ ʤɒmɾoŋ	direct towards/ go straight towards	J70	trɒŋ	be straight, direct	J74
tɒmɾoy/ ʤɒmɾoy	tracking signs	J71	troy	put branches as a sign	J77
tɒmɾɒːŋ/ ʤɒmɾɒːŋ	filter	J70	trɒːŋ	pass a liquid through a filter into a container	J74
tɒmɾəm/ ʤɒmɾəm	thought	J71	trəm	equal to, just up to the same point as	J77
tɒmʋaːɲ/ təmɓaːɲ təɓaːɲ/ ʤɒmɓaːɲ	equipment for weaving	J67/ 70	ʧaːɲ	weave	J74

Appendix III
The -mn- Infix

Examples of word derivations involving register differentiation with the infix *-mn-*

According to Jenner (1969: 166) the function of this infix is "to present the predication of the base as a process or operation conducing to some end in view". He terms it a "processive" aspect marker. Jenner suggests that this infix is an allomorph of the -N- infix because it only occurs with primary bases.

Page listings are from either Headley et al. (1977) designated as H or Jacob (1968) designated as J.

-mn- + base word	gloss	page #	base word	gloss	page #
cɒmnaɤy	expense, spending	J46	caɤy	spend	J42
cɒmnaek	section, part	J46	caek	divide	J45
cɒmnah	age	J46	cah	be old, grown up	J43
cɒmnam	remembrance	J46	cam	remember	J48
cɒmnaom	crowd, group	J46	caom	encircle, surround	J45
cɒmnaot	question, problem	J46	caot	pose/have a question	J45
cɒmneh	knowledge	J46	ceh	know, know how to	J45
cɒmneŋ	profit	J46	ceŋ	go out from, leave	J44
cɒmnoːl	coming in, income	J46	coːl	enter	J44
cɒmnoh	cargo	J46	coh	go down	J44
cɒmnət	section	J46	cət	slice	J43
cùmnìeŋ	skill, craft	J58	cìeŋ	artisan, craftsman	J55
cùmnòː	flood	J58	còː	flood, flow	J58
cùmnòan	period of time	J58	còan	take possession of one's soul	J55-6
cùmnùəh	replacement	J58	cùəh	replace	J57
cùmnùəy	aid	J58	cùəy	help	J57
cùmnùəŋ	business	J58	cùəŋ	do business	J57
cùmnùən	flood	J58	cùən	flood	J54
cùmnɨə	belief	J58	cɨə	believe	J57
ɗɒmnac	end (of a period of time)	J67	ɗac	end (of time)	J65

ɗɒmnaə	journey, trip; story, fact	J67	ɗaə	proceed on a journey	J66
ɗɒmnaəl	place or object which belongs to someone and which may be handed down as an heirloom	J67	ɗael	already; has/have ever at some time in the past	J66
ɗɒmnak	chalet	J67	ɗak	put; put down; affect; towards	J65
ɗɒmnam	plant	J67	ɗam	plant, grow	J68
ɗɒmneɛk	sleep, rest; bedroom	J67	ɗeɛk	lie down, sleep, rest	J66
ɗɒmnɒk	act of making puddles	H296	ɗɒk	to make puddles	H277
ɗɒmnɒm	wound, blow	J67	ɗɒm	hit with a hammer	J67
ɗɒmnəŋ	news, information	J67	ɗəŋ	know, have heard	J65
tɒmnaːŋ/ ɗɒmnaːŋ	representative	J74	taːŋ	represent,	J71
tɒmnaeŋ/ ɗɒmnaeŋ	post, position (at work)	J74	taeŋ	have the habit of	J73
tùmnɨ̀ŋ	goods, things bought	J89	tɨ̀ŋ	buy	J85
tùmnɨ̀ey	prediction, prophecy	J89	tɨ̀ey	prophesy, predict	J84
tùmnɔ̀ːŋ	way, course (verb) be like, seem like	J89	tɔ̀ːŋ	shoot, matter, cause	J81
tùmnə̀ːp	impulse	J89	tə̀ːp	have just	J87
tùmnùəŋ	lament	J89	tùəŋ	lament	J87
tùmnùk	method of keeping	J89	tùk	put away, keep	J86
tùmnùp	dyke, dam	J89	tùp	block the way	J83
kɒmnaːp	poetry, poem	J12	kaːp	poetry	J7
kɒmnaːc	naughty	J12	kaːc	bad, evil	J7
kɒmnaən	levy, calling up of manpower	J12	kaən	levy	J11
kɒmnaət	birth	J12	kaət	be born, arise, happen	J10
kɒmnan	that which one holds	J12	kan	hold	J7
kɒmnat	section, part, cut piece	J12	kat	cut	J7
kɒmnɒl	support, fee for service of doctor or teacher	J12	kɒl	support from underneath	J6
kɒmnɒt	fix; note down	J12	kɒt	note down	J3
kùmnɔ̀ː	pile	J34	kɔ̀ː	pile up	J31
kùmnòal	audience of the king	J34	kòal	be present, enter the presence of	J31
kùmnòap	salute	J34	kòap	please, suit	J31

kùmnù:	design, picture	J34	kù:	draw, design	J33
kùmnùə	politeness	J34	kùə	proper, suitable	J33
kùmnù:h	trace	J34	kù:h	make a trace	J33
kùmnùm	enmity, revenge	J34	kùm	wish evil upon, plan revenge	J33
kùmnìt	thought, idea	J34	kìt	think, consider	J31
kùmròŋ	outline, plan	J31	kròŋ	prepare in advance	J36
sɒmna:m	trace	J190	sna:m	trace, scar	J208
sɒmna:p	rice seedling	J203	sa:p	sow	J195
sɒmnaen	offerings (to spirits)	J203	saen	offer (food to spirits)	J202
sɒmnaəc	laughter, a laugh	J203	saəc	laugh	J200
sɒmnak	place to stay	J190	snak	stay overnight	208
sɒmna:k	testing, trial	J203	sa:k	test, scrutinize	J194
sɒmnat	any object which is drifting	J203	sat	float on air or water	J194
sɒmno:k	bribe	J203	so:k	bribe	J199
sɒmno:m	request, requesting	J203	so:m	ask, ask a favor	J200
sɒmnɒ:ŋ	repayment	J203	sɒ:ŋ	repay a debt	J183
sɒmnɒl	surplus, remainder	J203	sɒl	remain, be left over	J193
sɒmnɒŋ	building	J203	sɒŋ	build	J183
sɒmnəŋ	sleep (of a monk)	J203	səŋ	sleep (monk vocab.)	J196
sɒmnuə	questions, interrogation	J203	suə	ask a question	J200
sɒmnuən	fitting, adequate	J204	suən	part	J200
ʔɒmna:c	power	J241	ʔa:c	have the power to	J232
ʔɒmnaoy	gift	J241	ʔaoy	give, let (someone) do	J240
ʔɒmnɒt	endure privation	J241	ʔɒt	be without, deprived of	J223
ʔɒmnuət	boasting	J241	ʔuət	boast	J239

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