

Volume 20 (2001)

University of Washington

Working Papers
in
Linguistics

Working Papers in Linguistics

University of Washington

Volume 20 (2001)

Editor:

Susannah Levi

Assistant Editor:

Julia Miller

Web page:

Joyce Parvi

For subscription, exchange, and advertising information, contact UWWPL editor at:

UW Working Papers in Linguistics
Department of Linguistics
University of Washington
Box 354340
Seattle, WA 98195-4340
(206) 543-2046
phoneme@u.washington.edu
<http://depts.washington.edu/lingweb/papers/index.html>

All papers in this volume remain the sole property of the author and may be protected by copyright; permission to duplicate should be sought from the individual author.

University of Washington
Working Papers in Linguistics

Volume 20

2001

Department of Linguistics
University of Washington
Box 354340
Seattle, WA 98195-4340
(206) 543-2046
phoneme@u.washington.edu
<http://depts.washington.edu/lingweb/papers/index.html>

Acknowledgments

Se thank the following contributors to
FRIENDS OF LINGUISTICS

CONTRIBUTIONS RECEIVED SINCE THE LAST PUBLICATION
JANUARY 2001 THROUGH NOVEMBER 2001

James L. Armagost
Than Chong Baskerville
Kristin E. Denham
David W. Dunham
Michael Gamon
Jennifer Lynn Harvey
James E. Hoard
Vincent Scott Kessler
John E. Lackstrom
Jack O. Lawson
Joseph Limacher
Anna and Colin McCartney
Microsoft Corporation
David Miles
Diana Peterson
The Seattle Foundation
Tatsuya Suzuki
Adriana Vanici
Heather Jean Worthley

Table of Contents

| | |
|--|-----|
| Initial clusters and minimality in Yakima Sahaptin..... (Sharon Hargus and Virginia Beavert) | 1 |
| Quality sensitive stress reconsidered..... (Sharon Hargus) | 25 |
| Glides in Korean syllables..... (Yungdo Yun) | 57 |
| German particle complement verbs in modern morphological syntactic theory: contering the “separable-prefix” misnomer..... (John H. G. Scott) | 99 |
| Why Early Immediat Constituents? The role of memory and locality... (Gabriel Webster) | 118 |
| Segmental analysis of Beijing Mandarin rhymes in Feature Geometry.. (Kening Li) | 159 |

Initial clusters and minimality in Yakima Sahaptin^{*}

Sharon Hargus

Virginia Beavert

University of Washington

Heritage College

sharon@u.washington.edu

1 Abstract

In the Yakima dialect of Sahaptin (YS), the smallest independent words in YS are CCV and CVC. We argue that CCV words are monosyllabic on the basis of phonotactic restrictions, the distribution of epenthetic vowels, and stress patterns. Therefore, we propose to analyze YS as presenting a new type of minimality, biconsonantal minimality.¹

2 Theoretical background

2.1 Approaches to the representation of initial clusters and geminates

The representation of initial clusters and geminates has been and continues to be an issue in syllable theory. Three types of representations have been proposed.

1. Syllabified clusters (e.g. Steriade 1982). In this approach, consonant clusters are syllabified except under special circumstances, such as word edge extraprosodicity. Steriade argues that both syllabified and unsyllabified clusters are required to account for different patterns of reduplication in Attic Greek:

(1) (after Steriade 1982)

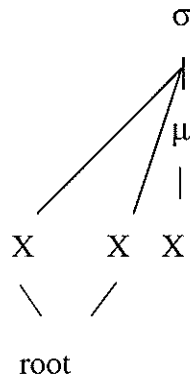
| | a. syllabified [g] | b. unsyllabified [g] |
|--------------|-----------------------|----------------------|
| | σ | σ |
| | / \\ | \\ |
| | g r a p ^h | g n o: |
| reduplicated | gegrap ^h a | egnɔ:ka |

^{*}Virginia Beavert is a native speaker of the Yakima dialect of Sahaptin. Thanks Setsuko Shirai, Emily Curtis and other members of the University of Washington Linguistic Phonetics Lab for comments and helpful discussion. An earlier version of this article was presented at the 2001 meeting of the Linguistic Society of America, Washington DC.

¹We thank Emmon Bach for suggesting this possible analysis to us.

More recently, Hume, Muller, and van Engelenhoven 1997 argue that initial geminates in Leti are syllabified as shown in (2), citing data related to stress.

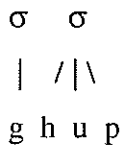
(2)



In other words, they propose that initial geminates are syllabified, but not weight-bearing.

2. Independent syllables (e.g. Sloan 1988, Shaw 1993, Urbanczyk 1996, Cho and King to appear). Syllables consisting only of consonants have been proposed for selected languages. The representation in (3) is posited by Sloan for the Mon-Khmer language Semai:

(3) (after Sloan 1988)



Sloan 1988 and Shaw 1993 call these consonantal syllables 'minor syllables'. One argument for minor syllables made by Sloan 1988 concerned the (then-) dominant theory of reduplication (McCarthy and Prince 1986), according to which the output of reduplication should be a well-formed phonological constituent. The reduplicated form corresponding to (3) is [gp-ghup], and if this form is syllabified [gp.g.hup], as suggested by Sloan, then the target of reduplication is a syllable. However, given subsequent developments in the theory of reduplication, this argument no longer holds: McCarthy and Prince 1995 convincingly argue that reduplicative morphemes are well-formed morphological constituents, affixes or stems, which have canonical but not invariant realizations as syllable and foot, respectively.

In Lushootseed words like [ck^wúsəd] ‘cane, walking stick’, Urbanczyk 1996 analyzes the initial consonant as syllabic ([c.k^wú.səd]). Urbanczyk advances three arguments for this analysis. First, Lushootseed has very few obstruent + sonorant sequences. If obstruent sequences were tautosyllabic, then the lack of obstruent + sonorant clusters is surprising.² Secondly, there are no restrictions on the distribution of laryngeal features in initial consonant sequences: [tq], [t’q], [tq’], and [t’q’] are all attested. Laryngeal features are said to be restricted if tautosyllabic (Greenberg 1978). However, if consonant sequences like [ck^w] are heterosyllabic, then the fact that all possible combinations of laryngeal features are attested is not surprising. Finally, there is free variation between words with consonant sequences and words with epenthetic [ə]: [s-qəq^wús] ~ [s-qq^wús] ‘small mat used to kneel in canoe’. Since voiceless stops are predictably aspirated ([sq^hq^{hw}ús]), the [ə] is simply a voiced variant of the aspiration: both are syllable nuclei.

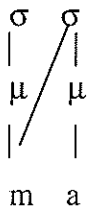
Cho and King (to appear) have proposed syllabic consonants, ‘demi-syllables’, for the initial clusters of Georgian, Polish and Bella Coola. For the controversial case of Bella Coola, they suggest that fricatives may function as syllable nuclei, similar to Urbanczyk’s analysis of Lushootseed. Cho and King propose that demi-syllables have the following cluster of properties: they lack syllable internal constituency (no nucleus, no coda), they are restricted to morpheme peripheral position, they are prosodically invisible (for purposes of stress or tone), and they constitute a subset of the well-formed onset clusters in the language. The latter two properties face challenges from the Mon-Khmer languages, since Sloan 1988 notes that in some of the languages (e.g. Kammu) minor syllables may be tone-bearing units. The onset cluster characterization of minor or demi-syllables also seems inappropriate for the reduplicated form [gp.g.hup], since [gp] is not a possible onset cluster in Semai, according to Sloan. Moreover, it may be

²However, as pointed out to me by Dale Kinkade, most Proto-Salish sonorants have become obstruents in Lushootseed (Thompson and Thompson-XX).

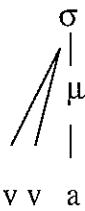
impossible to characterize well-formed onsets in a way which is independent of the controversial demi-syllables or minor syllables.³

3. Weight bearing approach. Hayes 1989 suggested a number of possible representations for syllable initial geminates within moraic theory, shown in (4):

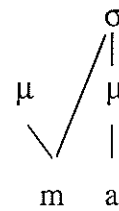
(4) Moraic representations of syllable initial geminates



a. Luganda



b. Russian



c. (predicted)

Subsequently, moraic, unsyllabified initial geminates represented as in (4)c. have been proposed for Trukese and Italian (Davis 1999). Moraic initial consonants in clusters have also been proposed for Arabic (McCarthy and Prince 1990), Bella Coola (Bagemihl 1991, Bagemihl 1998), and Piro (Lin 1997).

Unfortunately for the weight-bearing approach to the representation of geminates and clusters, the results of Gordon's (1999) survey of syllable weight phenomena have undermined the justification for the mora as weight unit. Briefly, Gordon 1999 found that weight mismatches within a single language, of the sort drawn attention to by Hyman 1992 and others, involving phenomena such as stress, tone (e.g. contour tone distribution), compensatory lengthening, minimal word phenomena, metrics, and syllable templates are at least as common as weight uniformity within a single language. In other words, syllable-final [n], for example, may not have a uniformly weight-bearing representation within a single language: it may count as heavy for tone but not stress, as it does in Lhasa Tibetan (Gordon 1999), not as predicted by theories such as Weight by Position, in which [n] should be uniformly heavy within a language. Gordon concluded that weight is not language-driven, but process-driven, and proposed that weight has no independent representation within the syllable, but is projected from a syllable's featural

³For example, Steriade 1999 suggests just the opposite, that word internal syllabification is guided by considerations of word edge phonotactic well-formedness.

content. Therefore, for theoretical reasons,⁴ we do not pursue the weight-bearing approach to YS initial consonants here, but consider the syllabified and independent syllables approaches.

2.2 *Minimality*

Following work by McCarthy and Prince 1986, cross-linguistic minimality patterns have generally been characterized as a well formed foot, thus two prosodic units, either two syllables or two moras. Disyllabic minimality is attested in Yidin^y (Nespor and Vogel 1986), in Diyari and Makkassarese (McCarthy and Prince 1986), and in Yoruba nouns (Pulleyblank 1988), among other languages. Bimoraic minimality has been proposed for Lardil and Ponapean (McCarthy and Prince 1986), English (Hammond 1999), Japanese (Itô 1990), Athabaskan roots (Leer 1979, Hargus and Tuttle 1997), Arabic nouns (McCarthy and Prince 1990), Axininca Campa (Spring 1991), and Spanish (Crowhurst 1992).

Given the results of Gordon 1999, the proper recharacterization of apparent bimoraic minimality becomes an open question. To mention one case that we know well, Athabaskan root minimality involves the following permissible root shapes:

(5) (after Leer 1979)

CV *-ʔa: ‘classify compact object’

CVC *-ʔa:č’ ‘few go’

Cv̆C, where v̆ = reduced vowel *-nəq ‘fabric falls’

If reduced vowels lack skeletal or weight positions, as has been suggested by Kager 1990 and Shaw 1992, then Athabaskan root minimality can be characterized as a minimum of two skeletal positions:

⁴However, in rejecting the mora, phonological theory is left without an explanation for the onset-coda asymmetry in compensatory lengthening. Also, the alternative model of the skeleton proposed by Gordon resurrects the feature [syllabic], the use of which had been criticized for its lack of surface contrastiveness (Clements and Keyser 1983-XX).

(6)
 X X
 | |
 ? a
 X X X
 | | |
 ? a č'
 X X
 | |
 n ə q

Athabaskan ‘bimoraic’ root minimality is thus analyzable as a minimum of two skeletal positions. Some former cases of bimoraic minimality may instead turn out to involve biconsonantal minimality, along the lines suggested below for YS.

3 Initial consonant clusters in Yakima Sahaptin

3.1 Background

By way of orientation to YS, segment inventories are provided in (7)-(8):

(7)

| | | | | | | | | | |
|----|----|-----|-----|----|----|-----------------|----|-----------------|---|
| p | t | tʰ | ts | č | k | k ^w | q | q ^w | |
| p' | t' | tʰ' | ts' | č' | k' | k ^{w'} | q' | q ^{w'} | ʔ |
| | | ʃ | s | š | x | x ^w | χ | χ ^w | h |
| m | n | l | | | | | | | |
| w | | | | y | | | | | |

(8)

i, ii ĩ u, uu
 a, aa

Sahaptin liberally allows initial consonant clustering, unlike its sister language, Nez Perce, which bans initial consonant clusters. For example, in a sample of 634 nominal and adjectival roots, 21% have an initial phonetic cluster ([Hargus, 2000 #492]).

The percentage of roots with an initial phonemic cluster (including underlying clusters which are pronounced with epenthetic [i]) is of course higher.

YS allows both obstruent initial and sonorant initial clusters. Up to four consonants are possible in an initial cluster, although phonetic CCCC is only attested in only two words:

(9)

| | | |
|------|--------|-------------------|
| CC | χnin | ‘golden currant’ |
| CCC | tχnána | ‘rolling thunder’ |
| CCCC | štχní | ‘horsefly’ |

Within the typology of obstruent clusters proposed by Morelli 1999, YS is a Type 6 language, allowing fricative-stop, stop-fricative, stop-stop, and fricative-fricative clusters. Geminate stop initial clusters are possible as well.

(10) Obstruent clusters (F= fricative, S = stop)

| | | |
|----|-----------------------|----------------|
| FS | χtu | ‘strong’ |
| | ʔk ^w i | ‘day’ |
| SF | čχaw | ‘fat’ |
| | q ^w šim | ‘mischievous’ |
| SS | ppaaw | ‘bullsnake’ |
| | ptis | ‘muskrat’ |
| FF | sχíχ- | ‘be angry’ |
| | šχ ^w íyaaš | ‘alkali brush’ |

In addition to obstruent+obstruent sequences, YS also allows obstruent+sonorant clusters:

(11) (N = nasal, L = lateral, Y = glide)

| | | |
|----|----------|---------------------------|
| SN | qqnáywi- | 'be busy' |
| SL | č'lay | 'pulverized dried salmon' |
| SY | twáti | 'medicine man' |
| FN | łmáma | 'old woman' |
| FL | χlaam | 'large cedar root basket' |
| FY | χyaw | 'dry' |

YS also allows limited sonorant initial phonetic clusters.

(12)

| | | |
|----|----------|---------------------|
| NY | myánaš | 'child' |
| NS | nč'i | 'big' |
| LS | ltáyltay | 'hemp shoulder bag' |

Most sonorant initial clusters, however, undergo obligatory [i] epenthesis, as will be discussed in 3.3.2.

3.2 *Minimality*

YS roots come in various shapes and can be one, two or three syllables in length. Nouns and adjectives can form independent words without affixation in YS. Verb roots always appear with some sort of affix, minimally a single consonant such as *-[k]* 2 sg. imperative. The type of minimality that we discuss here is thus a constraint on word, not root, shapes (cf. McCarthy and Prince 1986).

The shortest forms of nouns and adjectives include CVCV, CVV, CVC, CCV, and CV. The numbers of such words in the current corpus are given in (13).

| | | | |
|------|-------------------------|------------------|----|
| (13) | Minimality (first pass) | | |
| | CVCV | [k'úsi] 'horse' | 63 |
| | CVV ⁵ | [tii] 'tea' | 1 |
| | CVC | [pap] 'daughter' | 63 |
| | CCV | [kki] 'drooping' | 27 |
| | CV | [ts'i] 'sweet' | 1 |

Two small numbers in (13) are conspicuous: the numbers of CV and CVV roots. Only one of each is attested, and both are loans: [ts'i] 'sweet' is a loan from Chinook Jargon, and [tii] 'tea' could have any number of sources in Sahaptin. Eliminating the loans from (13), word minimality thus reduces to three segmental patterns in YS: CCV, CVC, and CVCV. Since CVCV is unquestionably disyllabic, the smallest shapes of interest are therefore CCV and CVC. In contrast to the absence of CV and CVV, CCV is reasonably well attested among the native vocabulary.

CCV words may contain a variety of consonant sonority combinations, although as discussed by Hargus and Beavert (to appear), certain types of underlying clusters receive an obligatory [i]. The latter are segregated in (15).

| | | | |
|------|--------------|----------------------|---|
| (14) | CCV as [CCV] | | |
| | SS | [pča] | 'mother' |
| | SF | [psa] | 'bark' |
| | SY | [twa] | 'teepee pole' |
| | FS | [tk ^w 'i] | 'day' |
| | FL | [χli] | 'pinstripe' |
| | FY | [šwa] | 'forehead' |
| | NS | [nč'i] | 'big' |
| | NY | [myu] | 'brother-in-law (man's wife's brother)' |

⁵Other CVV roots occur in [ts'áa-pa] 'nearby' and [sii-łá] 'Selah'. We do not include these in our tally of CVV roots because they are bound: [ts'aa] always occurs with the locative suffix -[pa], and [sii] is attested only in this place name with the agentive suffix -[łá].

(15) CCV as [CiCV]

| | | |
|----|-------------------|---|
| SN | /t'nu/ [t'inú] | 'viscous' |
| NF | /msa/ [misá misa] | 'jovial, clowning' |
| NN | /nnu/ [ninú] | 'sand' |
| YF | /wχa/ [wiχá] | 'foot, leg' |
| ?S | /ʔqu/ [ʔiqú] | 'heavy' |
| ?F | /ʔχa/ [ʔiχá] | 'alder' |
| ?N | /ʔni/ [ʔiní] | 'greenery used to line storage receptacle' |

Gordon 1999:261, in his survey of minimal word requirements, found that “the most common minimal word requirement is CVC, although the CVV and the disyllabic minimal word requirement are attested in a significant minority of languages.”

Interestingly, in Gordon’s sample, the YS minimality pattern, CCV or CVC as smallest word, also occurs in Czech, Tsou and Kashuyana.⁶ Gordon suggested that in those languages CCV could be considered a type of disyllable, since “in all three languages, the CCV words result from loss of the first vowel, either synchronically or diachronically, in an originally disyllabic word” (p. 264).

Could phonetic CCV in YS be analyzed as a type of disyllable, along the lines of the independent syllables approach to initial clusters and as Gordon’s statement above seems to predict? (16) gives a representation of a CCV word in that framework:

(16)

σ σ
| / |
p s a

Historically, the CCV words may have been disyllabic.⁷ Those for whom clear cognates in Nez Perce can be found are disyllables in Nez Perce (Aoki 1994):⁸

⁶According to Richard Wright (p.c.), Tsou does not have CCV minimality: ((C)C)VV is the minimal monosyllabic word (see Wright 1996).

⁷Many aspects of Proto-Sahaptian historical phonology have not been reconstructed. In the most recent, comprehensive statement of Sahaptian historical phonology, Rude 1999

(17)

| | | |
|----------------------|------------------------------------|--|
| Yakima Sahaptin | | cf. Nez Perce |
| [pča] | ‘mother’ | pike- in pikenú:t ‘motherless’ |
| [pti] | ‘blue grouse’ | ?tuy’é ‘blue grouse’ |
| [tk’u] | ‘cattail’ | tók’o ‘cattail, tule mat, tule, bulrush’ |
| [psa] | ‘bark’ | peqet ‘bark of trees’ |
| [pši] | ‘niece’ (woman’s daughter’s child) | ?pé:qiy ‘niece’ (man’s brother’s child) |
| [twa] | ‘teepee pole’ | tíwe ‘pole for a teepee’ |
| [ʔk ^w :i] | ‘day’ | lé:hey ⁿ ‘a day’ |
| [šwa] | ‘forehead’ | síwe ‘forehead’ |
| [nč’i] | ‘big’ | himé:q’is ‘big’ (sg.) (abs.) |
| /t’nu/ [t’ínú] | ‘viscous’ | tinníw ‘thick’ (e.g. of shoulder as the back of mountain sheep’s head) |
| /msa/ [misá misa] | ‘jovial, clowning’ | mic’f’c ‘funny looking, laughable’ |
| /nnu/ [nínú] | ‘sand’ | lilú:yin’ ‘dirty, unclean’ |
| /wχa/ [wiχá] | ‘foot, leg’ | ?éχwe ‘foot (of humans, animals, birds)? wé:yux ‘leg (of humans)?’ |
| /wši/ [wiší] | ‘rat’ | wísi: ‘rat, wood rat’ |
| /ʔqu/ [ʔiqú] | ‘heavy’ | wiʔxwíʔx ‘heavy’ |

As a synchronic analysis, disyllabicity initially appears to receive some support from inspection of the kinds of segments which can appear as C₁ in such words. As seen

notes that in cases where ‘Sahaptin words with initial consonant cluster...have cognates in Nez Perce in which the second vowel appears as a reflex of *i...it is not clear whether this vowel was lost historically in Sahaptin or added in Nez Perce (likely both processes have occurred).’

⁸The following have no apparent cognate in NP: [pč’i] ‘wealth, abundance’, [k’wi] ‘waist’, [χli] ‘pinstripe’, [šwu] ‘beard, moustache’, [myu] ‘brother-in-law (man’s wife’s brother)’, [ʔiχá] ‘alder’, [ʔiní] ‘greenery used to line storage receptacle’.

in (14), the initial C can be a fricative, nasal (which could occur in syllabic form in other languages) or voiceless stop. As noted by Jacobs 1931, Sahaptin voiceless stops have varying amounts of aspiration, as can be seen for prenasal [p] and prevocalic [t] in Figure 1.

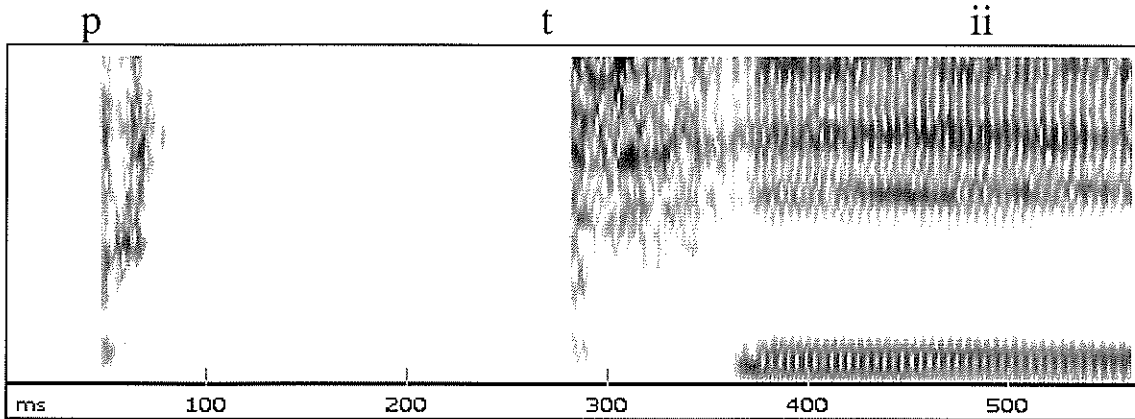


Figure 1. [ptiit] 'humid'

If the words in (14) were disyllabic, we might analyze this aspiration as a voiceless version of [i] along the lines of Urbanczyk's analysis of Lushootseed aspiration as voiceless [ə], a 'voiceless syllable', and Cho and King's proposal for Bella Coola that fricatives (and sonorants) may serve as syllable nuclei. However, glottalized consonants can also occur in C₁ position in CCV words, as in [k'wi] 'waist'.⁹ Although [k'] is not problematic as a semi-syllable for Cho and King, it seems intuitively less plausible for the voiceless syllable hypothesis for the silent period of an ejective to be counted as a syllable nucleus.

3.3 *The syllabic affiliation of initial clusters*

In this section we will argue against representations such as (16) for YS CCV and for the simpler representation in (18):

(18)

σ
/|\
p s a

⁹Note that [Cw] and [C^w] contrast in [χwiš] 'canyon' vs. [χ^wiš]- 'stretchy'.

In other words, we suggest that Sahaptin presents a case in which consonant clusters are syllabified rather than independent syllables.

3.3.1 Phonotactic restrictions

One argument for syllabified clusters was presented in Hargus and Beavert to appear. To briefly recapitulate that argument, not all possible combinations of obstruents or obstruent + sonorant occur in initial clusters. The consonants exhibit restrictions in place of articulation, which we take to be a sign of a close phonotactic connection between the consonants, tautosyllabicity, the reverse of the situation in Lushootseed, where combinations of segments which differ in laryngeal features are unrestricted.

The place restrictions can be summarized as follows. (1) Sequences of homorganic consonants are generally banned, unless geminate. (2) Syllable initial [kp] is well-attested (e.g. [k'pis] 'cold'), but labio+dorsal is unattested (except for one morpheme ([pχ^wi]- 'worry')). The asymmetry between [kp] vs. *[pk] is reminiscent of phonetic properties of labio-velar stops across languages: with such segments, the velar component must precede the labial component (Maddieson and Ladefoged 1989, Maddieson 1990). As noted in Hargus and Beavert (to appear), the velar+labial restriction in Sahaptin suggests a close prosodic relationship between the two consonants, consistent with the tautosyllabic analysis but surprising if these consonants are heterosyllabic. (3) If C₁ is a dorsal stop and C₂ is a sibilant, then if C₁ is [q], C₂ must be [š] ([q'šiš] 'tight-fisted') and if C₁ is [k], C₂ is [s] ([k'sit] 'cold (weather)'). (4) Sequences of fricatives are rare, and are limited to sequences of coronal + dorsal fricatives in that order. (5) If C₁ is dorsal and C₂ is [y], then C₁ is velar, not uvular ([kyaak] 'near', *[qy]).

3.3.2 [i] Epenthesis

A second argument for syllabified clusters concerns the distribution of epenthetic [i] in such clusters. We suggest that epenthetic [i] is added when needed to syllabify clusters; consonant sequences which lack epenthetic [i] are therefore syllabified.

The presence or absence of [i] in the initial clusters of words such as (15) has been subjected to acoustic scrutiny and reported on in Hargus and Beavert (to appear). The presence of [i] in a sonorant initial cluster is clearly visible in Figure 2, in contrast to its absence in the obstruent initial cluster in Figure 1:

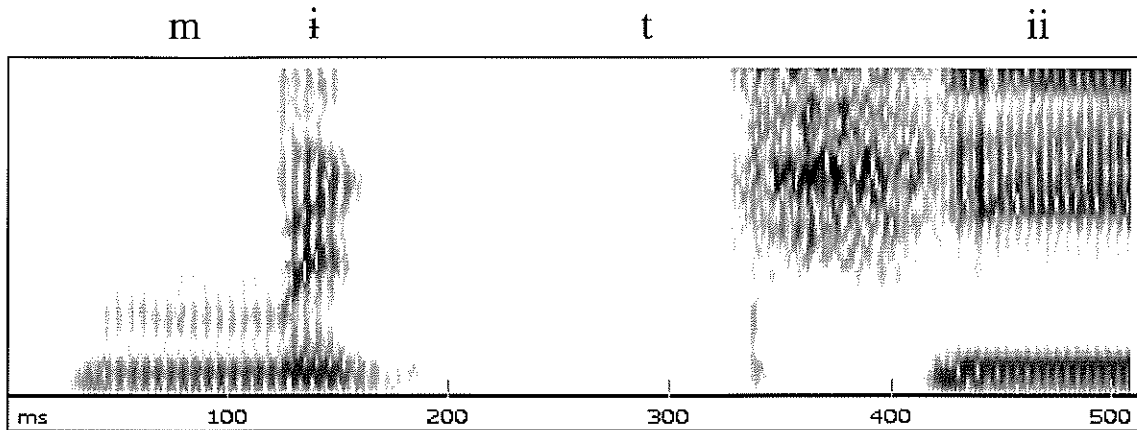


Figure 2. [mitíit] 'damp'

As noted by Hargus and Beavert (to appear), YS has both excrescent and epenthetic [i] in clusters. The truly phonological (as opposed to excrescent) status of the [i] which occurs in the clusters in (15) and Figure 2 is indicated by the fact that epenthetic [i] is (1) consistently present and (2) allows deletion of destressed [i] in reduplication. To understand the last point, note that Sahaptin affixes are either inherently stressed or unstressed.

(19) Some affixes

stressed

pá- INV ('he_i...him_j' etc.)

-lá AGT

unstressed

pa- 3p.NOM¹⁰ ('they')

-(y)i ADJ

Roots have usually been analyzed as lexically marked for stress on the basis of minimal pairs for stress (but see 3.3.3):

¹⁰We follow Rigsby and Rude 1996 in our choice of affix glosses. The affix gloss abbreviations are as follows: 3ABS = 3rd person absolutive, AGT = agentive, INV = inverse, 3p.NOM = 3rd person plural nominative, ADJ = adjective-forming, IMPV = imperfective, IMPER = imperative.

(20)

[pám̩ta] 'nephew'

[pamtá] 'bullfrog'

When a root is affixed with unstressed affixes, as in (21), the root surfaces with its stress and vocalism intact.

(21) [papítʰ'ašaam] 'they're baptizing you'

pa- pítʰ'a- -ša =am

3PL.NOM baptize IMPV 2SG

When a stressed prefix is added to a stressed root, the root stress is deleted, and if the root vowel is /i/, the vowel is deleted, as in (22):

(22) Destressed [i] deletion (CVCV root)

[páptʰ'aša] 'he is baptizing her'

pá- pítʰ'a- -ša

INV baptize IMPV

Destressed [i] deletion does not take place with roots that begin or end in clusters, as in (23):

(23) Destressed [i] deletion (CCVCV root)

ʔáχn̩mk, *ʔáχnmk 'dig it (hole)!'

ʔá- χn̩m -k

3ABS dig hole IMPER.SG

Now consider destressed [i] deletion in forms containing cluster-internal [i]. All of the words in (24) begin with a sonorant initial cluster and hence have undergone [i] epenthesis in both singular and plural. (The plural of inanimate nouns is formed with total reduplication.) Following deletion of destressed [i] in the plural forms, the only remaining vowel in the second morpheme of the reduplicated structure is epenthetic [i] (underlined in (24)), inserted to break up the sonorant-initial cluster.

(24) Destressed [i] deletion (retention of cluster-internal, epenthetic [i])

| | <i>sg.</i> | <i>pl.</i> | |
|--------|------------|------------|----------|
| /ykit/ | yikít | yikít yikt | ‘wild’ |
| /mχiš/ | mīχiš | mīχiš mīχš | ‘yellow’ |
| /mqit/ | miqít | miqít miqt | ‘orange’ |

These data suggest the phonological relevance of cluster internal [i]: were the cluster-internal [i] not present in (24), the deletion of destressed [i] should be blocked since there are no final clusters of the shape [tmqít] (e.g. *[mqítmqít]). In (25), note the lack of deletion of destressed [i] in the reduplicated plural:

(25) Lack of destressed [i] deletion (no cluster-internal, epenthetic [i])

| | <i>sg.</i> | <i>pl.</i> | |
|---------|------------|--------------|---------|
| /q'mit/ | q'mít | q'mít q'mít, | ‘cliff’ |
| | | *q'mít q'mít | |

In (25), deletion of destressed [i] in the second member of the reduplicated word is blocked, because there is no epenthetic vowel within the initial consonant sequence, and because [tq'mít] is not a possible word final consonant sequence. The cluster-internal [i] in the singular forms of (25) is thus referred to by a phonological process of YS, namely destressed [i] deletion.

Thus, there are two types of /CCV/ words, those which are phonetically disyllabic, pronounced [CiCV́], and those which are not clearly disyllabic in this way. Although there are special cases, reported on in Hargus and Beavert (to appear), YS basically disallows two sonorants in syllable initial position: cf. [tmaakt] ‘respect’, /tmna/ [timná] ‘heart’. In our view, epenthetic [i] thus serves the traditional role of syllabifier: [tm] is a well-formed syllable initial; however, [tmn] is too long to be an onset and is syllabified via [i] epenthesis:¹¹

¹¹We assume that [i] lacks a timing unit, which would account for its extra short duration (see Hargus and Beavert 2000).

(26)

```

      σ
    / / | \ \ \
  X X X X X X
  | | | / | |
  t m a k t
      σ   σ
    / \   / \
  X | X X X
  | | | | |
  t i m n a
    
```

3.3.3 Stress

Stress is widely assumed to be a property of syllables. In this section we will discuss evidence from stress which suggests that CCV does not pattern with the disyllables.

3.3.3.1 Trochaic, quantity-sensitive default

Rigsby and Rude 1996 describe stress in Sahaptin as ‘distinctive’. Despite such minimal pairs for stress as (20), there are certain statistical tendencies in stress placement, summarized in (27). Stress in CVCV and CVCCV roots is generally initial or trochaic, whereas stress in CVCVC roots is generally final or iambic. CVVCV and CVCVV roots are poorly attested, but the general tendency is to stress the syllable that contains the long vowel:

(27) Stress patterns in YS roots

| root shape | initial stress | | final stress | | sample size | | |
|---------------|----------------|----------------|----------------|-------|----------------|----|-----|
| | <i>example</i> | % | <i>example</i> | % | | | |
| CV.CV | p'íyu | 'nighthawk' | 78 | hulí | 'wind' | 22 | 119 |
| CV.CVC | ʔámaš | 'owl' | 42 | tamám | 'egg' | 58 | 113 |
| CVC.CV | wáptu | 'potato' | 76 | muxlí | 'fly' | 24 | 41 |
| CVV.CV | míimi | 'already' | 66 | miimá | 'old' | 37 | 6 |
| CV.CVV | málaa | 'insufficient' | 37 | małáa | 'clean' | 66 | 12 |

If stress occurred randomly on syllables in underlying representations, we would expect something closer to 50% in the columns of percentages in (27). Thus, the statistical tendency is for YS stress to be trochaic and quantity-sensitive, where coda consonants, like long vowels, contribute to syllable weight. We therefore suggest that roots are either underlyingly marked for stress (required for CVCV́, ĆVCVC, CVVCV́, and ĆVCVV), or not marked for stress, in which case they receive default stress assignment (ĆVCV, CVCV́C, ĆVVCV and CVCV́V). The lexical representations of roots are thus parallel to those of affixes, which, as discussed above, are also either underlyingly stressed or unstressed.

(28) Root stress

lexically specified: CVCV́, ĆVCVC, CVVCV́, ĆVCVV

predictable from

quantity-sensitivity: CVCV́C, ĆVVCV, CVCV́V

from left-headedness: ĆVCV

3.3.3.2 CCV is not disyllabic

Now let us consider the possibility that the initial C in CCV forms a syllable on its own. Regardless of whether epenthetic [i] is present or not, the initial C is never stressed. If CCV were a type of disyllable, C.CV, then the stress pattern in such words contrasts with the statistically unmarked stress pattern of disyllables containing two light

syllables. Although in the theory of Cho and King (to appear), demi-syllables are predicted to be prosodically invisible, we noted above that this prediction does not hold for the minor syllables of Mon-Khmer languages, which can be tone bearing.

Let us also compare stress patterns in trisyllabic roots with those in CCVCV

roots:

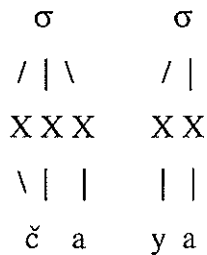
(29) Stress patterns in CVCVCV and CCVCV roots

| | | <i>example</i> | <i>%</i> | sample size |
|--------|------------------|----------------------|------------------------|-------------|
| CVCVCV | initial σ | pátaši | 'quail' 21.6 | 37 |
| | medial σ | ʔanáwi- | 'be hungry' 56.8 | |
| | final σ | k ^w ayawí | 'mountain lion' 21.6 | |
| CCVCV | initial "σ" | | 0 | 29 |
| | medial σ | ččáya | 'juneberry' 90 | |
| | final σ | tk ^w alá | 'trout, small fish' 10 | |

If CCVCV were a type of trisyllable, then the absence of stress on the initial syllable of such roots contrasts with the pattern seen with CVCVCV roots: we would expect initial stress to be at least as common with such roots as final stress.

On the other hand, if we consider CCVCV to be a type of disyllable, represented as shown in (30), does the percentage of trochaic (presumably predictable) and iambic (lexically specified) stress patterns fall within the range of variation seen with CVCV roots?

(30)



The percentage of trochaic CCVCV roots is larger at 90% than the percentage of trochaic CVCV roots, but a two-tailed *t* test which compares the percentage of trochaic roots in both groups shows that the difference is not significant.

However, note the difference in sample size between the CVCV and CCVCV groups. The CVCV root set will always be larger than the CCVCV root set, since clusters are universally less common than single consonants (Greenberg 1978). To see if the 90% trochaic pattern is within the realm of possibility for a hypothetically smaller set of CVCV roots, we divided the larger, CVCV set into 4 random groups, and performed the randomization 25 times, resulting in 100 samples of 25.¹² In doing so, we are simply replicating a basic premise of statistical theory, that each time a population is sampled, there will be some variation in the computation performed on the sample. In (31) we compare the sampling variation found in our 100 25-sample CVCV roots with our single 25-sample CCVCV root collection. The range of percentage of initial stress for each group is given in (31):

(31) Stress patterns in 4 x 25-n samples of (C)CVCV roots

| | | % trochaic |
|-----------|-------------------|------------|
| CVCV | 100 samples of 25 | 60-96 |
| cf. CCVCV | 1 sample of 25 | 90 |

90% thus falls within the range of trochaic patterns in 100 random samples of CVCV roots.

4 Conclusion

We have suggested that YS CCV cannot be analyzed as a type of disyllabic minimality for language-internal reasons. The data we have reviewed in this paper are summarized in (32):

¹²We thank Richard Wright for helpful discussion.

(32)

| <i>phenomenon</i> | <i>interpretation</i> |
|--------------------------------|--|
| Minimality | CCV and CVC are robust minimal word shapes |
| Place restrictions on CC | CC are syllabified |
| Distribution of unstressed [i] | contrast between phonetic disyllabic [CiCV] and monosyllabic [CCV] |
| Stress placement | initial consonants of clusters are never stressed |

For theoretical reasons (Gordon 1999), CCV cannot be analyzed as bimoraic minimality. Then what sort of minimality does CCV represent? We propose that the YS pattern of minimal CVC, CCV is a new type of minimality, biconsonantal minimality, which so far appears to be poorly attested cross-linguistically. On the other hand, reinspection of the literature on bimoraic minimality may turn up additional cases of this type.

5 References

- Aoki, Haruo. 1994. *Nez Perce Dictionary*. Berkeley: University of California Press.
- Bagemihl, Bruce. 1991. Syllable Structure in Bella Coola. *Linguistic Inquiry* 22:589-646.
- Bagemihl, Bruce. 1998. Maximality in Bella Coola (Nuxalk). In *Salish Languages and Linguistics: Theoretical and Descriptive Perspectives*, edited by E. Czaykowska-Higgins and M. D. Kinkade.) Berlin: Mouton de Gruyter, 71-98.
- Cho, Young-mee Yu and Tracy Holloway King. to appear. Semi-Syllables and Universal Syllabification. In *The Syllable in Optimality Theory*, edited by C. Féry and R. van der Vijner.) Cambridge: Cambridge University Press.
- Crowhurst, Megan. 1992. Diminutives and augmentatives in Mexican Spanish: a prosodic analysis. *Phonology* 9:221-254.
- Davis, Stuart. 1999. On the representation of initial geminates. *Phonology* 16:93-104.
- Gordon, Matthew. 1999. *Syllable Weight: Phonetics, Phonology, and Typology*. Ph.D., Linguistics, UCLA, Los Angeles.

- Greenberg, Joseph H. 1978. Some Generalizations Concerning Initial and Final Consonant Clusters. In *Universals of Human Language*, Vol. 2. Phonology, edited by J. H. Greenberg.) Stanford: Stanford University Press, 243-279.
- Hammond, Michael. 1999. *The Phonology of English: A Prosodic Optimality-Theoretic Approach*. Oxford: Oxford University Press.
- Hargus, Sharon and Virginia Beavert. 2000. *Predictable vs. underlying vocalism in Yakima Sahaptin*. Ms., University of Washington and Heritage College, Seattle and Toppenish.
- Hargus, Sharon and Virginia Beavert. to appear. Yakima Sahaptin clusters and epenthetic [i-]. *Anthropological Linguistics*.
- Hargus, Sharon and Siri G. Tuttle. 1997. Augmentation as Affixation in Athabaskan Languages. *Phonology* 14:177-220.
- Hayes, Bruce. 1989. Compensatory lengthening in moraic phonology. *Linguistic Inquiry* 20:253-306.
- Hume, Elizabeth, Jennifer Muller, and Aone van Engelenhoven. 1997. Non-moraic geminates in Leti. *Phonology* 14:371-403.
- Hyman, Larry. 1992. Moraic mismatches in Bantu. *Phonology* 9:255-265.
- Itô, Junko. 1990. Prosodic Minimality in Japanese. *Chicago Linguistic Society* 26 (V. 2: The Parasession on the Syllable in Phonetics and Phonology):213-239.
- Jacobs, Melville. 1931. A sketch of Northern Sahaptin grammar. *University of Washington Publications in Anthropology* 4:85-291.
- Kager, René. 1990. Dutch schwa in moraic phonology. In *Papers from the 26th Regional Meeting of the Chicago Linguistics Society. Volume 2: Parasession on the syllable in phonetics and phonology*, edited by M. Ziolkowski, M. Noske and K. Deaton.) Chicago: Chicago Linguistic Society, 241-56.
- Leer, Jeff. 1979. *Proto-Athabaskan Verb Theme Categories: I. Phonology*. Fairbanks: Alaska Native Language Center.
- Lin, Yen-Hwei. 1997. Syllabic and moraic structures in Piro. *Phonology* 14:403-436.
- Maddieson, Ian. 1990. Shona velarization: complex consonants or complex onsets? *UCLA Working Papers in Phonetics* 72:16-34.

- Maddieson, Ian and Peter Ladefoged. 1989. Multiply articulated segments and the feature hierarchy. *UCLA Working Papers in Phonetics* 72:116-138.
- McCarthy, John and Alan Prince. 1986. *Prosodic Morphology*. Ms., Linguistics, University of Massachusetts Amherst and Brandeis University.
- McCarthy, John and Alan Prince. 1990. Prosodic Morphology and Templatic Morphology. In *Perspectives on Arabic Linguistics II*, edited by M. Eid and J. McCarthy.) Amsterdam/Philadelphia: John Benjamins Publishing Co., 1-54.
- McCarthy, John J. and Alan S. Prince. 1995. Faithfulness and Reduplicative Identity. In *University of Massachusetts Occasional Papers in Linguistics 18: Papers in Optimality Theory*, edited by J. Beckman, S. Urbanczyk and L. Walsh. (University of Massachusetts Occasional Papers in Linguistics, 18.) Amherst: Graduate Linguistics Student Association, 249-384.
- Morelli, Frida. 1999. *The phonotactics and phonology of obstruent clusters in Optimality Theory*. Ph.D., Linguistics, University of Maryland at College Park, College Park.
- Nespor, Marina and Irene Vogel. 1986. *Prosodic Phonology*. Dordrecht: Foris.
- Pulleyblank, Douglas. 1988. Vocalic Underspecification in Yoruba. *Linguistic Inquiry* 19:233-270.
- Rude, Noel. 1999. *Data for a Nez Perce Phonology*. Ms.
- Shaw, Patricia. 1992. Templatic evidence for the syllable nucleus. In *Proceedings of NELS 23*.) Amherst, MA: Graduate Student Linguistic Association, 463-477.
- Shaw, Patricia. 1993. The prosodic constituency of minor syllables. In *Proceedings of the West Coast Conference on Formal Linguistics 12*, edited by E. Duncan, D. Farkas and P. Spaelti.) Stanford: CSLI, 117-132.
- Sloan, Kelly. 1988. Bare-Consonant Reduplication: Implications for a Prosodic Theory of Reduplication. *WCCFL* 7:319-330.
- Spring, Cari. 1991. How many feet per language? In *The Proceedings of the Ninth West Coast Conference on Formal Linguistics*, edited by A. Halpern.) Stanford: CSLI.
- Steriade, Donca. 1982. *Greek Prosodies and the Nature of Syllabification*. Ph.D., Linguistics, Massachusetts Institute of Technology, Cambridge MA.
- Steriade, Donca. 1999. Alternatives to the syllabic interpretation of consonantal phonotactics. In *Proceedings of LP'98 : Item order in language and speech*,

edited by O. Fujimura, B. Joseph and B. Palek.) Prague: Charles University Press (Karolinum), 205-242.

Urbanczyk, Suzanne. 1996. *Patterns of Reduplication in Lushootseed*. Ph.D., Linguistics, University of Massachusetts, Amherst.

Wright, Richard. 1996. *Consonant clusters and cue preservation in Tsou*. Los Angeles: UCLA Department of Linguistics.

Quality-sensitive stress reconsidered

Sharon Hargus*

University of Washington

sharon@u.washington.edu

1 Introduction

1.1 *Quality-sensitive stress*

Kenstowicz 1996 has drawn attention to a number of cases of ‘quality-sensitive stress’ (hereafter QLS), the hallmark of which is that vowel quality plays a role in determining the location of stress, similar to the role that vowel quantity plays in quantity-sensitive (QS) stress languages. For example, the Kobon vowel inventory has three levels of height as well as a peripheral/central¹ distinction (Kenstowicz 1996):

(1)

| | | |
|---|---|---|
| i | ĩ | u |
| | e | ə |
| | | o |
| | | a |

Kobon stress data provide evidence for the following metrical peak rankings:

(2) Peak_{Foot} a > e, o > i, u > ə > ĩ

Stress falls on the penultimate syllable when the two rightmost syllables contain vowels of equal rank according to the scale in (2):

(3)

| | |
|-----------|------------------------------|
| dúbu#dúbu | ‘to make noise by footsteps’ |
| kijĩgil | ‘tattoo’ |

Stress falls on the final syllable when the vowel of the final syllable outranks that of the penultimate syllable according to the scale in (2):

*This article was presented to colloquium audiences at UC Irvine, U. Alberta, and UBC, and has benefited enormously from the comments of Bernard Tranel, Robert Kirchner, Terry Neary, Sally Rice, Doug Pulleyblank, and Pat Shaw. Thanks also to Susie Levi and Ellen Kaisse, who provided valuable comments on the current version.

(4)

| | | |
|-----------------|-----------|----------------|
| $i < \emptyset$ | gisó#gisó | ‘to tap’ |
| $i < o$ | si.óg | ‘bird species’ |
| $i < a$ | ki.á | ‘tree species’ |
| $o < a$ | kidolmáN | ‘arrow type’ |

Kenstowicz 1996 presented about half a dozen cases of QLS in support of the generalized metrical peak constraints in (5).

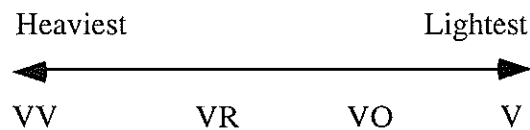
(5) Preferred nuclei (stress)

- a. Peak_{Foot} a, ä > e, o > i, u
 b. Peak_{Foot} a, ä, e, o, i, u > \emptyset

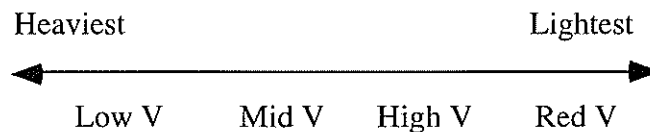
More recently, the results of Kenstowicz’ small survey have been bolstered by the large-scale survey of weight criteria in [Gordon, 1999 #577], who examined 388 languages and found that of the 127 languages which have weight-sensitive stress, syllable weight can be reduced to two independent hierarchies of weight for stress, summarized in (6)a-b.

(6)a. Universal hierarchies of weight for stress proposed by Gordon 1999

a.



b.



In Gordon’s survey, the scale in (6)a. is much better attested among the world’s language than is (6)b. Only 12 languages in his survey utilized the weight hierarchy in (6)b.

¹‘We consider a vowel “central” if it is bounded on either side of the vowel triangle by another vowel: thus, schwa is bounded by [e] and [o], and [i] is bounded by [i] and [u].’ Kenstowicz 1996:164.

1.2 *Quality-sensitivity and duration*

In this article I suggest that quality-sensitive stress can be considered a special case of quantity-sensitive stress, and requires no metrical peak-specific formalization. I present two new cases of QLS from Sahaptin and Witsuwit'en, unrelated Native American languages. Both languages contain vowel inventories with one central vowel, and in both languages the central/peripheral distinction is referred to by various phonological phenomena, not just stress. These languages are thus in accord with the Indo-European languages Dutch, Norwegian and French, which, as noted by Oostendorp 2000, also exhibit special distributions of [ə] with respect to not only stress but other syllable and positional properties. Thus separate scales for syllable peaks and metrical peaks are not needed in the grammars of Sahaptin and Witsuwit'en.

In both Sahaptin and Witsuwit'en, the central vowels are demonstrably shorter in duration than the peripheral vowels. I suggest that the phonological properties of central vowels in these languages have their roots in inherent durational properties of central vowels, as Kenstowicz in fact suggested (p. 185):

it is a well-known phonetic universal that vowel duration is correlated with height (Lehiste 1970)...Duration is one of the primary cues for stress. Thus, in the languages studied here stress exhibits a preference for vowels which more optimally express one of its primary perceptual correlates.

Kenstowicz notes that the authors of the description of Mari, one of the languages discussed in his article, mention that the central vowels of the Northwest dialect of Mari have a "weak articulation" and are "very short" though they provide no measurements of duration.' (p. 185) Gordon 1999:54 also notes that 'in languages in which centralized vowels are light, they are characteristically quite short.'

The new cases presented here thus support Kenstowicz's and Gordon's hypotheses that QLS may stem from durational differences between central and peripheral vowels, and cast doubt on the existence of quality-sensitive stress, at least the central/peripheral type, as a primary phenomenon independent of quantity-sensitivity. Thus, in place of *Peak/central >> *Peak/peripheral, I will suggest the ranking in (7):

(7) *P/ǃ >> *P/V

That is, extra short vowels make worse peaks (syllable, metrical) than less short vowels.

2 Sahaptin

In Sahaptin (Sahaptian), evidence from stress, diphthongs and the distribution of long vowels suggests a general, not just metrical, dispreference for the central vowel [ɨ]. All Sahaptin data presented here are from the Yakima dialect. Complete descriptive accounts of these data and other issues can be found in Hargus and Beavert 2000a and Hargus and Beavert 2000b.

2.1 Vocalism

The Sahaptin vowel inventory is provided in (8):²

(8) Sahaptin vowel inventory

i, ii ɨ u, uu
 a, aa

In Hargus and Beavert 2000a we provided phonetic measures of vowel duration which indicate that [ɨ] is phonetically shorter than the other vowels. Average duration for stressed long peripheral vowels, short peripheral vowels, and /i/ is graphed in Figure 1 and summarized in (9). (See Hargus and Beavert 2000a for word lists and methodology.)

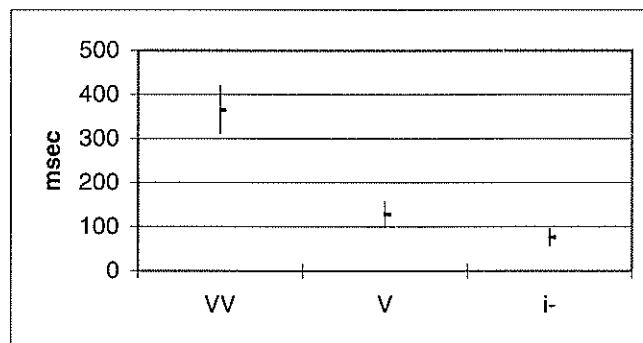


Figure 1. Average vowel duration in stressed final syllables (± 1 standard deviation)

²Previous analysts of Sahaptin have disagreed as to the phonological status of [ɨ]; i.e., whether it is underlying or entirely predictable. Hargus and Beavert 2000a argue that whereas unstressed [ɨ] in YS is predictable, stressed [ɨ] is not.

(9) Average vowel duration (msec). Standard deviations are parenthesized.

| | VV | V (i a u) | i |
|----------|------------|------------|-----------|
| duration | 365 (55.8) | 129 (29.7) | 76 (20.3) |
| n | 45 | 45 | 18 |

As can be seen from (9), in stressed word final syllables, long vowels are about three times as long as their short counterparts, and short /i a u/ are slightly more than 50% longer than /i/.

Figure 2 is an acoustic graph of vowel qualities (also taken from Hargus and Beavert 2000a).³

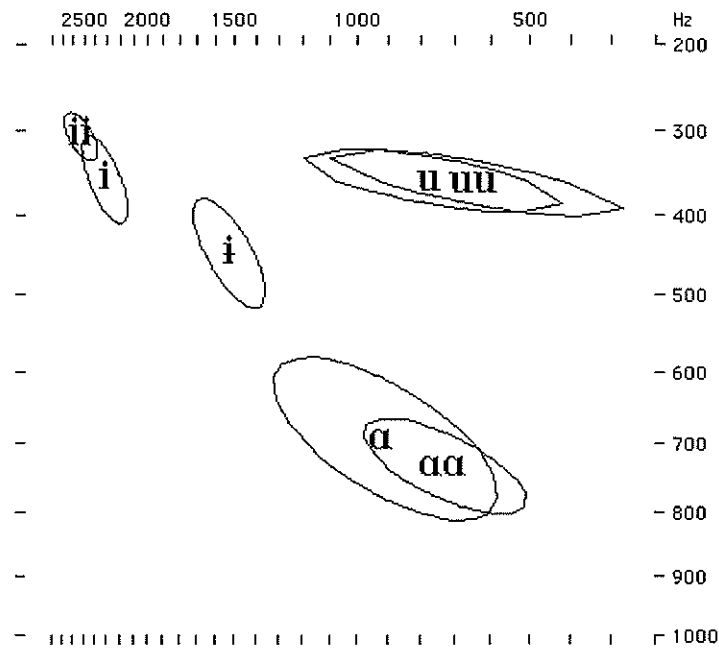


Figure 2. Long and short vowel qualities (F2 vs. F1).

(The radius of the ovals is one standard deviation.)

Note that the shorter durational properties of [i] and its more central location in the vowel space are reflected, to a lesser extent, by the peripheral vowels, suggesting that as duration increases, so does the peripherality of a vowel in the vowel space.

³Vowels were measured in two types of syllables, surrounded by labial consonants and surrounded by coronal consonants.

We will see that YS provides evidence for the ranking in (10), broadly conceived as avoidance of central vowel metrical and syllabic peaks.

(10) *P/i >> *P/i,a,u (after Kenstowicz 1996 and Gordon 1999)

One such avoidance is apparent in the set of possible diphthongs, or tautosyllabic vowel sequences. As discussed in Hargus and Beavert 2000a, the Sahaptin peripheral vowels occur, long or short, in combination with /w y/, so long as identical place sequences are avoided:⁴

(11) Vw, Vy

| | w | y |
|---|--|---|
| i | ʔiiwš ‘urine’ kiwkíwlas ‘handheld rawhide drum’ | -- -- |
| a | ppaaw ‘bullsnake’ šp’aw ‘ball’ | yaay ‘beargrass’ ʔáyʔay ‘magpie’ |
| u | -- -- | quyχ ‘white (animate)’ huuy ‘unable, vainly’ |

However, unlike the peripheral vowels, the central vowel [i] does not occur in diphthongs.

Donegan 1985 notes that in falling, out-gliding diphthongs of the sort found in Sahaptin ‘the syllabic [element] is given the role of sonority-bearer and it is lowered and often bleached [depalatalized and/or delabialized] to maximize this sonority.’ Thus there is an incompatibility between the asonorous [i] and the preference for a ‘sonority-bearer’ as the syllabic portion of the diphthong. In Dutch, Oostendorp 2000 notes that [ə] does not occur either post-vocally or pre-vocally. The absence of [i] in Sahaptin diphthongs is therefore one piece of evidence for the proposed ranking of markedness constraint in (10). Notice that the patterning of vowels in diphthongs does not refer to the stress system.

2.2 *Stress*

2.2.1 Avoidance of stressed [i]

Rigsby and Rude 1996 describe stress in Sahaptin as ‘distinctive’, apparently indicating that the location of stress must be lexically marked, as suggested by the near-minimal set for stress in (12).

(12)

| | |
|----------------------|-------------------------|
| wáwina- | ‘sing one verse’ |
| ʔanáwi- | ‘be hungry’ |
| k ^w ayawí | ‘cougar, mountain lion’ |

However, in a study of stress patterns in 119 CVCV nouns, verbs and adjectives in their corpus, Hargus and Beavert (this volume) found that 78% of such lexical items have trochaic stress, and 22% have final stress. Thus, despite the evidence of (12), there appears to be a strong trochaic tendency in Yakima Sahaptin: we suggest that stress is assigned trochaically unless lexically specified. Another trend not apparent from (12) is the avoidance of stressed [i].⁵ Only 9% of 119 CVCV roots contain stressed [i]:

⁴As noted by Stampe 1972, this is common in falling, out-gliding diphthongs: ‘diphthongization does not affect nonchromatic vowels’ (i.e. aa does not diphthongize) ‘and is therefore to be understood as a polarization of color’.

⁵There is no evidence that [a] is less marked as stress peak than [i u]. In fact, in the 119 CVCV words, [í ú] occur in 51%, as opposed to [á] in 40% and [i] in 10%. In the trochaic subset, [í ú] occur in 53%, vs. [á] in 36% and [i] in 11%.

(13) Stressed vowels in 120 CVCV roots

| | | | | # | |
|----------|---------|--------|-----------------------|----|-------|
| trochaic | á a | wána- | ‘flow’ | 22 | (18%) |
| | í/ú a | číwa | ‘Dolly Varden’ | 24 | (20%) |
| | á i/u | tápu | ‘marrow’ | 15 | (13%) |
| | í/ú i/u | k’úsi | ‘horse’ | 22 | (18%) |
| | í a | tlípa | ‘fox’ | 7 | (6%) |
| | í i/u | kítu | ‘fast’ | 3 | (3%) |
| iambic | a í/ú | mamí | ‘many’ | 12 | (10%) |
| | a á | ?asá | ‘fingernail, toenail’ | 6 | (5%) |
| | i/u í/ú | hulí- | ‘(wind) blows’ | 3 | (3%) |
| | i/u á | luts’á | ‘red’ | 5 | (4%) |
| | a í | | | 0 | |
| | i/u í | | | 0 | |

The absence of iambically stressed final [i] in CVCV roots is part of a larger pattern of avoidance of root or word-final [i]. Whereas the peripheral vowels [i a u] can occur root or word-finally, stressed or unstressed, the central vowel [i] does not occur, stressed or unstressed in root or word final position.⁶

(14) Root-final [i a u]

| | | | |
|--------|----------------|-------|------------------------|
| χaaslú | ‘star’ | wáptu | ‘potato’ |
| χmimsá | ‘hummingbird’ | wána- | ‘flow’ |
| hulí- | ‘(wind) blows’ | tqúni | ‘hole (in the ground)’ |

If stress were randomly assigned to vowels, we would expect 25% of trochaically stressed roots to contain [í] (since there are four vowels).

(15) 87 trochaically stressed roots

Observed stressed [í] 11%

Expected stressed [í] 25%

This fact alone suggests that (10) has played at least a historical role in the phonology of YS.

2.2.2 Stress deletion

Alternations between [í] and zero, seen in stress deletion contexts, indicate that (10) plays a synchronic role as well. To make this point, it is necessary to provide additional detail about the stress system.

As just seen, stress may be lexically specified on the morpheme level, the trochaic default notwithstanding. There appear to be no stressless roots. As in neighboring Salish languages (e.g. Columbian, Czaykowska-Higgins 1993), affixes divide into two groups with respect to stress: some affixes are underlyingly stressed (16) and others are unstressed (17):

(16) Some stressed affixes

/ʔá/- v[___]v[third person absolutive

-/ʔá/]v___]N agent

/pá/- v[___]v[inverse

(17) Some unstressed affixes

/pa/- v[___]v[third person plural nominative

-/ta/]v___]v future tense

We suggest that surface primary stress is determined as follows:

(18) suffix > prefix > root

That is, an inherently stressed prefix shifts main stress off a root, whether that root has lexically specified stress or regularly assigned stress, as is the case with [q'ínu]- 'see'.

⁶Below we will suggest that the absence of final [í] receives a principled explanation in

(19) páq'ínuša 'he sees him'

| | | |
|-----|-------|------|
| pá- | q'ínu | -ša |
| INV | 'see' | IMPV |

A stressed suffix shifts stress off a stressed root or stressed prefix (20):

(20) maykwatałá 'one who eats breakfast'

| | | |
|---------|--------|-----|
| may- | tkwáta | -łá |
| morning | eat | AGT |

Root stress therefore only surfaces with unstressed affixes.

(21) paq'ínuša 'they see him'

| | | |
|---------|-------|------|
| pa- | q'ínu | -ša |
| 3PL.NOM | see | IMPV |

2.2.3 Destressed [i] deletion

Stress deletion has different consequences for [i] than it does for the peripheral vowels. Roots containing [i] exhibit loss of [i] along with stress deletion when syllable structure conditions permit (see Hargus and Beavert 2000a for details).

When a root containing [i] such as [pítl'a]- 'baptize' is affixed with stressless affixes, the stress surfaces on the root vowel [i]:

(22)

paḗtl'ašaam 'they're baptizing you (sg.)'

| | | | |
|---------|---------|------|-----|
| pa- | pítl'a- | -ša | =am |
| 3PL.NOM | baptize | IMPV | 2SG |

However, when affixed with a stressed affix, the root stress is lost, and along with it, [i]:⁷

terms of Final Lengthening.

⁷There are certain complications involving stressed suffixes. See Hargus and Beavert 2000a for more information.

(23) Stressed prefix

páptl'aša 'he/she is baptizing him/her'

pá- pítl'a- -ša

INV baptize IMPV

(24) Stressed suffix

paptl'ašá 'priest' (lit. 'baptizer')

pá- pítl'a- -šá

INV baptize AGT

Note that vowels other than [i] are not deleted as a consequence of stress removal:

(25)

páčatikša 'he's ringing it'

pá- čátik -ša

INV ring bell IMPV

cf. [čt] in [pačt] 'woman's younger brother/male cousin'

ʔáwχinaaš 'I lost it'

ʔá- wχí -na =aš

3ABS lose PST 1SG

cf. [χn] in [taχnútway] 'playmate, relative'.

Destressed [i] deletion therefore provides evidence for the ranking of vowels in

(10). The constraint Max-V (preserve underlying vocalism) intervenes between *P/i and

*P/i,a,u in the ranking hierarchy:

(26) *P/i >> Max-V >> *P/i,a,u

| | *P/i | Max-V | *P/i,a,u |
|-------------|------|-------|----------|
| /ʔá-pítya/ | | | |
| [ʔápítya] | *! | | |
| → [ʔáptya] | | * | |
| /ʔá-wχí-na/ | | | |
| → [áwχina] | | | * |
| [ʔáwχna] | | *! | |

Notice that *P/i and *P/i,a,u are independent of stress. These constraints simply evaluate the need for [i] vs. the peripheral vowels as syllable peak. When [i] is not needed for stress or syllabification, this vowel is preferably deleted.

2.3 If central then short in Sahaptin

In the preceding sections, we have seen evidence of the markedness of [i] relative to the peripheral vowels in YS. All of the properties listed in (27) are among the special properties of [ə] in Dutch, French and/or Norwegian noted by Oostendorp 2000.

(27) Properties of [i] in Sahaptin

| | |
|-------------------|--|
| stress | [i] rare relative to [í ú á] |
| destressed nuclei | [i] deletes; [i a u] do not |
| diphthongs | [i] absent from diphthongs; [i a u] possible |
| final position | [i] non-existent; [i a u] well-attested |

Notice that only one of these phenomena refers to stress outright. I therefore propose that one and the same markedness hierarchy is active in Sahaptin. (10), based on Kenstowicz 1996 and Gordon 1999, states that central vowels are more marked than peripheral vowels. I suggest that (10) may be generalized still further, as (28):

(28) *P/V >> *P/V

That is, the markedness of central vowels relative to peripheral vowels may be regarded as a special case of the markedness of short vowels relative to modal length vowels. I suggest that (28) follows from (10) via (29):

(29) If central then short./If long then peripheral.

There is ample cross-linguistic evidence to support (29). In Nawuri, central vowels are phonetically shorter than peripheral vowels (Rod Casali, personal communication to Robert Kirchner mentioned in Kirchner 1997). Casali 1995:651 also notes that ‘long vowels never centralize’. Ladefoged and Maddieson 1996 note (p. 109) that ‘lax vowels of all kinds are normally taken to be more centralized.’ The non-low lax vowels [ɪ ʊ ɛ] of English are centralized as compared to their tense counterparts [i u e] (e.g. Peterson and Barney 1952, Hillenbrand, Getty et al. 1995, Hagiwara 1995 (although Peterson and Barney did not measure [e])). Peterson and Lehiste 1960 found that of the vowels and diphthongs of English, [ɪ ʊ ɛ ə] had the shortest duration. In Tsou (Austronesian), which has /i i:/ (as well as five peripheral vowels), Wright 1996:32 notes that ‘words with [i:] are rare even though the short vowel i is quite common’.

Within the grammar of YS, we have seen phonetic support for (29) from duration figures and from the interaction of duration and vowel quality in YS. The central vowel has about two-thirds the duration of the combined peripheral vowels, and as noted above, the long peripheral vowels are more peripheral in the vowel system than the short peripheral vowels.

It is also immediately apparent that (29) has been phonologized in the vowel system to the extent that whereas /i a u/ have long counterparts, there is no long /i/ in YS. This point is reinforced in morphological contexts which require long vowels, such as in the formation of stative adjectives from lexical items of other categories. In such cases, [i] lengthens to [ii] or [aa]:

(30) Base [i]: lengthening + ablaut

| <i>base</i> | | <i>lengthened + ablauted stem</i> | |
|-------------|-----------------|---------------------------------------|---------------------------------|
| k'pɪs | 'cold (object)' | k'paas | 'cool, cooled down' |
| šlɪp | 'dizzy' | šlaap | 'woozy' |
| k'pɪt | 'bead' | k'piit | 'round, spherical; baseball' |
| χmɪt | 'ridged' | χmɪit χmiit | 'cantaloupe' |

Although the quality of the lengthened vowel is not entirely predictable, the main point is that the lengthened vowel is not [iɪ]. The peripheral vowels generally simply lengthen with no quality change:

(31) Lengthening of /i a u/ (many examples)

| <i>base</i> | <i>base gloss</i> | <i>ablauted stem</i> | <i>gloss</i> |
|-------------|-------------------|----------------------|--------------------------|
| k'puɫ | 'short' | k'puuɫ | 'really short' |
| q'li- | 'bend' | q'lii | 'rounded, bent, crooked' |
| ɬkápni | 'lazy' | ɬkaap | 'tired' |

(Note that the data in (31) indicate that the [i] of the (e.g.) [i]~[aa] alternation cannot be the result of shortening and neutralization of [aa] to [i]: [aa] would also shorten to [a].)

These facts then provide evidence for (a portion of) (29): if the central vowel is required to be long, as it is in certain morphological contexts, then it must be peripheral.

Another context where long vowels may be required is in final position. Kirchner 1997 has motivated a Phrase-Final Lengthening constraint:

(32) Phrase-Final Lengthening: V]_{Phrase} → [+partially long]

(32) is a Grounding Condition in the sense of Archangeli and Pulleyblank 1994, who propose (p. 167) that 'conditions used in natural language directly reflect physical correlates of the F-elements involved.' There is also a fair amount of cross-linguistic evidence for (32). In Thompson (Thompson, Thompson, and Egesdal 1996:615), /i a u/

do not reduce to [ə] in certain contexts, one of which is word-finally. Kirchner 1997 has noted that in Nawuri (Casali 1995), the short, front vowels centralize except when word final or word initial. There is an extensive instrumental phonetic literature showing that segments are lengthened word finally and/or phrase finally (e.g. Oller 1973, Beckman and Edwards 1990). In English the lax vowels (apart from [ə]) do not occur in word final position (e.g. Wells 1982). Compare also Standard German, in which [ɪ y ε œ u ɔ], ‘the short full lax nonlow vowels’ do not occur in word final position (Hall 1999:109).⁸ In Jicarilla Apache, [Tuttle, to appear #555] finds that rhymes (including coda consonants) lengthen in phrase final position, whereas onsets lengthen in other stressed positions. Oostendorp 2000 notes that epenthetic [ə] does not occur word finally in Dutch and Norwegian, and that ‘word-peripheral positions are disallowed for schwa-like vowels in many languages’ (p. 228). Gordon 1999:201-202 notes that in Javanese, “reduced vowels do not appear in open word-final syllables in the native vocabulary, presumably in order to avoid lengthening reduced vowels in final position, a common position for vowel lengthening (Wightman et al. 1992). A similar avoidance of lengthened reduced vowels is found in Yupik in which underlying reduced vowels in word-final position become the low vowel /a/ which is more amenable to lengthening (Reed et al. 1977).”

We have seen that YS does not allow central vowels in root or word final position. This is also evidence of the incompatibility of central vowels, which are inherently short, with final position, a position which is frequently associated with length.

2.4 Summary of Sahaptin

We began this section with the markedness constraint inherited from Kenstowicz’s study, *P/i >> *P/V. We saw that this constraint receives support from stress-related phenomena in YS, but that it must be generalized beyond stress to account for a range of other phonological phenomena. I have suggested that the diverse phenomena summarized in (33) are best understood in terms of inherent durational differences between [i] and the peripheral vowels of Sahaptin. We have seen that [i] is

⁸Hall posits a word level phonotactic Lax Vowel Constraint: *[-tense, -low, -long]]_w.

phonetically shorter than the peripheral vowel, does not occur word finally, and must undergo a quality change in morphological lengthening contexts. Unlike the peripheral vowels, [ɨ] does not occur in diphthongs, and deletes under certain conditions.

(33)

| | <i>phenomenon</i> | <i>explanation</i> |
|---------------------|---|--|
| stress | [ɨ] rare relative to [í ú á] | stress frequently realized as longer duration |
| destressed nuclei | [ɨ] deletes; [i a u] do not | shorter vowels delete |
| diphthongs | [ɨ] absent from diphthongs; [i a u] possible | most sonorous member of diphthong should have greater duration (?) |
| final position | [ɨ] non-existent; [i a u] well-attested | final segments are long |
| phonological length | [ɨ] has no long counterpart; lengthens to [ii] or [aa] | central vowels are inherently short |

I have suggested that if central vowels are inherently shorter than peripheral vowels, then the markedness of central vowels might be seen as a special case of the markedness of extra-short vowels. In the next section I will present additional evidence from an unrelated language for the proposal “If central then short/if peripheral then long” and for the markedness of short vowels.

3 Witsuwit’en

Witsuwit’en [wətsúwət’èn] is a dialect of the Bulkley Valley-Lakes District (BVLD) language, an Athabaskan language which has also been known as Babine, Northern Carrier, Western Carrier, Babine/Witsuwit’en, and Witsuwit’en/Babine, among other names.

Witsuwit’en has, on the face of it, a quality-sensitive stress system in which central vowels are not stressed in certain contexts where peripheral vowels must be stressed, thus providing primary evidence for QLS. However, Witsuwit’en contains

additional phonological asymmetries between /ə/ and the other vowels, which I suggest may also be explained in terms of durational differences between /ə/ and the peripheral vowels.

3.1 Vocalism

Following Hildebrandt and Story 1974 and Story 1984:25, I posit the following vowel inventory for Witsuwit'en:

(34) Witsuwit'en vowel inventory

| | | |
|-------|-------|-------|
| i, ii | | u, uu |
| e, ee | ə | o, oo |
| | a, aa | |

The long peripheral vowels are rare in morphologically non-derived forms. See 3.3.1.

Witsuwit'en provides phonetic evidence for the proposal in that central vowels are shorter than peripheral vowels. Figure 3 presents durational data for five of the vowels from six speakers (see Hargus in preparation-b for additional information). (For historical reasons, the vowel /a/ is rare in certain consonantal contexts, and was not included in this data set.) The vowels in Figure 3 divide into three sets: the mid vowels [e o] are the longest, averaging 144 msec; the high vowels [i u] (average 121 msec) are shorter than the mid vowels; and the central vowel [ə] has less than half the duration of the high vowels, averaging 46 msec.

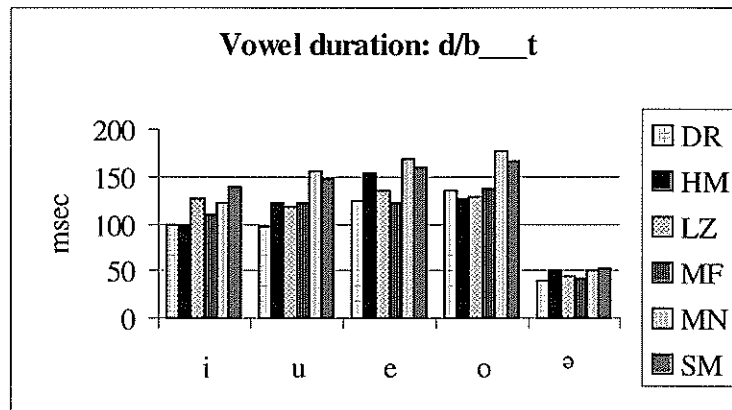


Figure 3. Witsuwit'en vowel duration.

These studies show that /ə/ has roughly half the duration of a peripheral vowel in stressed obstruent closed syllables in Witsuwit'en. The phonetic properties of peripheral and central vowels in Witsuwit'en thus support the proposal that central vowels are inherently shorter than peripheral vowels.

Next, as with Sahaptin, I will suggest that the phonetic differences in duration between central and peripheral vowels are phonologically reflected in the relative markedness of central vowels.

3.2 *Stress*

In Witsuwit'en, stress is predictable from a small set of phonological and morphological parameters, which I have described in detail in Hargus in preparation-b and Hargus in preparation-a, including experimental verification of some of these parameters.

(35)

| <i>parameter</i> | <i>stress attracted to</i> |
|------------------------------|--|
| morphological category | stems (vs. affixes) |
| vowel quality | peripheral /i e a o u/ (vs. central /ə/) vowels |
| vowel quantity | long (vs. short) peripheral vowels |
| position of syllable in word | left edge of word (vs. word medial) |
| syllable type | closed (vs. open) syllables |

Of greatest interest for present purposes are the vowel quality and quantity parameters, which I will reduce to a single parameter. Stress patterns in disyllables provide the clearest evidence of the difference between central and peripheral vowels with respect to stress. If the initial syllable contains a peripheral vowel, it is always stressed, whereas if it contains a central vowel, it is never stressed. The examples in (36) all consist of one prefix syllable and one stem syllable (final):

(36) Peripheral vs. central vowels in disyllables

| V | [ə] |
|---|--|
| négèʔ 'it healed' | nək ^w áz 'he's driving around' |
| désyə̀χ 'I'm dying' | dəstl'əs 'I'm painting it' |
| yéx ^w ɪdâc 'you (pl.) are talking' | yəx ^w ɪʔəs 'you (pl.) are sneezing' |

In longer words whose non-final syllables contain peripheral vowels of the same or different qualities, main stress falls on the leftmost syllable in the word. The final syllable contains a secondary stress. (It is debatable whether or not the medial syllable is also stressed.)

(37) Stress in longer peripheral vowel words

| | |
|----------|------------------------|
| déwesyèl | 'I didn't walk inside' |
| níninGì | 'it's dried out' |
| nédibìs | 'nighthawk' |

In longer words containing [ə] in non-final syllables, stress placement depends on whether the first or second syllable of the word is closed. If the first syllable is open and the second closed, then stress falls on the second syllable.

(38) Longer words with nonfinal [ə] syllables: second syllable stress

| | | |
|--------|---------------|----------------|
| LH[σ] | nəgólwəs | 'I'm hot' |
| LHL[σ] | nəc'əznəqə̀y' | 'we're sewing' |

Otherwise, stress falls on the first syllable.

(39) Longer words with nonfinal [ə] syllables: initial syllable stress

| | | |
|----------|------------------|---|
| LL[σ] | hónədèç | ‘they’re dancing’ |
| LLL[σ] | nóc’ə̀nəqə̀y’ | ‘she is sewing something’ |
| LLLL[σ] | hóbəc’ədə̀ts’ət | ‘someone is scratching them’ |
| LLLLL[σ] | nóc’ə̀bə̀yənətən | ‘he is carrying something via a rigid object’ |

The preceding data suggest that Witsuwit’en stress is assigned by forming left-aligned, left-headed quantity-sensitive feet: (nóc’ə̀)(bə̀yənətən). The word initial LH pattern suggests that [ə̀C] syllables are heavy: nə̀(dól)(k^wə̀z).

In words containing a mixture of central and peripheral vowels in non-final syllables, main stress falls on the second syllable if the first contains a central vowel and the second contains a peripheral vowel, even if the central vowel syllable is closed and the peripheral vowel syllable is open:

(40)

| | |
|----------------|--------------------|
| ʔtə̀ndíʔq’ə̀’n | ‘it has red in it’ |
| c’ə̀ztáʔə̀ʔ | ‘we’ll eat’ |

Finally, long peripheral vowels attract stress even when non-word initial:

(41)

| | |
|----------------|---------------------------------------|
| dól néyeldə̀c | ‘he’s talking to himself again’ |
| dól neyéeldə̀c | ‘they’re talking to themselves again’ |

| | |
|-----------------|-----------------|
| yə̀qáʔə̀ninzə̀n | ‘he wants it’ |
| nqáʔáə̀ninzə̀n | ‘they want you’ |

In words containing more than one long peripheral vowel, main stress falls on the leftmost long peripheral vowel:

(42)

| | |
|-------------------|---------------------------------|
| ts'enéeboðłdzìt | 'let them wake them up' |
| ts'enéebaàtałdzòł | 'they're going to wake them up' |
| ts'énéwéebaàłdzìt | 'they haven't woken them up' |

The analysis that emerges from the preceding data is that stress is attracted to heavy syllables, and that syllables are ranked for weight as in (43):

(43) $VV > V(C) > əC > ə$

There is therefore clear evidence for the markedness of central vowels in the stress system of Witsuwit'en. Moreover, the scale has a clear basis in inherent durational differences between VV, V, and ə.

3.3 *If central then short in Witsuwit'en*

I next survey other phenomena in Witsuwit'en which distinguish /ə/ and the peripheral vowels, and which support the proposed constraint If central then short/If long then peripheral.

3.3.1 Long vowels and lengthening

As seen in the Witsuwit'en vowel inventory (34), duration is also used to make distinctions among peripheral vowels. The existence of long peripheral vowels has been noted in prior work on the BVL language (Hildebrandt and Story 1974, Kari 1975), but minimal pairs are rare:

(44) Tautomorphic [V] vs. [VV]

| | |
|--------------------------|-------------------------|
| soʔ | 'well, nicely' |
| sooʔ ~ hooʔ ⁹ | 'no' |
| bətanec'ətasdlit | 'I'll add to it' |
| bətaanec'ətasdlit | 'I'll subtract from it' |

⁹For some speakers, 'no' is obligatorily disyllabic: [soʔGec] ~ [hoʔGec].

| | |
|--------------|---------------------------|
| tsac'ədilye | 'he took a laxative' |
| tsaac'ədilye | 'he fasted' ¹⁰ |

Most surface instances of the long peripheral vowels [VV] can be shown to result from sequences /Vhə/ or /əhV/, where /h/ is deleted intervocalically and the V-ə sequence coalesces: /Vhə/ --> [Və] --> [VV].

(45)

| | | |
|-------|--|--|
| | | cf. |
| /əhV/ | [ʔoondzən] /ʔəhondzən/ 'it (areal) is' | cf. [hɔnzʊ] 'it (areal) is good', [ʔəndzən] 'it is' |
| /Vhə/ | [neɛgeʔ] /nehəgeʔ/ 'they healed' | [negeʔ] 'he/she healed' |

Unlike the peripheral vowels, which merely lengthen,¹¹ /ə/ undergoes a change in quality to [a] when it coalesces with another /ə/.

(46) Lengthening

| | | |
|-------|---|------------------------------|
| | | cf. |
| /əhə/ | [ʔat'ah] or [ʔaat'ah] 'they're working' | [ʔət'ah] 'he/she is working' |
| | [ʔaqt] or [ʔaaqt] 'they're clapping' | [ʔəqt] 'he/she is clapping' |

Why does /ə/ but no other vowel undergo a quality change when it lengthens?¹²

As in Sahaptin, I suggest that Witsuwit'en /ə/ is inherently short and phonetically incompatible with extra length. In other words, the constraint proposed above that long

¹⁰For some speakers, 'fast' is /za#c'-d-D-le/ [zac'ədilye] 'he fasted', not a minimal pair for length with 'take laxative'.

¹¹There are some complications in lengthening of /u/. See Hargus in prep.

vowels must be peripheral is highly ranked in the grammar of Witsuwit'en. Thus, the central vowel must become peripheral when it lengthens.

(47)

| /əhə/ | *VhV | If long then peripheral | Preserve-[ə] |
|-------|------|-------------------------|--------------|
| [əhə] | *! | | |
| [əe] | | *! | |
| → [a] | | | * |

The distribution of vowel qualities with respect to length contrasts thus also makes sense if the central vowel is phonologically shorter than the peripheral vowels.

3.3.2 Word final vowels

Leer 1979 posits a prohibition against root-final open or laryngeal-closed reduced vowel syllables for Proto-Athabaskan, and Witsuwit'en has much the same constraint.¹² In word final/stem syllables of all lexical categories, /ə/ is rare in open syllables or in syllables closed with the laryngeal consonants [ʔ h] (Hargus in preparation).

(48) Final heavy syllable: The word final/stem syllable must be heavy.

¹²And why does /ə/ lengthen to [aa] and not [a]? Some speakers do lengthen only to [a], as predicted. I suggest that the extra lengthening that other speakers produce is by analogy with the other long peripheral vowels.

¹³However, I suggest that it is a prohibition against word final light (root) syllables. [Cə] (and shorter) roots exist in Witsuwit'en, but not in absolute word final position. Note the [Cə] incorporated postpositions (underlined) in the following:

-yə yənex^wdədləx^w 'you (pl.) are laughing at yourselves'

-ts'ə st^s'ədix^wyən 'you (du.) stand facing me'

-q'ə yəq'əsde 'he's sitting on it'

-0 bə₋weudic^tyeh 'I don't know it'

Also, in future and progressive forms of momentaneous aspect verbs, root-final /t/ is deleted when the suffix -[t̚] is added, leading to a surface [Cə] verb root:

c'əts'otaqə-t̚ 'we'll buy'; cf. c'əts'onqet 'we bought'

netaqə-t̚ 'it'll snow'; nenqat 'it snowed'

However, peripheral vowels are well-attested in word final open or laryngeal closed syllables:

(49) /V/ in open or laryngeal closed root syllables

| | peripheral vowel | central vowel |
|-------------|---------------------------|---------------|
| <i>open</i> | sa ‘sun, moon’ | *Cə |
| <i>h</i> | dəc’ah ‘bush, wilderness’ | *Cəh |
| <i>ʔ</i> | saʔ ‘long time, slow’ | *Cəʔ |

Phrase-final lengthening would not predict the absence of [əʔ] and [əh], since the vowel is not phrase-final in these cases but separated from final position by the laryngeal consonant. We must assume that in Witsuwit’en, all consonants except laryngeals contribute to syllable weight. Concerning the special properties of laryngeals, Bagemihl 1991 analyzes [ʔ] in Bella Coola as non-moraic, in contrast to all other consonants. In her recent survey of compensatory lengthening phenomena, Kavitskaya 2001 finds that [ʔ] can be weight-bearing or not. In Witsuwit’en, [ʔ] is also exceptional as the only consonant that may occur as C₂ in coda clusters with sonorants and glides: [yʔ], [wʔ], [mʔ], [nʔ].¹⁴

The absence of word final [ə] thus also makes sense if we consider this vowel to be weightless: by itself or in combination with a laryngeal consonant, it will not satisfy the Final Heavy syllable requirement.

3.3.3 Allomorph selection

Another asymmetry between /ə/ and peripheral vowels involves the verbal areal prefix (Hargus 1995, Hargus in preparation-b). In Witsuwit’en, the verbal areal prefix has a special allomorph [ho]- before peripheral vowels, such as /e i u/ in (50). In contrast, the allomorph [w]- occurs before /ə/.

¹⁴Oostendorp 2000 notes that Dutch [ə] cannot be tautosyllabic with [h] or [ʔ], and analyzes this as a prohibition against adjacent segments with empty root nodes.

(50) Verbal areal prefix: ho- ~ w-

| ___V | | ___ə |
|-------|--|---|
| ___ e | <u>h</u> ot'əy' 'he owned (areal object) (/w/ho-e-) cf. y <u>i</u> t'əy' 'he had it' (</y-e-/) | <u>w</u> ət'əy' 'he owns (areal object) cf. y <u>ə</u> t'əy' 'he has it' |
| ___ i | yəχ <u>h</u> ont'əy 'you own a house' cf. <u>i</u> nt'əy 'you own it' | |
| ___ u | <u>h</u> ozi 'she is naming it (place) y <u>u</u> zi 'she is naming him' | |

The nominal/postpositional areal prefix has a different range of shapes, which are also sensitive to the central/peripheral distinction. The areal prefix in this morphological context has a lowering effect on the quality of a peripheral vowel, but not a central vowel.

(51) Nominal and postpositional areal prefix: w- (lowering) ~ w-

| ___V | | ___ə |
|---------|--|--|
| ___ a~e | soʔ <u>w</u> asədlel 'I had a nice dream' cf. ye <u>s</u> ələl 'she dreamed about it' | st'aq <u>w</u> əzqəyʔ 'blood from my back' cf. səncən <u>h</u> əzqəyʔ 'blood from my arm' |
| ___ e~i | <u>w</u> enən 'hillside' b <u>i</u> nən 'its hill' | |
| ___ o~u | yən təχ <u>w</u> oziʔ 'place name' b <u>u</u> ziʔ 'her name' | |

Areal prefix allomorphy also thus distinguishes the central and peripheral vowel classes.

I suggest that the behavior of the areal prefix in Witsuwit'en reflects an Athabaskan family specific constraint. As noted by Leer 1979, labialization on uvulars

was lost in Proto-Athabaskan unless the vowel that followed was reduced (i.e. central). In (57), [V] represents a full (peripheral) vowel:

(52)

$$\begin{array}{cc} *Q^w & V \\ | & | \\ X & X \end{array}$$

Thus the feature [labial] was lost in phonologically long syllables, consistent with the frequent observation that central vowels are more susceptible to assimilation of features of neighboring consonants than are peripheral vowels (Browman and Goldstein 1992, Bates 1995).

For synchronic, modern Witsuwit'en, I suggest the following analysis of the verbal areal prefix. There are two allomorphs of the areal prefix, -[ho] and -[w], the use of which is regulated by Areal = ho and Areal = w. Forms which lack the [ho]- alternant receive a penalty for Areal = ho; forms which lack the [w]- alternant receive a penalty for Areal = w. I also posit a constraint $*wV$ (the reflex of the Proto-Athabaskan loss of labiality discussed above), which penalizes representations which contain [w] followed a peripheral vowel. In order to ensure that the w- allomorph is selected before [ə], I suggest the constraint ranking in (53):

(53) $*wV \gg \text{Areal} = w \gg \text{Areal} = \text{ho}$ ¹⁵

These constraints will select the allomorph [ho] when a peripheral vowel follows:

(54) /{ho,w}+it'əy'/

| | $*wV$ | Areal=w | Areal = ho |
|-----------------------|-------|---------|------------|
| → ho-it'əy' [hot'əy'] | | * | |
| w-it'əy' [wit'əy'] | *! | | * |

¹⁵In support of the ranking Areal = w \gg Areal = ho, note that in other Athabaskan languages, such as Sekani, the ho- allomorph has been lost altogether. This fact is predicted by the ranking Areal = w \gg Areal = ho: the less preferred ho- allomorph is used in fewer contexts.

(55) /{ho,w}+ət'əy/

| | | | |
|-------------------|-----|---------|------------|
| | *wV | Areal=w | Areal = ho |
| ho-ət'əy [hot'əy] | | *! | |
| → w-ət'əy | | | * |

Areal prefix allomorphy distinguishes the central and peripheral vowel classes, and receives a coherent, if historical explanation, via Leer's observation that labiality is lost before full vowels but not before reduced, thus supporting the general point that If central then short.

3.3.4 Verb stem variation

In a study of Witsuwit'en verb roots and aspectual suffixation in a corpus of 449 roots (Hargus 1999), I noted that the range of root-final consonant contrasts in verbs depends on whether the root vowel is central or peripheral. When the root contains a peripheral vowel, the final consonant, if a fricative, generally alternates in voicing in morphologically predictable ways: the voiced fricative occurs in the perfective stem, and the voiceless fricative occurs in the imperfective, future and optative stems (the 'Canadian' pattern, Story 1984). In such cases, the root final fricative is therefore unspecified for voicing ("S" in (56)-(57)). Root-final voiced and voiceless fricatives are possible but rarer following peripheral vowels.

(56) Final fricatives in /VC/ verb roots

| <i>C</i> <i>specification</i> | <i>example</i> | <i># roots of this type</i> | <i>% sample</i> |
|----------------------------------|---|-----------------------------|-----------------|
| S (s~z) | -/coS/ 'handle clothlike O': -[coz] ~ -[cos] | 122 | 20.7 |
| ʃ | -/caʃ/ 'yawn' | 3 | .7 |
| z | -/liz/ 'cook O by boiling' | 16 | 3.6 |

However, when the root vowel is /ə/, root-final fricatives which are specified for voicing are more common than root final fricatives which alternate between voiced and voiceless:

(57) Final fricatives in /əC/ verb roots

| <i>C</i> <i>specification</i> | <i>example</i> | <i># roots of this type</i> | <i>% sample</i> |
|----------------------------------|------------------------------------|-----------------------------|-----------------|
| S (s~z) | -/γəS/ 'bathe': -[γəz] ~ -[γəs] | 3 | 3.6 |
| s | -/wəs/ 'froth' | 34 | 7.6 |
| z | -/ləz/ 'urinate' | 63 | 14.0 |

Following a suggestion by Doug Pulleyblank, I hypothesize that the ə/V asymmetry in this case is due to vowel duration as a secondary cue to stem-final voicing, with longer vowels occurring before voiced fricatives and shorter vowels occurring before voiceless fricatives. Voicing in the perfective has been reconstructed for Proto-Athabaskan due to the voiced nature of the perfective suffix, *-ŋ (Krauss and Leer 1981). I hypothesize that the voicing alternation is maintained in Witsuwit'en with peripheral vowel roots but not central vowel roots because the length differences between [Vs] vs. [Vz] are greater than for [əs] vs. [əz], a testable hypothesis that remains to be confirmed or disconfirmed. The voicing alternation is thus more susceptible to being lost with central vowel roots.

3.4 Summary of Witsuwit'en

Witsuwit'en stress provides evidence that central vowels are phonetically and phonologically shorter than peripheral vowel peaks. I have suggested that the stress facts may be part of a deeper pattern of asymmetrical behavior of central vowels, stemming from the fact that central vowels are phonetically shorter than peripheral vowels. Other phonological differences between central and peripheral vowels include the inability of central vowels to occur long, the avoidance of central vowels in final position, the avoidance of voicing alternations with central vowel roots, and historical labialization leading to synchronic allomorphy in the areal prefix.

4 Conclusion

I have presented two new cases of central/peripheral quality-sensitive stress from two unrelated Native American languages. I have tried to make two main points. First, quality-sensitive stress should be considered part of a more general dispreference for the central vowel (as syllable or metrical peak). Secondly, I have suggested that this dispreference may stem from the phonetic shortness of central vowels:

(58) If central then short/If long then peripheral.

More speculatively, I have suggested that short vowels (ǃ) are less optimal peaks:

(59) *P/ǃ >> *P/V

If correct, this speculation raises the question of how to integrate the finding of Rosenthal 1997 that long vowels are synchronically marked in vowel systems: *VV. Possibly, Rosenthal's research might be incorporated into the ranking in (60) as follows:

(60) *P/ǃ, *P/VV >> *P/V

That is, languages might prefer vowels which are not too short, and not too long, but just right. On the other hand, in metrical systems, the longer the peak the more it attracts stress. Clearly more work remains to be done on the cross-linguistic markedness of degrees of vowel length.

5 References

- Archangeli, Diana and Douglas Pulleyblank. 1994. *Grounded Phonology*. Cambridge: MIT Press.
- Bagemihl, Bruce. 1991. Syllable Structure in Bella Coola. *Linguistic Inquiry* 22:589-646.
- Bates, Sally R.A. 1995. Acoustic Characterisation of Schwa: A Comparative Study. *ICPhS* 95:230-233.
- Beckman, Mary and Jan Edwards. 1990. Lengthenings and shortenings and the nature of prosodic constituency. In *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech*, edited by J. Kingston and M. Beckman. Cambridge: Cambridge University Press, 152-178.
- Browman, Catherine and Louis Goldstein. 1992. Targetless schwa: an articulatory analysis. In *Papers in Laboratory Phonology II*, edited by B. Ladd and G. J. Docherty. Cambridge: Cambridge University Press, 26-67.

- Casali, Roderic. 1995. Labial Opacity and Roundness Harmony in Nawuri. *Natural Language and Linguistic Theory* 13:649-663.
- Czaykowska-Higgins, Ewa. 1993. Cyclicity and Stress in Moses-Columbia Salish (Nxa'amxcin). *Natural Language and Linguistic Theory* 11:197-278.
- Donegan, Patricia J. 1985. *On the Natural Phonology of Vowels*. New York: Garland.
- Hagiwara, Robert. 1995. *Acoustic Realizations of American /R/ as Produced by Women and Men*. Los Angeles: UCLA Phonetics Lab.
- Hall, T. Alan. 1999. Phonotactics and the Prosodic Structure of German Function Words. In *Studies on the Phonological Word*, edited by T. A. Hall and U. Kleinhenz. Amsterdam/Philadelphia: John Benjamins, 99-131.
- Hargus, Sharon. 1995. The areal prefix in Witsuwit'en. Paper read at Athabaskan Language Conference, at University of New Mexico, Albuquerque, NM.
- Hargus, Sharon. 1999. General patterns and special features of Witsuwit'en verb stem variation. Paper read at Athabaskan Languages Conference, at Albuquerque NM.
- Hargus, Sharon. in preparation-a. Prosody in Two Languages of Northern British Columbia. In *Athabaskan Prosody*, edited by S. Hargus and K. Rice. Amsterdam: John Benjamins.
- Hargus, Sharon. in preparation-b. Witsuwit'en Grammar: Phonology and Morphology. Seattle: University of Washington.
- Hargus, Sharon and Virginia Beavert. 2000a. *Predictable vs. underlying vocalism in Yakima Sahaptin*. Ms., University of Washington and Heritage College, Seattle and Toppenish.
- Hargus, Sharon and Virginia Beavert. 2000b. Yakima Sahaptin clusters and epenthetic [i-]. Paper read at The Thirty-Fifty International Conference on Salish and Neighbouring Languages, at Mount Currie, B.C.
- Hargus, Sharon and Virginia Beavert. this volume. *The representation of initial clusters in Yakima Sahaptin*, Linguistics, University of Washington and Heritage College, Seattle and Toppenish.
- Hildebrandt, Henry and Gillian Story. 1974. *A Historically Oriented Study of Babine (Northern Carrier) Phonology*. Ms., Burns Lake, B.C.

- Hillenbrand, James, Laura A. Getty, Michael J. Clark, and Kimberlee Wheeler. 1995. Acoustic characterizations of American English vowels. *Journal of the Acoustical Society of America* 97:3099-3111.
- Kari, James. 1975. *Babine, A New Linguistic Grouping*. Ms., Alaska Native Language Center, University of Alaska Fairbanks, Fairbanks.
- Kavitskaya, Darya. 2001. Are glottal stops really stops? The evidence from compensatory lengthening. Paper read at Linguistic Society of America, at Washington DC.
- Kenstowicz, Michael. 1996. Quality-sensitive stress. *Rivista di Linguistica* 9:157-187.
- Krauss, Michael and Jeff Leer. 1981. *Athabaskan, Eyak and Tlingit Sonorants*. Fairbanks: Alaska Native Language Center.
- Ladefoged, Peter and Ian Maddieson. 1996. *Sounds of the World's Languages*. Oxford: Blackwell.
- Leer, Jeff. 1979. *Proto-Athabaskan Verb Theme Categories: I. Phonology*. Fairbanks: Alaska Native Language Center.
- Oller, D. 1973. The effect of position in utterance on speech segment duration in English. *Journal of the Acoustical Society of America* 54:1235-1247.
- Oostendorp, Marc van. 2000. *Phonological Projection: A Theory of Feature Content and Prosodic Structure*. Berlin: Mouton de Gruyter.
- Peterson, Gordon and Harold Barney. 1952. Control Methods Used in a Study of the Vowels. *Journal of the Acoustical Society of America* 24:585-594.
- Peterson, Gordon and Ilse Lehiste. 1960. Duration of Syllable Nuclei in English. *Journal of the Acoustical Society of America* 32:693-1960.
- Rigsby, Bruce and Noel Rude. 1996. Sketch of Sahaptin, a Sahaptian Language. In *Languages*, Vol. 17, edited by I. Goddard. (Handbook of North American Indians edited by W. C. Sturtevant.) Washington DC: Smithsonian Institution, 666-692.
- Rosenthal, Sam. 1997. The distribution of prevocalic vowels. *Natural Language and Linguistic Theory* 15:139-180.
- Stampe, David. 1972. On the natural history of diphthongs. *Chicago Linguistics Society* 8:578-590.

- Story, Gillian. 1984. *Babine and Carrier Phonology: A historically oriented study*.
Arlington: Summer Institute of Linguistics.
- Thompson, Laurence C., M. Terry Thompson, and Steven M. Egedal. 1996. Sketch of
Thompson, a Salishan Language. In *Languages*, Vol. 17, edited by I. Goddard.
(Handbook of North American Indians edited by W. C. Sturtevant.) Washington
D.C.: Smithsonian Institution, 609-643.
- Wells, J.C. 1982. *Accents of English*. Cambridge: Cambridge University Press.
- Wright, Richard. 1996. *Consonant clusters and cue preservation in Tsou*. Los Angeles:
UCLA Department of Linguistics.

Glides in Korean syllables¹

Yungdo Yun

yyun@u.washington.edu

1. Introduction

There has been a controversy on the position of on-glides within syllables in Korean: some researchers (such as Y. Lee 1994; S.-C. Ahn 1985, 1988; C.-G. Gim 1987; J.-S. Lee 1992) argue that Korean on-glides occur under onset (called the onset hypothesis); others (such as H.-S. Sohn 1987; Y.-K. Kim-Renaud 1978; J.-M. Kim 1986; Y. Kang 1991; C.-W. Kim & H.-Y. Kim 1991) that they occur under nucleus (called the nucleus hypothesis). The aim of this paper is to investigate whether on-glides occur under onset or nucleus. In this paper, I will argue that they occur under both onset and nucleus depending on presence of a preceding tautosyllabic consonant: when there is a tautosyllabic consonant before them, they occur under nucleus, whereas they occur under onset when they are syllable-initial glides².

While I have been doing this research, I have noticed that many examples provided by onset hypothesis supporters have syllable-initial glides, whereas the ones by nucleus hypothesis supporters mostly have glides after a tautosyllabic consonant. However, this is well explained if we consider that onset position is filled immediately after a vowel takes its nucleus position within a syllable, and then the remaining glide is adjoined to nucleus if applicable.

H.-S. Sohn (1987) and K.-O. Kim (1978) claim that Korean has eight vowels underlyingly, namely, /i, ɨ, u, e, ə, o, æ, a/. However, it has been reported by many

¹ An excerpt from this paper was presented at the Western Conference on Linguistics in October 2001. I would like to thank Ellen Kaisse, who has contributed many valuable comments on this paper. I also thank Sharon Hargus, Richard Wright, and David Corina, for reading the previous version of this paper and for their advice and criticism. All remaining errors are my own.

² In Korean there is only one diphthong that has an off-glide, whose underlying form is /ɨi/. But we are now losing this. For example, /uli + ɨi/ → [u.li.e] in word-final, and /cuii/ → [cu.i] in morpheme-final, /ɨisa/ → [ɨ.sa] in word-initial position. This diphthong does not occur with any segment within a syllable, and hence *C/ɨi/, */ɨi/C, *C/ɨi/C, *G/ɨi/, *G/ɨi/C, *CG/ɨi/C ('G' stands for a glide in this paper). Since this does not affect the syllable structure mentioned in this paper, I will not talk about this. And also this is beyond the scope of this paper.

researchers that in Korean front vowels /e/ and /æ/ (or /ɛ/ depending on researchers) have merged to /e/. Y. Hong (1987) says that Southern dialects such as the Kyungsang and the Cholla dialects do not distinguish /e/ and /æ/. After the Second World War, speakers of these dialects immigrated to north and hence other dialects have been losing the distinction between these vowels. C.-W. Kim (1971) reports that /æ/ has been raised to /e/ in the Seoul dialect. H.-B. Lee (1971) also reports that there is a generation split among Seoul dialect speakers: speakers over 30 years of age (in 1971) distinguish /e/ and /ɛ/, whereas those under 30 years of age do not. Y. Hong (1986, 1987, 1991) also supports this finding. After series of experiments, Y. Hong (1991) reports that there was merger of these vowels produced by Korean speakers under the age range between 45 and 50 years (in 1991): the ones above 45-50 years of age still have the distinction whereas others under 45-50 years of age do not (cited from Ingram and Park 1997). Therefore, I will use the seven vowel system in this study. The following is the Korean vowel system (adopted from H.-S. Sohn 1987:79, with deletion of /æ/):

(1) Korean vowel system

| | -back | | +back | |
|------|--------|--------|--------|--------|
| | -round | +round | -round | +round |
| high | i | | ɨ | u |
| mid | e | | ɐ | o |
| low | | | a | |

In the following section, Korean syllable structures proposed by researchers will be cited³. Then, I will explain how syllables are built.

³ The issue of syllable structure is beyond the scope of this paper. I will simply cite those for readers. Position of glides, which is the main focus of this paper, is not affected by those structures.

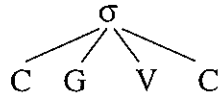
2. Syllable structure and syllabification algorithm

2.1. Syllable structure

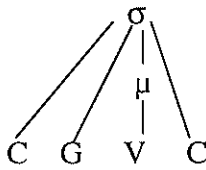
The following are Korean syllable structures proposed by researchers:

(2) Flat structure

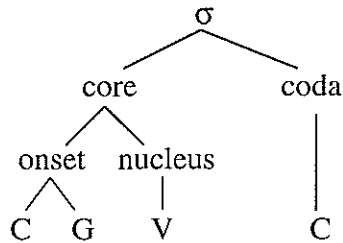
a. Flat structure without moras (Y.-S. Kim 1984)



b. Flat structure with moras (Y. Lee 1994)

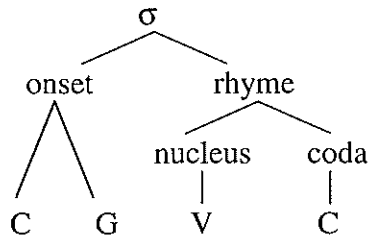


(3) Left-branching structure (C.-G. Gim 1987; S.-C. Ahn 1988): glide as onset

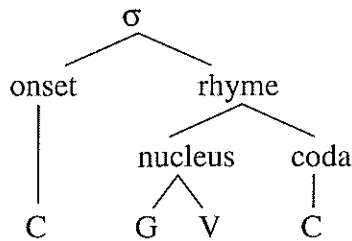


(4) Right-branching structure

a. Glide as onset (B.-G. Lee 1982; S.-C. Ahn 1985)



- b. Glide as nucleus (Y.-K. Kim-Renaud 1978; J.-M. Kim 1986; H.-S. Sohn 1987; C.-W. Kim and H.-Y. Kim 1991)



Y.-S. Kim (1984) and Y. Lee (1994) assume the flat structures shown in (2a) and (2b), respectively. They do not think that the syllable-internal hierarchical structure is needed. C.-G. Gim (1987) and S.-C. Ahn (1988) assume the structure (3) by providing evidence from ideophones and language games⁴. Leaving aside this issue, I adopt Levin's (1985) syllable structure in this paper, which is shown in the following:

(5) Syllable structure



The above structure is equivalent to the structures shown in (4a) and (4b). Therefore, the main focus of this paper is which structure is the right one between (4a) and (4b). In the following section, I will explain how syllables are built.

2.2. Syllabification algorithm

In Korean, syllables have the form of (C)(G)V(C). The following are all possible types of Korean syllables:

⁴ Y. Kang (1991) criticizes flat structures and the left-branching structure.

(6) Types of syllables

- | | | |
|------------------------|----------------------------------|------------------|
| a. [V] _σ | e.g., [o] 'five' | [i] 'teeth' |
| b. [CV] _σ | e.g., [nə] 'you' | [ku] 'nine' |
| c. [VC] _σ | e.g., [ək] 'million' | [ip] 'mouth' |
| d. [CVC] _σ | e.g., [kaŋ] 'river' | [tal] 'moon' |
| e. [GV] _σ | e.g., [je] 'yes' | [we] 'why' |
| f. [GVC] _σ | e.g., [jək] 'station' | [waŋ] 'king' |
| g. [CGV] _σ | e.g., [p [*] jə] 'bone' | [hwa] 'anger' |
| h. [CGVC] _σ | e.g., [pjək] 'wall' | [kwaŋ] 'storage' |

When two vowels are adjacent, they belong to different syllables, as shown in the following⁵:

(7) [V]_σ

/au/ → [a.u] 'younger brother/sister' /oi/ → [o.i] 'cucumber'

When there are consonants before a vowel, the one immediately before the vowel becomes an onset segment of the syllable to which the vowel belongs. The following illustrate that (the examples in (8b) are cited from Y.-S. Kim 1984:351):

⁵ There is an exception: if the first one is a high vowel /i/ or /u/, that can become a glide. This will be explained later.

(8) [CV]_σ

- a. /ənə/ → [ən.ə] 'language' /kukə/ → [ku.kə] 'the Korean language'
 /kʰilita/ → [kʰi.ri.ta] 'to draw' /peku/ → [pe.ku] 'volleyball'
- b. /ps^{*}al/ → [s^{*}al], not*[ps^{*}al]'rice' cf. /co + ps^{*}al/ → [cop.s^{*}al] 'millet rice'
 /pt^{*}e/ → [t^{*}e], not *[pt^{*}e] 'time' cf. /i + pt^{*}e/ → [ip.t^{*}e] 'this time'
- c. /ip^h/ 'leaf' + /e/ 'in' → /i.p^he/ /ip/ 'mouth' + /e/ 'in' → [i.pe]
 cf. /ip^h/ → [ip] /ip/ → [ip]
 /ip^h/ + /to/ 'also' → [ip.t^{*}o] /ip/ + /to/ → [ip.t^{*}o]
- d. /os/ 'cloth' + /e/ 'in' → [o.se] /oc^h/ 'lacquer' + /e/ → [o.c^he]
 cf. /os/ → [ot] /oc^h/ → [ot]
 /os/ + /to/ 'also' → [ot.t^{*}o] /oc^h/ + /to/ → [ot.t^{*}o]

As shown in (8a), a consonant between vowels becomes an onset segment, not a coda segment. That is, onset position is filled before coda position. The examples in (8b) illustrate that the consonants immediately before vowels become onset segments. They also illustrate that in Korean only one segment is possible in onset position, and hence the remaining consonants are deleted in word-initial position, or become coda segments when there is a preceding vowel⁶. In the examples (8c) and (8d), voiceless obstruents are neutralized to lenis stops when they occur in coda position, but they are not when they are followed by a vowel, namely in onset position⁷. So, onset position is filled with only one segment if we do not consider glides.

Coda position is also filled with only one segment. The following illustrate that (the example (9a) and (9b) are cited from Iverson and Kim 1987):

⁶ [CGV(C)] structure will be explained later.

⁷ This is the well-known 'coda neutralization'. In Korean, there are 3 series of stop phonemes, namely, lenis, aspirated, and fortis stops. They become lenis stops in coda position: /p, p^h, p^{*}/ → [p]; /t, t^h, t^{*}/ → [t]; /k, k^h, k^{*}/ → [k]. Coronal obstruents also become [t] in coda position: /s, s^{*}/ → [t]; /c, c^h, c^{*}/ → [t]. For detailed analysis, see H.-S. Sohn (1987: 263-278).

(9) [CVC]_σ

- a. /kaps/ → [kap] 'price'
 b. /moks/ → [mok] 'share'
 c. /talk/ → [tak] 'hen/rooster'

In the above examples, the coda positions are filled with only one consonant. When there are two underlying consonants after a vowel, the coronal consonant is deleted. This is further supported by the well-known 'three-consonant cluster avoidance in word-medial position', which has been explained by many researchers (such as Y.-K. Kim-Renaud 1974, 1978; Y.-S. Kim 1984; S.-C. Ahn 1985; Iverson and Kim 1987; C.-W. Kim and H.-Y. Kim 1991; among others). In Korean, a three-consonant cluster is impossible in word-medial position, and hence one of them should be deleted. The following (cited from Iverson and Kim 1987:387) illustrate that:

(10) Three-consonant cluster avoidance

- | | |
|--|---|
| a. /kaps + to/ → [kap.t*o] 'price also' | cf., /kaps + i/ → [kap.si] |
| /moks + to/ → [mok.t*o] 'share also' | cf., /moks + i/ → [mok.si] |
| /palp + a/ → [pal.pa] | cf., /palp + a/ → [pal.pa] |
| /ɪlp ^h ta/ → [ɪp.t*a] 'to cite' | cf., /ɪlp ^h + ə/ → [ɪl.p ^h ə] |
| /hɪlk + to/ → [hɪk.t*o] 'soil also' | cf., /hɪlk + i/ → [hɪl.ki] |
| b. /anc + ko/ → [an.k*o] 'to sit and' | cf., /anc + a/ → [an.ca] |
| /halt ^h ta/ → [hal.t*a] 'to lick' | cf., /halt ^h + a/ → [hal.t ^h a] |

(where /i/ is a nominative case marker, and /ə/ and /a/ are stative suffixes.)

In the examples of (10a), the third consonants in the clusters, which occur immediately before a vowel, become onset segments first since onset position is filled first. Then, between the remaining consonants, a non-coronal consonant fills in coda of the first syllable. Finally, the remaining coronal consonant is deleted because only one segment is possible in both onset and coda. In the examples in (10b), the third consonants also fill in the onset of the second syllables. However, these examples are different from those in

(10a). In (10b), the remaining consonants are both coronal consonants. In this case, the first one, namely, the one immediately after the first vowel, takes coda position of the first syllable. Then, the other coronal consonant is deleted. According to Iverson and Kim (1987:387), the deletion of consonants can be explained by the Stray Erasure Convention proposed by Steriade (1982), which is shown in the following:

(11) Stray Erasure Convention (Steriade 1982:89, cited from Iverson and Kim 1987)
Erase segments and skeleton slots unless attached to the higher levels of structure.

So far I have explained how onset and coda positions are filled. But what if there is a glide after the medial three-consonant cluster? The following examples (cited from Iverson and Kim (1987:387) except the last one) illustrate that:

(12) Three-consonant cluster followed by a glide

a. /kaps + kwa/ → [kap.k*wa] 'price and'

 /moks + kwa/ → [mok.k*wa] 'share and'

b. /salm + kwa/ → [sam.gwa] 'life and'

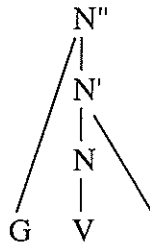
 /talk + p*jə/ → [tak.p*jə] 'chicken bone'

In the above examples, there are four segments between vowels, namely a three consonant cluster followed by a glide. It should be noticed that the glides are not deleted in these examples. However, they do not affect the syllabification process that has been mentioned so far if we consider that glides go with vowels. Namely they are nuclear segments after a tautosyllabic consonant. But even if we considered a consonant followed by a glide as a possible onset, the same result would obtain. What about glides in syllable-initial position? Do they occur under onset position or nucleus position (namely, the first segment of an onsetless syllable)? I will claim that they are onset segments in syllable-initial position. In the following section, I will argue that glides are both onset and nuclear segments depending on syllabification: since onset position is filled immediately after a vowel takes nucleus position, syllable-initial glides are onset

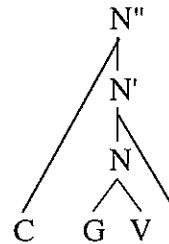
segments whereas they are nuclear segments after a tautosyllabic consonant. The following are positions of glides within syllables that are claimed in this paper:

(13) Position of glides⁸

a. Onset in syllable-initial position



b. Nucleus after a tautosyllabic consonant



Leaving aside this issue for the next section, I summarize the syllabification algorithm that has been mentioned so far in the following:

(14) Syllabification algorithm (SA)

a. First, nucleus position is filled with a vowel.

b. Second, onset position is filled with a segment one by one to the left of nucleus.

Condition I: There can be only one segment in onset.

Condition II: When two segments are available for onset, where the first one is a consonant and the second one is a glide, the consonant takes onset position.

c. Third, among the remaining segments the one to the left of nucleus adjoins to nucleus, and the one to the right of that becomes a coda segment.

Condition I: There can be only one segment in coda.

Condition II: Coda is filled one by one immediately after nucleus.

Condition III: When two segments are available for coda, the non-coronal segment takes precedence over the coronal segment.

d. Fourth, the Stray Erasure Convention (SEC) is applied.

⁸ In Korean, [ji], [jɨ], [wi], [wu], and [wo] are impossible sequences of diphthongs. For detailed explanation, see H.-S. Sohn (1987).

Among the above steps, conditions in (14b), which is the main focus of this paper, have not been explained with evidence so far. This will be clear after we go through the following sections with many pieces of evidence. Based on the above syllabification algorithm, I provide syllabification process of some examples in the following:

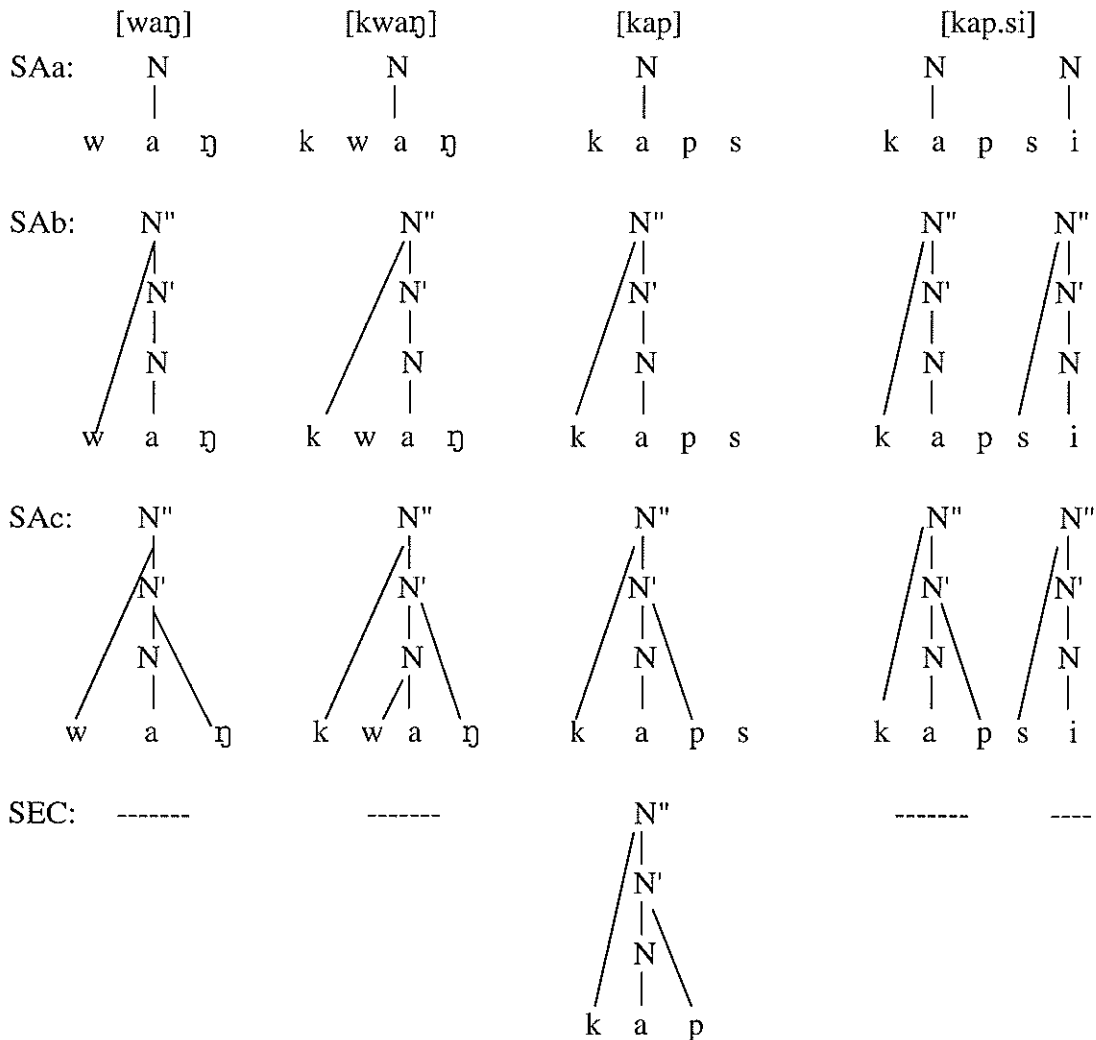
(15) Syllabification

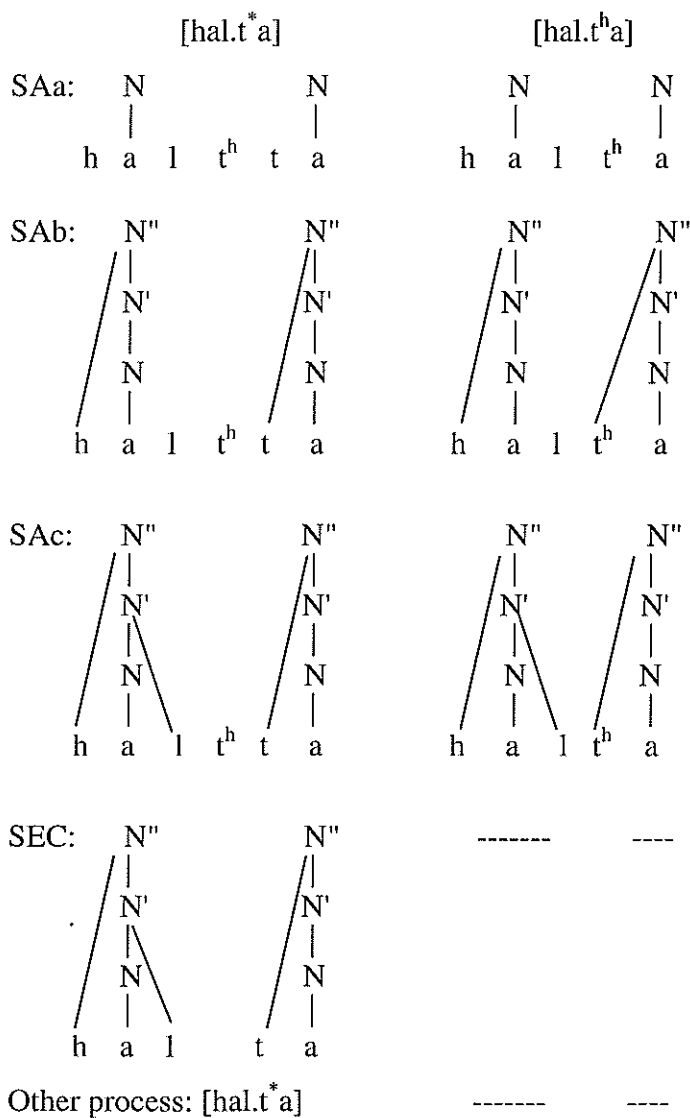
a. /waŋ/ → [waŋ] 'king'

b. /kwaŋ/ → [kwaŋ] 'storage'

c. /kaps/ → [kap] 'price'

d. /kaps + i/ → [kap.si] 'price (NOM)'

e. /halt^hta/ → [hal.t^a] 'to lick'f. /halt^h + a/ → [hal.t^ha] 'to lick (STATIVE)'



As shown above, glides are onset segments when there is no preceding tautosyllabic consonant, whereas they are nuclear segments when they occur after a tautosyllabic consonant. This is because onset position is filled first, and then the remaining glide adjoins to nucleus. Then we can expect that they have different characteristics depending on their position within a syllable. In the following section, I will provide the evidence for that.

3. Glides in syllables

In the above section, I have claimed that glides are both onset and nuclear segments depending on syllabification: since there can be only one segment in onset, the syllable-initial glides are onset segments whereas the ones after a tautosyllabic consonant are nuclear segments. Since they occur in different positions within syllables, they have different characteristics. This can be illustrated well when they are followed by front vowels⁹. In the following, I list examples where the high front glide /j/ occurs before a front vowel /e/:

(16) High front glide /j/ before a front vowel /e/

a. /je/ → [je] 'example', not *[e] /jesan/ → [je.san] 'budget', not *[e.san]

b. /p^hje/ → [p^hje] ~ [p^he] 'bother'

c. /kje/ → [kje] ~ [ke] 'a traditional mutual financial association'

 /kjesan/ → [kje.san] ~ [ke.san] 'calculation'

d. /nje/ → [nje] ~ [ne] 'yes'

e. /salje/ → [sa.rje] ~ [sa.re] 'reward'

As shown in (16a), the syllable-initial /j/ cannot be deleted before a front vowel /e/, whereas the ones after a tautosyllabic consonant are optionally deleted. In other words, by the current hypothesis they have different characteristics with respect to syllabification: a syllable-initial /j/, which is an onset segment, cannot be deleted whereas the one after a tautosyllabic consonant, which occurs under nucleus, can be optionally deleted. However, /j/ is not deleted before a non-front vowel, as shown in the following¹⁰:

⁹ [ji] is an impossible sequence for a diphthong in Korean as mentioned before.

¹⁰ [jɨ] is an impossible sequence for a diphthong in Korean as mentioned before.

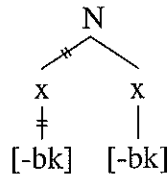
(17) High front glide /j/ before a non-front vowel

- | | |
|---------------------------------|---------------------------------|
| a. [jə.su] 'name of a place' | [ja.ku] 'baseball' |
| [ju.san] 'inheritance' | [jo.ku] 'request' |
| b. [pjə] 'rice plant' | [ti.tjə] 'to step on (STATIVE)' |
| [kjə] 'chaff' | [ka.rjə] 'to cover (STATIVE)' |
| c. [tal.kjal] 'egg' | [a.rjaŋ] 'generosity' |
| d. [kjul] 'tangerine' | |
| e. [p ^h jo] 'ticket' | [kjo.caŋ] 'principal' |
| [ca.rjo] 'material' | |

Therefore, /j/ is deleted only between a tautosyllabic consonant and the front vowel /e/.

The following analysis illustrates that:

(18) OCP effect within nucleus (optional)



The above analysis shows that the OCP effect holds in this case where the x-slot and the segment with [-bk], namely [j], are optionally deleted before another [-bk] segment. This process occurs under nucleus, and hence this is the evidence that the high front glide occurs under nucleus when it follows a tautosyllabic consonant, and it occurs under onset when it does not follow any consonant within a syllable. For example, in the case of /jesan/, where there is no preceding consonant before the glide [j], the glide is not deleted because that occurs under onset. There is a well-known cross-linguistic fact that syllables with onsets are less marked than the ones without onsets. Therefore, /jesan/ does not become *[e.san] since the first syllable of this word, otherwise, would end up with an empty onset. If a cluster /Cj/ were assumed to be in onset position, deleting /j/ would yield a simple but filled onset. No motivation is found for this process. The argument that supports nuclear /j/ here is based on the fact that the vowel's quality is crucial, suggesting

that the /j/ is in the nucleus in /Cje(C)/. Therefore the only explanation for that is to relate /j/-glide to the following vowel. That is, they both occur under nucleus when there is a preceding tautosyllabic consonant.

A high back rounded glide /w/ also shows different characteristics when it occurs before front vowels, depending on its position within a syllable: /w/ remains unchanged when it occurs in syllable-initial position, whereas it is changed to [ɥ] before front vowels /i/ and /e/ when it follows a tautosyllabic consonant¹¹. In the following examples, /w/ occurs before /i/:

(19) High back rounded glide /w/ before a front vowel /i/

a. /wi/ → [wi] 'above', not *[ɥi]

b. /twi/ → [tɥi] 'back/after'

c. /kwi/ → [kɥi] 'ear'

d. /cwi/ → [cɥi] 'rat'

e. /nwi/ → [nɥi] 'who'

As shown above, the syllable-initial /w/ is not changed whereas the ones after a tautosyllabic consonant are changed to [ɥ] before a front vowel /i/. The same is true when /w/ occurs before the other front vowel /e/, which is shown in the following:

¹¹ Many researchers (such as K.-O. Kim 1978, H.-S. Sohn 1987 and Levin 1987 among others) use the symbols [ü] and [ö] instead of [ɥi] and [ɥe], respectively. They claim that [(C)wi] and [(C)we] are in free variation with [(C)ü] and [(C)ö], respectively. Their transcriptions for [kɥi] 'ear' and [k*ɥe] 'wisdom', for instance, are [kwi] ~ [kü] and [k*we] ~ [k*ö], respectively. K.-O. Kim (1978) claims that [(C)wi] and [(C)we] are derived from the underlying /(C)ü/ and /(C)ö/ by some phonological rules (e.g., /ö/ → [öi] ([i] insertion) → [öe] (lowering) → [we] (glide formation)). H.-S. Sohn (1987) claims the opposite of it: for example, /(C)we/ ([+rd], [-bk, -hi]) → [(C)ö] ([+rd, -bk, -hi]) by nucleus degemination. However, my intuition as a native speaker of Korean does not agree with them. It might be possible that there were the monophthongs /ü/ and /ö/ in the history of Korean. (To my knowledge, no one has provided the evidence for this.) But in modern Korean they do not exist. For example, [k*ɥe] should not be transcribed as [k*ö]: while Korean speakers are pronouncing this word, their lips are rounded first and then spread, and hence they are diphthongs. It should not be transcribed as [k*we] either: when /k*/ is produced, the front of the tongue touches the hard palate instead of the velum with the tip of the tongue against the lower teeth, which is the typical pronunciation of palatal sounds as explained by Ladefoged (2001:144). This is due to the influence of the following [-bk] segment, namely [ɥ]. Therefore, the correct transcription is [k*ɥe]. Later, I will explain that /w/ becomes [ɥ] between a consonant and a front vowel. W. Huh (1985) also uses [(C)ɥi] and [(C)ɥe].

The next piece of evidence for syllable-initial glides as onset segments comes from /p/-irregular verbs. When those verbs are followed by a stative suffix /ə/, /p/ becomes [w].

The following illustrate that:

(24) p/w alternation with stative suffix /ə/

- a. /təp + ə/ → [tə.wə] 'hot' cf., /təp + ko/ → [təp.k*o] 'hot and'
 b. /kup + ə/ → [ku.wə] 'to bake' cf., /kup + ko/ → [kup.k*o] 'to bake and'
 c. /cup + ə/ → [cu.wə] 'to pick up' cf., /cup + ko/ → [cup.k*o] 'to pick up and'
 d. /mip + ə/ → [mi.wə] 'to hate' cf., /mip + ko/ → [mip.k*o] 'to hate and'

In the above examples, the underlying /p/ becomes [w] between vowels¹³. As explained in section 2.2, a consonant between vowels is always a syllable-initial segment, whereas it becomes a coda segment when there is a following consonant that occurs before another vowel (See the examples in (8) and (10)). In other words, /p/ becomes [w] in onset and [p] in coda¹⁴. Therefore, the syllable-initial [w] is an onset segment. One might argue that [w] is always under nucleus. However, since the syllable-initial [w] shown above is derived from the consonant /p/, it is not motivated that it occurs under nucleus.

Hiatus resolution is also evidence for syllable-initial glides as onset segments. As Y. Lee (1994:138) argues, syllables without onset are marked cross-linguistically, and hence when vowels are adjacent to each other, glides are inserted sometimes to avoid syllables without onset, which is shown in the following:

¹³ This phonological process works only with /p/-irregular verbs. /p/-regular verbs do not show this process: for example, /cip + ə/ → [ci.pə] 'to pick up'.

¹⁴ This is more complicated than it appears. Y.-K. Kim-Renaud (1974) and S.-C. Ahn (1985) claim /p/ analysis, whereas H.-S. Sohn (1987) and Y. Jeong (1998) claim /w/ analysis. I follow the /p/ analysis in my paper. Actually /p/ remains in syllable-initial position in the Kyungsang dialect: for example, /təp + ə/ → [tə.pə] 'hot'. In any case, it is obvious that [w] alternates with [p]. I take this as evidence that syllable-initial glides are onset segments.

(25) Glide insertion for hiatus resolution¹⁵

a. /kal + kə + e + jo/ → [kal.kə.je.jo] 'I will go'

/ha + ə/ → [ha.jə] 'to do (STATIVE)'

cf., /mək + ə/ → [mə.kə] 'to eat (STATIVE)'

b. /cin.se + a/ → [cin.se.ja] 'Cinse! (vocative)' cf., /cinsuk + a/ → [cin.su.ka] 'Cinsuk!'

If the second vowel is high, it is changed to a glide, which is shown in the following (The first example is cited from Y. Lee (1994:138) except the cf.):

(26) Glide formation for hiatus resolution

a. /c^hiu + ə/ → [c^hi.wə] 'to clean' cf., *[c^hi.u.ə]

/k^hiu + ə/ → [k^hi.wə] 'to bring up' cf., *[k^hi.u.ə]

/peu + ə/ → [pe.wə] 'to learn' cf., *[pe.u.ə]

/s^{*}au + ə/ → [s^{*}a.wə] 'to fight' cf., *[s^{*}a.u.ə]

b. /mei + ə/ → [me.jə] 'to choke' cf., *[me.i.ə]

/moi + ə/ → [mo.jə] 'to gather' cf., *[mo.i.ə]

/p^hai + ə/ → [p^ha.jə] 'to be dug' cf., *[pa.i.ə]

(where /ə/ is a stative suffix.)

As Y. Lee (1994:138) says, when two syllables are adjacent to each other, if the second one does not have an onset, glide insertion or formation occurs to avoid hiatus. Since they occur in syllable-initial position, this is evidence that syllable-initial glides are onset segments¹⁶.

¹⁵ I use my own examples here. But the basic idea is from his arguments.

¹⁶ Many researchers (such as J.-S. Lee (1992); among others) talk about compensatory lengthening with glide formation of a high front vowel /i/. For example, /p^hiə/ → [p^hi.ə] ~ [p^hjə:] 'to blossom' (cited from J.-S. Lee 1992:45). (I think /p^hiə/ → [p^hi.jə] is also possible.) But this example is different from the ones in (26) above. In /p^hiə/ → [p^hjə:], two vocoids occur within the same syllable, whereas in (26), the second

3.2. Glides after a tautosyllabic consonant as nuclear segments

As I claimed before, glides after a tautosyllabic consonant are nuclear segments since glides take their position only after onset position is filled, where only one segment is possible. One piece of the evidence comes from diphthongization within nucleus, which is shown in the following (where the examples (27b) and (27e) are cited from H.-S. Sohn (1987:74) except the cf.'s)¹⁷:

(27) Diphthongization within nucleus¹⁸

a. /kucəl/ → [ku.cəl] ~ [kɥi.cəl] 'phrase'

cf., /ucəŋ/ → [u.cəŋ], not *[wi.cəŋ] or *[ɥi.cəŋ] 'friendship'

b. /cukita/ → [cu.ki.ta] ~ [cɥi.ki.ta] 'to kill'

cf., /ukita/ → [u.ki.ta], not *[wi.ki.ta] or *[ɥi.ki.ta] 'to insist'

c. /nu/(ku) → [nɥi] ~ [nɥi.ki] 'who'¹⁹

d. /sokoki/ → [so.ko.ki] ~ [sɥe.ko.ki] 'beef'

e. /koki/ → [ko.ki] ~ [kɥe.ki] 'meat'

cf., /oki/ → [o.ki], not *[we.ki] or *[ɥe.ki] 'obstinacy'

f. /mosita/ → [mo.si.ta] ~ [mɥe.si.ta] 'to escort'

cf., /osita/ → [o.si.ta], not *[we.si.ta] or *[ɥe.si.ta] 'to come'

vowels, which are also high vowels, occur between vowels, and do not affect syllabification of the first syllable.

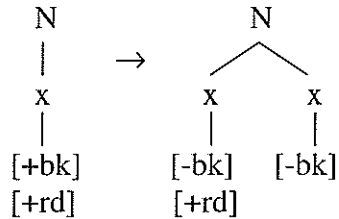
¹⁷ In H.-S. Sohn (1987:74), the examples (27b) and (27e) are transcribed as: /cukita/ → [cükita], and /koki/ → [k öki]. She explains these with vowel fronting before front vowels. But I don't agree with these transcriptions. The first vowels should be transcribed as diphthongs [ɥi] and [ɥe], respectively since while Korean native speakers are pronouncing these words, they show lip rounding followed by spreading. These examples undergo fronting with diphthongization, and hence, /u/ → [ɥi] and /o/ → [ɥe], respectively.

¹⁸ The argument for this process might be weak since it is restricted to only a few words (less than 30 words, to my knowledge). However, it should be noted that the diphthongization is possible after consonants with almost all types of manners and places of articulation.

¹⁹ [nɥi] is found in the standard dialect, whereas [nɥi.ki] is in some North Korean dialects.

It is obvious that vowels occur under nucleus. In the above examples, rounded vowels alternate with diphthongs when they occur after a tautosyllabic consonant, but they do not in syllable-initial position. This is the evidence that glides after a tautosyllabic consonant are nuclear segments. The following is the analysis:

(28) Diphthongization within nucleus



Another piece of evidence comes from H.-S. Sohn (1987). She provides some examples where diphthongs are monophthongized, which she calls nucleus degemination. The following examples (cited from H.-S. Sohn (1987:162)) illustrate that:

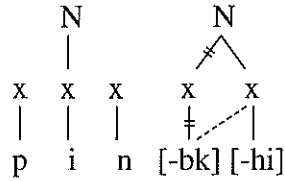
(29) Nucleus degemination

- a. /kjə/ → [kjə] ~ [ke] 'chaff'
- b. /pinjə/ → [pi.njə] ~ [pi.ne] 'stick hairpin'
- c. /mjənɪli/ → [mjə.nɪ.li] ~ [me.nɪ.li] 'daughter in law'
- d. /pjəlak/ → [pjə.lak] ~ [pe.lak] 'thunder'
- e. /p^{*}jam/ → [p^{*}jam] ~ [p^{*}em] 'cheek'²⁰

She refutes C.-W. Kim's (1968) metathesis analysis, and claims that this process can be accounted for by degemination of two segments within nucleus. She provides the formalization of this process, which is shown in the following (cited from Sohn 1987:162):

²⁰ She transcribes this word as: [p^{*}jam] ~ [p^{*}æm]. But as I mentioned before, /æ/ and /e/ are merged to /e/, and hence I use /e/.

(30) [pi.njə] ~ [pi.ne]



According to H.-S. Sohn (1987:162), a glide followed by a vowel yields a single vowel, and so both x-slot and the segment are delinked. She claims that this process can be explained when both a glide and a vowel occur under the same nucleus. In the following, I provide some other examples:

(31)

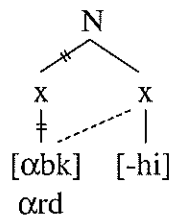
a. /ka + si + ə + jo/ → [ka.sjə.jo] ~ [ka.se.jo] 'go! (command - honorification form)'

b. /tu + ə + la/ → [tu.ə.ra] ~ [twə.ra] ~ [to.ra] 'put! (command)'

c. /cu + ə + la/ → [cu.ə.ra] ~ [cwə.ra] ~ [co.ra] 'give (command)'

As shown in the examples (29) and (31), not only /jə/ and /ja/ but also /wə/ is denuclearized: /wə/ becomes /o/. It should be noticed that the denuclearized vowels, namely [e] and [o] have the same [round] feature that the original glides have. That is, /j/ and [e] have the same [-round] feature whereas /w/ and [o] [+round] feature. Therefore, H.-S. Sohn's (1987) analysis shown in (30) should be changed to explain the cases for both /j/ and /w/. The following analysis illustrates that:

(32)



It should also be noticed that in all the examples in (29) and (31), glides occur after a tautosyllabic consonant. The nucleus degemination does not work for syllable-initial glides²¹. The following illustrate that:

(33)

- a. /jəɭim/ → [jə.lim], not *[e.lim] 'summer'
- b. /pujə/ → [pu.jə], not *[pu.e] 'name of a place'
- c. /wəncə/ → [wən.ca], not *[on.ca] 'atom'
- d. /kuwəl/ → [kuwəl], not *[ku.ol] 'September'

Therefore, syllable-initial glides are onset segments whereas glides after a tautosyllabic consonant are nuclear segments. It should be noticed that back vowels show interesting characteristics: [+ round] vowels are diphthongized as shown in (27), whereas a glide followed by a [- round] vowel is denuclearized as shown in (29) and (31).

However, Y. Lee (1994:140-141) argues that this process is an onset simplification process where /j/ occurs under onset and the preceding consonant is the trigger of this process since this process is not possible in a word-initial GV sequence. He explains that this onset simplification process is obligatory in the Kyungsang dialect as in:

(34) More examples of nucleus degemination (cited from Y. Lee 1994:141)

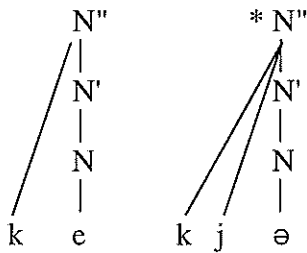
| | <i>Standard dialect</i> | <i>Kyungsang dialect</i> |
|----|-------------------------|--------------------------|
| a. | [kyə.ca] 'mustard' | [ke.ca] |
| | [yə.ca] 'woman' | [yə.ca], not *[e.ca] |
| b. | [kyə.ul] 'winter' | [ke.ul] |
| | [yə.ul] 'stream' | [yə.ul], not *[eul] |

²¹ She argues that glides are nuclear segments only.

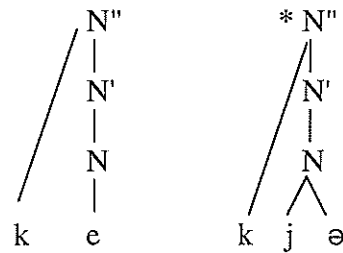
As shown in the above examples, glides never occur after a tautosyllabic consonant within a syllable. That is, in the Kyungsang dialect, GVC and CVC are well-formed syllables, but CGVC is never found²². Based on this observation, he proposes that a syllable onset constraint exists in the Kyungsang dialect: only one consonant must occur under onset, which he calls the Single Onset Consonant Constraint (SOCC). However, I claim that since there cannot be a glide after a tautosyllabic consonant, we can also say that in the Kyungsang dialect, there is single nuclear segment constraint (SNSC): only one segment is possible under nucleus. In other words, Both the SOCC and the SNSC can explain this phenomenon. Compare the following analyses of the Kyungsang dialect:

(35) [ke.ca] 'mustard'

a. SOCC



b. SNCC



As shown above, the analyses are the same just because there cannot be a glide after a tautosyllabic consonant. Therefore, examples from the Kyungsang dialect should not be used to prove whether glides after a tautosyllabic consonant are onset or nuclear segments since they never occur after a tautosyllabic consonant.

Another piece of evidence comes from metathesis of features within nucleus followed by fronting. The following (where the example (36b) is cited from H.-S. Sohn (1987:163)) illustrate that²³:

²² I think that what he meant by the Kyungsang dialect is the Southern Kyungsang dialect. In the Northern Kyungsang dialect, like other dialects, glides can appear after a tautosyllabic consonant. Since the Northern Kyungsang dialect does not have any difference from other dialects with respect to glides within a syllable, I will use the term 'the Kyungsang dialect' for 'the Southern Kyungsang dialect' hereafter.

²³ She transcribes this example as: /p^{*}jocok/ → [p^{*}ö.cok] to explain nucleus degemination. I do not agree with her transcription and analysis.

(36)

- a. /kjupə̃m/ → [kju.pə̃m] ~ [kɥi.pə̃m] 'law'
 cf. /jusan/ → [ju.san] 'inheritance', not *[wi.san] or *[ɥi.san]
- b. /p**jocok*/ → [p**jo.cok*] ~ [p**ɥe.cok*] 'sharp'
- c. /mjo/ → [mjo] ~ [mɥe] 'tomb'
 cf. /jose/ → [jo.se] 'fortress', not *[we.se] or *[ɥe.se]
- d. /k^hjuripuin/ → [k^hju.ri.pu.in] ~ [k^hɥi.ri.pu.in] 'Madam Curie'²⁴
- e. /tẽpju/ → [te.pju] ~ [te.pɥi] 'debut'

In the above examples, a high front glide /j/ followed by a back rounded vowel alternates with a high front rounded glide [ɥ] followed by a front unrounded vowel. However, syllable-initial glides do not undergo these changes. As explained before, /w/ becomes [ɥ] between a consonant and a front vowel. Then, we can analyze the above examples as in the following:

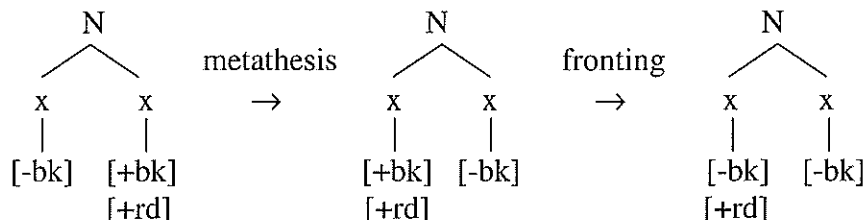
(37)

- a. /kjupə̃m/ → [kwipə̃m] → [kɥi.pə̃m]
- b. /p**jocok*/ → [p**wecok*] → [p**ɥe.cok*]
- c. /mjo/ → [mwe] → [mɥe]
- d. /k^hju.ri.pu.in/ → [k^hwi.ri.pu.in] → [k^hɥi.ri.pu.in]
- e. /tẽpju/ → [te.pwi] → [te.pɥi]

The following is the analysis for these phonological processes:

²⁴ The examples (36d) and (36e) are loan words. They are originally French words where the first vowel in (36d) and the second vowel in (36e) are both /ü/. It is not clear whether they were borrowed from French or English. This vowel became [ju] and [ɥi] in Korean. This means that Korean speakers do not produce the monophthong /ü/.

(38) Metathesis followed by fronting of features within nucleus



As shown above, metathesis occurs within nucleus, and also fronting of [w] to [ɥ] before [-bk] segment occurs within nucleus. Since this process occurs only after a tautosyllabic consonant, this is evidence that glides after a tautosyllabic consonant are nuclear segments. Consider the examples in (27), (29), and (31) again, and compare those with (37). The following summarize that:

(39) Characteristics of back vowels under nucleus²⁵

[+ round] vowel: diphthongization (e.g., /Cu/ → [Cɥi], /Co/ → [Cɥe])

metathesis (e.g., /Cju/ → [Cwi] → [Cɥi], /Cjo/ → [Cwe] → [Cɥe])

[- round] vowel: nucleus degemination (e.g., /Cjə/ → [Ce], /Cja/ → [Ce], /Cwə/ → [Co])

As shown above, back vowels show different characteristics depending on their [round] feature when they occur under nucleus.

Another piece of evidence comes from /l/ to [r] alternation. It is well known that /l/ becomes [r] between vowels in Korean. C.-W. Kim and H.-Y. Kim (1991) claim that the /l/ to [r] alternation is evidence that glides are nuclear segments. The following examples illustrate that (cited from C.-W. Kim and H.-Y. Kim 1991:118):

²⁵ An unrounded back vowel /i/ is excluded since [jɪ], [wɪ], and [ɥɪ] are impossible in Korean.

(40) /l/r alternation

- | | | | |
|-------------|------------|-------------|---------------|
| a. /iljoil/ | [i.rjo.il] | *[i.ljo.il] | 'Sunday' |
| b. /səlʝok/ | [sə.rʝok] | *[sə.lʝok] | 'vindication' |
| c. /kɪlwəl/ | [kɪ.rwəl] | *[kɪ.lwəl] | 'writing' |
| d. /milwəl/ | [mi.rwəl] | *[mi.lwəl] | 'honeymoon' |

As shown above, /l/ also becomes [r] between a vowel and a glide. They consider this as evidence for glides as nuclear segments since they patterns with vowels. However, Y. Lee (1994:149-150) argues that this analysis can also be interpreted as glides as onset segments using examples from the Kyungsang dialect. He claims that in the Kyungsang dialect, /l/ cannot become [r] between a vowel and a glide, namely, /iljoil/ → [il.jo.il]. He says that /l/ remains in coda position and /j/ becomes onset because of the single onset consonant constraint. But I do not think that it matters. As I mentioned before, in the Kyungsang dialect, there cannot be a glide after a tautosyllabic consonant, and hence /l/ remains in coda position and the glide /j/ becomes an onset segment. Again, since glides cannot occur after a tautosyllabic consonant in the Kyungsang dialect, examples from that should not be used to illustrate position of glides within syllables.

J.-S. Lee (1992:42) also provides counter examples for this, which are shown in the following:

(41)

- a. /hemul + joli/ → [hemuljori] 'sea food'
 b. /sikol + juci/ → [sikoljuci] 'rich person in a countryside'

But it should be noticed that all these examples are compounds and have only /j/-glide in them. The word-medial [l] is actually ambisyllabic, and hence his transcription should be changed to the ones shown in the following:

(42)

a. /hemul + joli/ → [he.mul.ljo.ri]

b. /sikol + juci/ → [si.kol.lju.ci]

In compounds, [n] is inserted before /j/, for example, /ap^h + jəp^h/ 'front and side' → [ap^hnjəp^h] → [am.njəp]. As Iverson and Kim (1987:381) say, when [n] and [l] are adjacent, [n] becomes [l], for example, /talnala/ 'moon' → [tal.la.ra]; /c^halna/ 'moment' → [c^hal.la]. So, the derivations of the above examples should be the following:

(43)

a. /hemul + joli/ → [hemulnjori] → [hemul.ljori]

b. /sikol + juci/ → [sikolnjuci] → [si.kol.lju.ci]

The above analyses show that [l] does not occur at all between a vowel and a glide, and hence do not affect C.-W. Kim and H.-Y. Kim's (1991) argument. In the case of /w/-glide, this process does not occur, which is shown in the following:

(44)

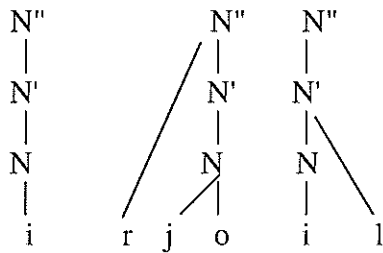
/ital + wəlki:p/ → [i.ta.rwəl.ki:p] 'this month's salary'

not *[i.ta.wəl.ki:p] or *[i.ta.lwəl.ki:p]

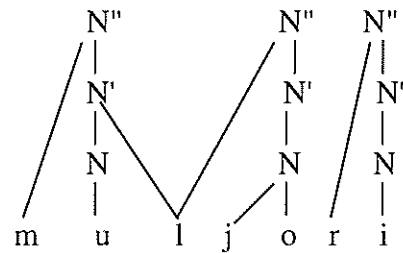
Therefore, J.-S. Lee's argument does not affect C.-W. Kim and H.-Y. Kim's (1991) argument. In the following, I provide the analysis for [i.rjo.il] and [he.mul.ljo.ri]:

(45)

a. [i.rjo.il]



b. [he.mul.ljo.ri]



As shown above, [r] occurs only in pure onset position. It is obvious that [l] occurs in coda position. The reason why /l/ remains in [he.mul.ljo.ri] is that it is ambisyllabic. In other words, [l] can be both an onset and a coda segment. Therefore, C.-W. Kim and H. Y. Kim's argument should be revised: /l/ becomes [r] in pure onset position, not in ambisyllabic position. If we assume that [r] occurs in both onset and coda position, we should explain why *[he.mur.rjo.ri] is not possible. No motivation for that is found. Therefore, we should say that /l/ becomes [r] between vowels, and also this process occurs between a vowel and a glide. This is evidence that glides occur under nucleus when there is a tautosyllabic consonant.

4. Re-examination of language games

Many researchers have mentioned language games for both the nucleus hypothesis (such as H.-S. Sohn 1987; C.-W. Kim and H.-Y. Kim 1991; among others) and the onset hypothesis (such as C.-G. Gim 1987; Y. Lee 1994; S.-C. Ahn 1988; among others). First, I will talk about the arguments for glides as onset with respect to language games.

According to C.-G. Gim (1987:51), he is familiar with a language game called the Pepeli Language that was used in Changwon and Masan in Kyungsang Province, where he was born and lived in his early years. His arguments and examples for this language game are cited by many researchers (such as Y. Lee 1994; S.-C. Ahn 1988; among others). He uses ideophones and language games to support the left-branching structure of syllables mentioned in the beginning of this paper. Leaving aside the syllable structure since this is beyond the scope of this paper, I will talk about the arguments related to the

position of glides within syllables. Following C.-G. Gim (1987), Y. Lee (1994:141) provides the following examples:

(46)

- a. [sa.ta.ri] 'ladder' → [sa.pa.ta.pa.ri.pi]
- b. [cam.sil] 'place name' → [ca.pam.si.pil]
- c. [sa.ram] 'person' → [sa.pa.ra.pam]

As shown above, in the inserted syllables, onset consonants are replaced by [p], and vowels are copied, but coda consonants simply become the coda of the inserted syllables²⁶. If there is no onset consonant, [p] is simply epenthesized. The following data, cited from C.-G. Kim (1987:52), illustrate that:

(47)

- a. [in.su] 'name of a person' → [i.pin.su.pu]
- b. [i.ri] 'here' → [i.pi.ri.pi]
- c. [o.nə.ra] 'come (command)' → [o.po.nə.pə.ra.pa]

According to Y. Lee (1994:142-143), when there is a glide before a vowel, it is also replaced by [p] as shown in (48a) below, and the same is true of a consonant followed by a glide as shown in (48b, c, and d). That is, a consonant followed by a glide can also be replaced by [p] if they occur in onset position. He provides the following examples (cited from Y. Lee 1994:142-143):

²⁶ For further explanation, see Y. Lee (1994:142) and Y. Kang (1991:48), where they explain that coda consonants are extra syllabic. Since this is beyond the scope of this paper, I will not investigate this.

(48)

- a. [jəŋ.kam] 'grandpa' → [jə.pəŋ.ka.pam]
 b. [hak.kjo] 'school' → [ha.pak.kjo.po]
 c. [hjəŋ.kwaŋ.tiŋ] 'fluorescent lamp' → [hjə.pəŋ.kwa.paŋ.ti.pŋ]
 d. [kwən.t^hu] 'boxing' → [kwə.pən.t^hu.pu]

Using these examples, he claims that glides are onset segments, but not nuclear segments, and hence they are replaced by [p] along with onset consonants.

It seems that the above data and analysis are problematic for the analysis I am developing. However, I here provide an argument against the language game as supporting evidence for position of glides within syllables. According to C.-G. Gim (1987), this language game was used in Changwon and Masan in Kyungsang province. Those places are in the southern part of Kyungsang province. As I mentioned before, glides do not occur after a tautosyllabic consonant in the dialect spoken in the southern part of Kyungsang province. If this language game were applied to other dialects, the above data might be obtained by replacing the Kyungsang dialect's input syllables with inputs with /CGV(C)/ sequences. I am a Cholla dialect speaker. But I am not aware of this language game. I have consulted with many Korean native speakers including all the dialects of Korean in South Korea. But no one knows this language game including even Kyungsang dialect speakers. I suspect that this language game has been lost, and only some older Kyungsang dialect speakers might remember it. The following examples illustrate how this language game is applied in the Kyungsang dialect (The Kyungsang dialect examples are cited from Y. Lee (1994:141, 150):

(49)

- | <i>Standard dialect</i> | <i>Kyungsang dialect</i> → <i>Application of Language Game</i> |
|-----------------------------------|--|
| a. [kjə.ca] 'mustard' | [ke.ca] → [ke.pə.ca.pə], not *[kjə.pə.ca.pə] |
| b. [kjə.ul] 'winter' | [ke.ul] → [ke.pə.u.pul], not *[kjə.pə.u.pul] |
| c. /iljoil/ → [i.rjo.il] 'Sunday' | [il.jo.il] → [i.pil.jo.po.i.pil.], not *[i.pi.rjo.po.i.pil] |

As shown above, since only one segment can occur under both onset and nucleus in the Kyungsang dialect, we cannot have glides after a tautosyllabic consonant within syllables. As I mentioned before, the Kyungsang dialect should not be used to explain position of glides since glides cannot occur after a tautosyllabic consonant. I also argue that this language game should not be used either since it is a part of the Kyungsang dialect.

Second, H.-S. Sohn (1987) uses this language game to support glides as nuclear segments, and C.-W. Kim and H.-Y. Kim (1991) cite her examples. Interestingly, her examples are different from the ones provided by C.-G. Gim (1987) et al. The following examples are cited from H.-S. Sohn (1987:108):

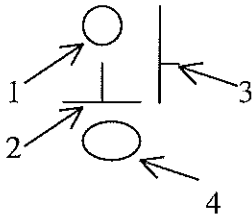
(50)

- a. [we.tiŋ] 'wedding' → [we.pwe.di.piŋ]
- b. [kwən.se] 'power' → [kwə.pwən.se.pɛ]
- c. [ja.ku] 'baseball' → [ja.pja.ku.pu]
- d. [cwa.sək] 'seat' → [cwa.pwa.sə.pək]

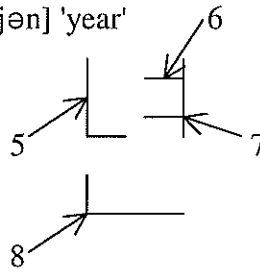
She conducted an experiment and obtained the above data from her subjects. First of all, my intuition as a native speaker of Korean does not agree with her data at all. Nor do C.-G. Gim (1987), S.-C. Ahn (1988), J.-S. Lee (1992), Y. Lee (1994), and even the supporters of nucleus hypothesis (such as Y. Kang 1991). I claim the same argument that I mentioned while I was criticizing C.-G. Gim et al's data and analysis: this language game should not be used because it is a part of the Kyungsang dialect where glides cannot occur after a tautosyllabic consonant. C.-G. Gim (1987:47-50) and Y. Lee (1994:143-144) criticize on her examples in detail. They claim that her data might be affected by the Korean orthographic system. According to Y. Lee (1994:143), in the Korean orthographic system, glides are a part of vowels. He provides the following Korean orthographies (cited from Y. Lee (1994:144)):

(51) Representation of glides in Korean orthographies

a. [waŋ] 'past'



b. [njəŋ] 'year'



(where 1: \emptyset , 2: [o], 3: [a], 4: [ŋ], 5: [n], 6 (namely, 'ㄹ'): [j], 7 (namely, 'ㄷ'): [ə], 8: [n])

Korean has a syllabary orthographic system. That is, each letter usually represents a syllable. In the letter (51a), the symbol #1 is a placeholder: when there is no syllable-initial consonant, this circle is inserted. Usually this is the place for onset consonants. The symbol #2 is for the vowel [o]. The symbol #3 represents the vowel [a]. Finally, the symbol #4, which is a circle, represents the consonant [ŋ]: the circle is a placeholder in onset position whereas it is [ŋ] in coda position in the Korean orthographic system (if it were the case that each symbol represented segments within a syllable). Based on this orthographic system, the vowel [o] with [a] becomes a diphthong [wa], and there is no onset consonant. That is, the glide [w] is a part of a vowel in this system, but not an onset element, which is the same as the conclusion Sohn et al draw. In the letter (51b), the symbol #5 and #8 represent [n], which are an onset and a coda consonant, respectively. The symbol #6 is for [j]. The symbol #7 represents [ə]. Notice that the symbol for [j] and [ə] are combined and they are considered as a diphthong in this system. In other words, the glide /j/ is a part of a vowel in this orthographic system.

Y. Lee (1994:144) argues that if subjects, who are not familiar with this language game, are asked to give the language game form, then they will provide the form based on this orthographic system since they cannot produce the appropriate form. In other words, they will simply manipulate the symbols used in the orthography. If this is the case, the forms obtained from them will be the ones found in (50).

In conclusion, I assume that both supporters of the onset hypothesis (such as C.-G. Gim et al) and those of the nucleus hypothesis (such as H.-S. Sohn et al) applied this

language game to other dialects. Since this language game is used only in the Kyungsang dialect where glides cannot occur after a tautosyllabic consonant, it should not be used to prove the position of glides within syllables.

5. Glides as both onset and nuclear segments found in other languages

While I have been doing this research, I have found that not only Korean but also other languages show that syllable-initial glides are onset segments whereas the ones after a tautosyllabic consonant are nuclear segments. In this section, I cite some researches done for Spanish, Slovak, and French.

5.1. Spanish examples

Harris and Kaisse (1999) did research on Spanish on-glides. I discuss their work in this section. In Spanish syllables, segments are ordered based on sonority. The following illustrates that (cited from Harris and Kaisse (1999:125)):

(52) Possible order of segments within a syllable

obstruent (O) - sonorant consonant (S) - glide (G) - vowel (V) - C (any consonant) - /s/

They also list additional conditions on Spanish syllables (cited from p.125):

(53) Well-formedness conditions on Spanish syllables

- a. At most five segments may be chosen.
- b. One of the five is a vowel.
- c. There are no contrastively long vowels; more generally, rhymes do not contain sequences of identical segments.
- d. Complex onsets are of the form obstruent-liquid; these must meet further conditions, some dialect-particular²⁷.
- e. Only /s/ can follow a tautosyllabic postpeak consonant or glide.

Many Spanish researchers (such as Harris (1983:6-13) and Hualde (1989, 1991:479-480)) provide evidence that glides do not occur together with consonants under onset.

²⁷ For detailed explanation, see Harris and Kaisse (1999, footnote 18).

Harris and Kaisse (1999) also provide the evidence: in most dialects of Spanish, syllable-initial glides are optionally or obligatorily changed to obstruents, whereas the ones after a tautosyllabic consonant are not. The following illustrate that (cited from p.127):

(54)

a. *crec-/io/* → *cre.c[jó]* 's/he grew'

b. *cre-/io/* → *cre[.jó]*, *cre[.jó]*, *cre[.ʝó]*²⁸, *cre[.ʒó]*, *cre[.ǰó]* 's/he believed'

Their obstruent forms are different from dialect to dialect, from context to context. As shown above, a syllable-initial glide [j] alternates with obstruents. According to them, Spanish does not allow consonants as syllable nuclei. Even sonorant consonants cannot be syllable nuclei except for some borrowings from indigenous languages. They conclude that when the underlying prevocalic /i/ occurs in syllable-initial position, it becomes an onset segment²⁹. This is evidence that syllable-initial glides are onset segments. Their conclusion is supported by the observation that there can be three segments within a rhyme, which was established by Harris (1983). The following illustrates that (cited from Harris and Kaisse (1999:127)):

(55)

a. Well-formed

GVCs

[juks].taponér 'to jukstapose'

b. Ill-formed

CGVCs

*[Cjuks]

In the example (55a), the glide [j] occurs under onset, whereas other segments occur under rhyme. The form in (55b) is not found in Spanish. If we assume that [j] were under nucleus, there would be four segments under rhyme, which is impossible in Spanish syllables. If we assume that [j] were under onset, there would be three segments. But this syllable is still not okay because glides cannot cluster with a consonant in onset (p.127).

²⁸ [j] and [ʝ] are voiced palatal obstruents, which have [+cont] and [-cont] features, respectively. For further explanation, see Harris and Kaisse (1999:121-122) and papers cited therein.

They also provide evidence that glides are nuclear segments when they occur after a tautosyllabic consonant. They give some examples where mid vowels /e/ and /o/ are diphthongized under stress. The following illustrate that (cited from p.128):

(56) Diphthongization of mid vowels

- a. v[e]nímos 'we are coming' vs. v[jé]nen 'they are coming'
 b. tr[o]nába 'it was thundering' vs. tr[wé]na 'it is thundering'

It is well known that verbs have stress on penultimate syllables in Spanish, which is also the default case for most Spanish words. The above verbs also have stress on penultimate syllables. In Spanish, stress depends on syllable count and weight. In other words, stress assignment follows syllabification. In the above examples, since the diphthongization is caused by stress, it is obvious that the source vowels /e/ and /o/ are under nucleus before diphthongization. If the glide made by the diphthongization remains under nucleus, no other explanation is needed. However, if we consider that the glides move to onset position, where other consonants are already placed after syllabification, we need to explain what motivates this process. No motivation for this process is found (p.128). This is evidence that glides after a tautosyllabic consonant are nuclear segments.

Harris and Kaisse (1999:130) also mention that Slovak and French have the same phenomena. That is, glides are onset segments in syllable-initial position, whereas they are nuclear segments after a tautosyllabic consonant within a syllable. In the following section, I cite the cases found in Slovak.

5.2. Slovak examples

Citing Rubach (1993, 1998), Harris and Kaisse (1999) discuss that in Slovak a heavy syllable undergoes shortening after another heavy syllable, which is shown in the following (cited from Rubach (1998:169)):

²⁹ In Spanish, there is no underlying /j, w/. Instead, the surface forms [j, w] and [i, u] are derived from underlying /i, u/.

(57) Rhythmic Law

V: → V / V: ___

Heavy syllables with complex nuclei (such as the syllables with nucleus that has a long vowel, a diphthong, or a long syllabic consonant) can contribute to this rule. The following illustrate that (cited from Rubach (1998:170)):

(58)

- a. No Rhythmic Law: žen + ám [žena:m] 'woman' (dat.pl)³⁰
- b. Rhythmic Law: mín + am [mi:nam] 'mine' (dat.pl)
- c. Rhythmic Law: v'rb + am [vr:bam] 'willow' (dat.pl)
- d. Rhythmic Law: riek + am [riekam] 'river' (dat.pl)³¹
 kôr + am [kuoram] 'surface' (dat.pl)
 čiar + am [čiam] 'line' (dat.pl)

The dative plural suffix has a long vowel in the underlying representation. It appears when the stem has a short vowel, which is shown in the example (58a). The examples in (58b) and (58c) show that a long vowel and a long syllabic consonant trigger shortening of the vowel of the following syllable. In the examples in (58d), a diphthong, which occurs after a tautosyllabic consonant, also triggers this process. This is evidence that glides after a tautosyllabic consonant are nuclear segments since they pattern with long vowels and long syllabic consonants, which are obviously nuclear segments.

Consider the following examples (cited from Rubach (1998:171)):

(59) jiričk + a [jiri:čka] 'linnet'

He argues that if the syllable-initial [j] were under nucleus with the vowel [i], this word would have two heavy syllables that are adjacent to each other, which is the violation of the Rhythmic Law. Therefore, the syllable-initial [j] is under onset. This is supported by

³⁰ Rubach says that the acute accent indicates a long vowel in the Slovak orthography.

³¹ In the transcriptions provided by Rubach (1998), [ie], [uo], [ia] are diphthongs.

a lengthening rule: vowels are lengthened in some grammatical contexts, for example, in the genitive plural form of a noun. The following illustrate that (cited from Rubach (1998:171)):

(60) Vowel lengthening

slin + a (nom.sg.) 'saliva' vs. slín [sli:n] (gen.pl)

According to him, complex nuclei cannot undergo the lengthening process since there can be at most two moras within a nucleus in Slovak syllables, as shown in the following (cited from p.171):

(61)

a. lúk + a [lu:ka] 'meadow' vs. lúk [lu:k] (gen.pl)

b. riek + a [rieka] 'river' vs. riek [riek] (gen.pl)

As shown in the example (61b), the genitive plural form, which has complex nucleus, does not undergo the lengthening since it is already bimoraic. However, the syllable-initial [ji] does undergo this process as shown in the following (cited from Rubach (1998:171)):

(62) krajín + a [krajina] 'countryside' vs. krajín [kraji:n] (gen.pl)

That is, the syllable-initial /j/ is an onset segment, but not a complex nucleus (p.171).

In conclusion, Slovak syllables also show the same pattern as Korean and Spanish syllables. In the following section, French syllables are explained.

5.3. French examples

In French, glides are also both onset and nuclear segments. However, unlike Korean, Spanish, and Slovak, French has underlying contrast between glides (Harris and Kaisse, 1999:130). This is explained by presence and deletion of the vowel of the article *le* /lœ/.

Tranel (1987) provides the following examples (cited from Harris and Kaisse, 1999:130):

(63)

- a. le whiskey [lœ wiski] 'the whisky' vs. l'oiseau [lwazo] 'the bird'
 b. le yod [lœ jod] 'the yod' vs. l'iode [ljod] 'the iodine'

According to Harris and Kaisse (1999:130), and Tranel (1987:117), in words like *whiskey* and *yod*, glides occur in onset position, and hence the article /lœ/ does not undergo deletion of its vowel. In words like *oiseau* and *iode*, glides occur under nucleus, and hence the vowel in /lœ/ is deleted. Since there is no phonetic difference between glides in the examples of both (63a) and (63b), the distinction must be lexically specified (Scullen 1993, cited from Harris and Kaisse 1999:130). Although French does not pattern with Korean, Spanish, and Slovak, it should be clear that glides are both onset and nuclear segments in French.

6. Conclusion

In this paper, I have argued that glides are both onset and nuclear segments depending on syllabification: syllable-initial glides are onset segments, and the ones after a tautosyllabic consonant are nuclear segments. This is because onset position is filled immediately after a vowel takes its nucleus position, and then if there is a remaining glide, it adjoins to nucleus position. Since they occur in different positions, they show different characteristics. I showed that when they occur after a tautosyllabic consonant in a syllable, /j/ is optionally deleted before a front vowel /e/, and /w/ is obligatorily changed to [ɥ] before front vowels /i/ and /e/. However, when they occur in syllable-initial position, they remain unchanged.

Syllable-initial glides as onset segments were justified via various examples. First, the evidence comes from p/w alternation. When /p/-irregular verbs are followed by a stative suffix /ə/, the /p/ sound becomes [w], which remains in syllable-initial position. Second, hiatus resolution is also evidence. When vowels are adjacent to each other, glides are inserted. But if the second vowel is high, it is changed to a glide. These glides

occur in syllable-initial position. It is well-known that syllables without onsets are marked. In this case, glides are inserted, or changed from high vowels to avoid marked syllables.

Glides after a tautosyllabic consonant as nuclear segments are also motivated through many examples. First, the evidence comes from diphthongization within nucleus. A single rounded vowel becomes a glide followed by an unrounded vowel. Since this process occurs under nucleus, this is evidence that glides after a tautosyllabic consonant are nuclear segments. Second, nucleus degemination also illustrates that. A glide followed by a vowel becomes a single vowel when it occurs after a tautosyllabic consonant. Third, metathesis followed by fronting of features is another piece of evidence: /j/ followed by a rounded vowel after a tautosyllabic consonant is changed to [ɥ] followed by a vowel, for example, /Cju/ → [Cwi] → [Cɥi]. Fourth, l/r alternation also proves that. In Korean /l/ becomes [r] between vowels. This is also true when there is a glide before the second vowel. Finally, I talked about a language game. Researchers have used the language game to support both onset and nucleus hypothesis. In this paper, I argued that this language game cannot be used to prove position of glides within syllables because this language game is found in the Kyungsang dialect, in which glides are not possible after a tautosyllabic consonant.

I also mentioned that Korean is not the only language that shows glides as onset segments in syllable-initial position whereas nuclear segments after a tautosyllabic consonant. Other languages such as Spanish, Slovak, and French also differentiate between syllable-initial glides and the ones after a tautosyllabic consonant. Therefore, glides are both onset and nuclear segments cross-linguistically.

References

- Ahn, Sang-Cheol (1985). The interplay of phonology and morphology in Korean. Unpublished doctoral dissertation, University of Illinois, Urbana-Champaign.
- Ahn, Sang-Cheol. (1988). A revised theory of syllabic phonology. Linguistic journal of Korean 13, 333-362.
- Gim, Cha-Gyun. (1987). Kwuke-ey eumcel kwuco-wa eumcelhayk-aneyse ilenanun eumunloncek kwaceng [A study on syllable structure and some processes in its nucleus in Korean]. Mal 12, 25-68. Yeonsei University: Seoul, Korea.
- Harris, James W. (1983). Syllable structure and stress in Spanish: a nonlinear analysis. Cambridge, MA: MIT press.
- Harris, James W. & Kaisse, Ellen M. (1999). Palatal vowels, glides and obstruents in Argentinian Spanish. Phonology, 16 117-190.
- Hualde, José I. (1989). Silabeo y estructura morfé mica en español. Hispania, 72 821-831.
- Hualde, José I. (1991). On Spanish syllabification. In H. Campos & F. Martínez-Gil (Eds.), Current studies in Spanish linguistics (pp.475-493). Washington, D.C.; Georgetown University Press.
- Huh, Woong. (1985). Kwuke eumunhak: Urimal soriey oneul, eche [Korean phonology: Contemporary and past Korean sounds]. Seoul, Korea: Saem Moonhwasa.
- Hong, Yunsook. (1986). An acoustic study of modern Korean vowels. Journal of Korean linguistics Vol.4.
- Hong, Yunsook. (1987). The e/ä merger in modern Seoul Korean. Harvard studies in Korean linguistics II (pp. 367-376). Proceedings of the 1987 Harvard Workshop on Korean linguistics (Harvard WOKL-1987), February 13-14, 1987.
- Hong, Yoonsook. (1991). A sociolinguistic study of Seoul Korean. Korean unification Studies, Serious 12, Seoul Research Center for Peace & Unification of Korea.
- Ingram, John & Park, See-Gyoon. (1997). Cross-language vowel perception and production by Japanese and Korean learners of English. Journal of Phonetics 25, 343-370.
- Iverson, Gregory K. & Kim, Kee-Ho (1987). On word-initial avoidance in Korean. Harvard studies in Korean linguistics II (pp. 377-393). Proceedings of the 1987

Harvard Workshop on Korean linguistics (Harvard WOKL-1987), February 13-14, 1987.

- Jeong, Yongkil. (1998). Development of P-irregular verbs in Korean: A metrical analysis.
Unpublished manuscript, University of Washington at Seattle.
- Kang, Yongsoon. (1991). Phonology of consonant-vowel interaction: With special reference to Korean and dependency phonology. Unpublished doctoral dissertation, University of Illinois, Urbana-Champaign.
- Kim, Chin-Wu. (1968). The vowel system of Korean. Language 44, 516-527.
- Kim, Chin-Wu. (1971). Two phonological notes: A-sharp and B-flat. In M. K. Brame (Ed.), Contributions to generative phonology (pp. 155-170). Austin, TX: University of Texas Press.
- Kim, Chin-Wu & Kim, Hyoung-Youb (1991). The character of Korean glides. Studies in the linguistic sciences, 21(2), 113-125.
- Kim, Jong-Mi. (1986). Phonology and syntax of Korean morphology. Unpublished doctoral dissertation, University of Southern California, Los Angeles.
- Kim, Kong-On. (1978). Vowel system of Korean revisited. In C.-W. Kim (Ed.), Papers in Korean linguistics (pp. 247-256). Columbia, SC: Hornbeam Press.
- Kim, Young-Seok. (1984). On the treatment of consonant reduction. Language Research, 20, 345-366. Seoul, Korea.
- Kim-Renaud, Young-Key. (1974). Korean consonantal phonology. Unpublished doctoral dissertation, University of Hawaii, Manoa.
- Kim-Renaud, Young-Key. (1978). The syllable in Korean phonology. In C.-W. Kim (Ed.), Papers in Korean linguistics. Columbia, SC: Hornbeam Press.
- Ladefoged, Peter. (2001). A course in phonetics (4th ed.). Forth Worth, TX: Hartcourt College Publishers.
- Lee, Byung-Gun. (1982). A well-formedness condition on syllable structure. In C.-W. Kim (Ed.), Linguistics in the morning calm II (pp. 489-506). Seoul, Korea: Hanshin Publishers.
- Lee, Hyun-Bok. (1971). Sewulmaluy mowumcheykyey [The vowel system of Seoul

- Korean]. Language Research, 7(2), 19-24. Seoul, Korea: Language Research Institute, Seoul National University.
- Lee, Yongsung. (1994). Onset analysis of Korean on-glides. In Y.-K. Kim-Renaud (Ed.), Theoretical issues in Korean linguistics (pp. 133-156). Stanford, CA: Stanford Linguistics Society.
- Lee, Jin-Seong. (1992). Phonology and sound symbolism of Korean ideophones. Unpublished doctoral dissertation, Indiana University, Bloomington.
- Levin, Julliette. (1985). A metrical theory of syllabicity. Unpublished doctoral dissertation, MIT, Cambridge.
- Levin, Julliete. (1987). Underspecification theory and Korean vowels. Harvard studies in Korean linguistics II (pp. 404-420). Proceedings of the 1987 Harvard Workshop on Korean linguistics (Harvard WOKL-1987), February 13-14, 1987.
- Rubach, Jerzy. (1993). The lexical phonology of Slovak. Cambridge, MA & Oxford: Clarendon Press.
- Rubach, Jerzy. (1998). A slovak argument for the onset-rhyme distinction. LI, 29(1) 168-179.
- Scullen, Mary Ellen. (1993). The prosodic morphology of French. Unpublished doctoral dissertation, Indiana University.
- Steriade, Donca. (1982). Greek prosodies and the nature of syllabification. Unpublished doctoral dissertation, MIT, Cambridge.
- Sohn, Hyang-Sook. (1987). Underspecification in Korean phonology. Unpublished doctoral dissertation, University of Illinois, Urbana-Champaign.
- Tranel, Bernard. (1987). The sounds of French. Cambridge: Cambridge University Press.

German Particle-Complement Verbs In Modern Morphological and Syntactic Theory: Countering the “Separable-Prefix” Misnomer

John Hamilton Gordon Scott

oneman@justoneman.net

1. Introduction

The syntactic structure of the so-called “separable-prefix” verbs in German has been ineffectively examined in past German verbal analysis, and usually left as a problem to be explained as some special case or as a topic for future study. The enigmatic quality of these verbs has led many to put them aside because explanation of their nature is not easily covered within the scope of other adjacent topics. I show that the analysis and formal description of these verbs as a class is not only possible when with the benefit of qualitative statistical analysis, the contemporary development of I-Adjunct theory, and the work of Chomsky (1994) and Collins and Thráinsson (1996), but also that this analysis is greatly helpful in negotiating the compatible juxtaposition of these theories in a single language environment.

Brehmer (1985), in his dissertation on German verb prefixes in the context of generative phrase structure, sadly only gives a total of eleven pages of his 210-page study to the matter of these most unusual verbs, and he still drops his analysis as inconclusive, leaving these verbs to be a mystery as he continues with the rest of his argument.¹ That a dissertation specifically on German verbal prefixes leaves such an issue unanswered shows that there is a great need to look at these verbs specifically with the benefit of recent research in order to put an end to the chronic negligence they have been given.

I will begin in sections 2-4 by introducing prosodic, semantic, and syntactic arguments for taking the so-called “separable-prefix” verbs (a misnomer that I will mark with quotes until I introduce a more appropriate term) as their own natural class. In

¹ Brehmer (1985: 117-27, 160-62) has a distinct disadvantage in that he seems only partly acquainted with the syntactic analysis he tries to make. This is most clearly shown by his misapplication of a gapping test, from which he falsely assumes certain parts of his brief syntactic analysis. As it turns out, gapping does not work as he expects it to in phrasal verb constructions, either. To his credit, the syntactic theories of NP-Object Shift, I-Adjunct, and clitic structure and the morphological theories of suppletion and faulty paradigms I work with in my proposed structure were either very new or still undeveloped when he did his study.

deletion has no regular formula in German), which only had conjugations of its own in the indicative mood that were in turn based on the indicative paradigms of verbs like *gân* ‘gehen’. In the case of *hân*, the periphrastic paradigm eventually merged back with simple transitive *haben* paradigm through morphological change, resulting in a mixed suppletive paradigm in Modern High German that shares an irregular distribution pattern in the indicative with verbs like *lesen* ‘read’, which have the first-person stem vowel alternation *ich lese – du liest – er liest*.³ By analogy, it is reasonable to assume that “separable-prefix” verbs also undergo a period of transition wherein their paradigms are unstable or incomplete, and that the anomalous forms presented by Brehmer (1985: 160-62) are merely verbs “caught in the act” of their transition at the moment of synchronic sampling.

In short, the evidence of phonological stress carriage, allowance of the participle affix *ge-*, the position of infinitive *zu-* and participle *ge-* affixes when overt, and the syntactic “stranding phenomena” of “prefix”-final finite matrix clauses constitute sufficient evidence to consider “separable-prefix” verbs a distinct prosodic class.

3. Establishing the “separable prefix” verbs as a semantic class

In trying to determine the status of “separable-prefix” verbs as either one word or two and as a distinct class of verbs, it would be helpful to have semantic support for the verdict. The approach most commonly taken toward this end is comparison of the concreteness of the “separable-prefix” verbs to the abstractness of the inseparably prefixed verbs. Brehmer (1985:119) states, “[...] the generalization is often made that the meanings of the latter [“separable”] are more concrete (and hence compositional) than those of the former [inseparable].” This would seem to establish a definite trend toward two semantic classes, but he immediately counters, “But compositionality cannot be used as an argument against the prefix-status of the latter [“separable”]. Many morphological constructions are compositional.” He finally points out Fleischer’s (1975:

³ The development of the irregular paradigm of *haben* in Modern High German is a classic example in morphological literature on suppletive paradigms, for it demonstrates both irregular phonological shift and morphological shift, which both lead to new suppletive paradigms that are no longer seen as being in conflict with Naturalness Theory. See the following for more complete coverage of the development of suppletion in morphological paradigms and its role in Naturalness Theory: Werner (1977; 1987b); Dressler (1986); Ronneberger-Sibold (1987; 1988; 1990); Nübling (1998b; 1999).

325) conclusion that a direct abstract-concrete classification fails because “*an-*, *aus-*, *um-*, *über-*, etc. enter into many relationships of synonymy and antonymy with the classical prefixes *be-*, *ent-*, etc.” Fleischer and Brehmer leave it at that and throw out semantic classification as unhelpful, but the argument for an abstract-concrete contrast still has great potential for establishing a *directional scalar* analysis which, though not resolving the prefix-or-separate-word dilemma⁴, does serve to establish a division of classes between “separably” and inseparably prefixed verbs.

Fleischer (1975) and Brehmer (1985) reject the abstract-concrete analysis on the premise that it must classify the verbs precisely and without semantic overlap of their ranges of abstractness and concreteness, a verdict that I see as premature. They look for an exclusive differentiation that is not necessary in order to classify these verbs as two distinct classes, and the prefixes they compare are not the most telling choices available.

Brehmer (1985) and Fleischer (1975) initially examine the abstract-concrete class hypothesis based on a great number of verbs which cleanly demonstrate it, such as *durchsieben* ‘riddle’ vs. *durch-sieben* ‘sift’ (Breitsprecher, Terrell, Schnorr, & Morris 1998: 322), *überlegen* ‘deliberate’ vs. *über-legen* ‘put/lay’ (Breitsprecher et al. 1998: 1198), *überstehen* ‘overcome’ vs. *über-stehen* ‘jut’ (Breitsprecher et al. 1998: 1202), and *unterschlagen* ‘misappropriate’ vs. *unter-schlagen* ‘cross’ (Breitsprecher et al. 1998: 1236). However, they abandon the hypothesis when confronted with apparent counterexamples of synonymy, such as *durchreisen/durch-reisen* ‘travel through’ (Breitsprecher et al. 1998: 319), and *überspringen/über-springen* ‘jump (over)’ (Breitsprecher et al. 1998: 1202), which they claim invalidate any theory of systematic difference in abstractness (Breitsprecher et al. 1998).

A more detailed look at the minimal pairs reveals a much more complex relationship between the “separably” and inseparably prefixed verbs, wherein each part of a minimal pair has multiple meanings that cover a certain range of abstractness or concreteness. For example, in the pairs *durch-schauen* ‘look/see through’ vs. *durchschauen* ‘see through/clearly, comprehend’ and *über-treten* ‘flood, convert to, overstep’ vs. *übertreten* ‘cross (a border), infringe’, the “separable” members of the pairs have meanings ranging mostly in physical, concrete references, while the inseparable,

⁴ I propose a structural solution to this dilemma in section 5 below.

though partially overlapping with the “separable”, tend to extend into more abstract areas. (Breitsprecher et al. 1998) Though there is overlap, the two classes have different semantic *centers of gravity*, as it were.

When approaching the abstractness or concreteness of a lexeme, as with any basic semantic variable, a binary feature-based classification is insufficient. For example, *blue* or *bird* in a binary feature system might be indicated as [-yellow, -red, +primary color] and [+animal, +winged, +warm-blooded, -mammal] respectively. One of many basic problems with this approach is defining which features are most important, and how these features are themselves defined. This inevitably leads to indefinable figurative references, such as how to classify a *toy bird*, and endless circular references, such as *blue* being defined in terms of the other primary colors, which are in turn defined in terms of *blue* and each other. Just as a basic concept for *blue* or *bird* cannot be satisfactorily defined using binary features, it is similarly difficult to accept binary notions of *abstract* or *concrete*. The alternative is to consider abstractness to be a scalar trait, where a meaning can be placed on a continuous scale between the notions of *concrete* and *abstract*, which merely indicate opposite directions on the same axis.

In examining the prefixed verbs, the sense of *abstract* most useful for comparison is the sense of how abstracted from the constituent lexemes’ meanings the composite forms are. For example, the inseparable form *überlegen*, ‘deliberate, consider’, has little connection to the meanings of its parts *über* ‘over’ and *legen* ‘lay’. In contrast, the “separable” form *über-legen* ‘put or lay something over something’ has a quite transparent semantic derivation (Breitsprecher et al. 1998: 1198).

Rather than comparing the “separable” prefixes to Fleischer’s “classical” prefixes, it is more appropriate to use the wealth of minimal pairs available. Thus rather than comparing the “separable” *durch-*, *hinter-*, *über-*, *um-*, *unter-*, and *wider-* to the inseparable *be-*, *ent-*, and so on, the comparison should be to the *inseparable correlates* of *durch-*, *hinter-*, *über-*, *um-*, *unter-*, and *wider-*. This isolates the target semantic variables most effectively. A global comparison of these minimal pairs reveals a correlation between so-called “separability” and concreteness that, while not as precise as Fleischer (1975) and Brehmer (1985) were looking for, is distinctly significant from a statistical standpoint. The imprecision lies mainly in two areas: synonymy between

minimal pairs and occasional occurrences of abstract or figurative meanings for a “separable” form where none exists for its inseparable correlate (Breitsprecher et al. 1998).⁵

If the synonymy between certain minimal pairs actually exists in the lexicon of individual native speakers⁶, then the mutually exclusive classification pattern that Fleischer (1975) and Brehmer (1985) sought must be ruled out; however, a directional classification pattern, as per the concept of metaphor presented by Lakoff and Johnson (1980), is easily discerned. Since Lakoff and Johnson (1980) deal directly with the notions of *abstract* and *concrete* in their theory of construction of metaphor through analogous association between physical and intellectual ideas, it seems appropriate to look at how they implement their directional analysis.

Hagen (2000) presents the basics of Lakoff and Johnson’s (1980) metaphor theory by presenting the examples LOVE IS A JOURNEY and ARGUMENT IS WAR. With these examples she demonstrates the concepts of source domain, target domain, and metaphor mapping.⁷ In this framework, concrete ideas like WAR and JOURNEY provide a physical source for analogously conceptualizing more abstract concepts such as LOVE and ARGUMENT. These concepts then analogously share a structure that can be mapped. The composite structure, then, is what comprises the metaphors, which “work by matching abstract concepts with very concrete experiences or even the bodily perception of reality”. (Hagen 2000: Chapter 3.3). While the full structure of the metaphor probably plays a great role in the generation of new verbs in the so-called “separable” class, what is most relevant to establishing distinct “separable” and inseparable verb classes is the notion of directionality from the concrete to the abstract. If the *centers of gravity*

⁵ By “occasional”, I mean that it occurs, but not with any appreciable degree of statistical significance. What occurrences there are must also be questioned based on the sampling technique for the minimal pairs’ definitions. In my qualitative look at the statistical lay of these pairs and their definitions, I used lists compiled from the *Pons Wörterbuch für Schule und Studium*, which is probably based mainly on type and token analysis from their corpora, and does not retain demographic details from the sampled community. It is likely that a certain amount of these recorded forms do not exist in the speaking community in the minimal pairs as they are entered in the published dictionary. This factor should also be considered with the following argument on the synonymy of minimal pairs.

⁶ A situation which I judge as probable based on the significant frequency of partial and even full synonymy in the set of minimal pairs as listed by Breitsprecher et al. (1998).

⁷ Hagen (2000) also expands on the work of Lakoff & Johnson (1980) by including a cross-linguistic sample of metaphors, which I believe adds its own valuable support for Lakoff & Johnson (1980), which unfortunately only supplies examples from English.

described above were to be plotted graphically, they would constitute two distinct clusters, one weighted toward the concrete end of the axis and one toward the abstract.

The direction of the relation is established in these minimal pairs by the statistical correlation of the set of more concrete meanings to the set of “separably” prefixed verbs and the set of more abstract meanings to the set of inseparably prefixed verbs. At this point, the occurrences of synonymy become harmless: synonymy is only a threat to an exclusive classification pattern, not to a statistically weighted directional classification pattern. In a scalar analysis, the “distance” from the concrete source to the abstract target is not locked between pairs. In the case of synonymy or near synonymy, the scalar “distance” merely approaches zero. As long as the meaning of the inseparable member of each minimal pair is not less abstracted than that of the “separable” member, the directional relationship is preserved, and a directional pair of classes, source-“separable” and target-inseparable, is defined.⁸ Having answered Fleischer’s (1975) and Brehmer’s (1985) objections to the concrete-abstract correlation by presenting a directional classification rather than their exclusive model, I feel it appropriate to consider the “separably” prefixed and inseparably prefixed verbs in German to be two distinct semantic classes.

4. Establishing the “separable prefix” verbs as a syntactic class

The obvious heart of the peculiarity of “separable-prefix” verbs is the fact that the “prefixes” seem to move independently of the verb stem, which is, by definition, not what a prefix should do. The patterns of this syntactic phenomena are easily mistaken for other verb phrase types, as well, and so must be considered with a discerning eye for their exact syntax. To demonstrate the environments of separation for these verbs, the minimal pair *über-treten* and *übertreten* will be partially conjugated for comparison.

⁸ There are a few apparent counterexamples to this trend that are worth consideration, such as the separable *durch-segeln*, which can mean ‘fail or flunk (a test)’ and its inseparable correlate *durchsegeln*, which means simply ‘sail across’. Though this initially appears to directly violate the directional trend I propose, it is important to note that, unlike many other pairs in this group, these two lexemes subcategorize for different auxiliary verbs: *durch-segeln* takes a *sein* auxiliary. This difference in argument structure could be a decisive difference that would restrict acceptable minimal pairs to those that take the same auxiliary, and is taken as such here. A detailed account of the exact effects of differing argument structure, though beyond the scope of this work, would definitely be worth further study.

Matrix Clause: Present Tense

(2) a. Ich trete die Linie über.

I step the line over

'I step over (cross) the line.' (in sports)

b. Ich übertrete die Befehlungen des Kapitäns.

I contravene the orders of-the captain

'I contravene the captain's orders.'

Matrix Clause: Present Perfect (ge-)

(3) a. Ich habe die Linie übergetreten.

I have the line over-stepped

'I stepped over (crossed) the line.' (in sports)

b. Ich habe die Befehlungen des Kapitäns übergetreten.

I have the orders of-the captain contravened

'I contravened the captain's orders.'

Subordinate Clause: Infinitival (zu-)

(4) a. Ich finde es schwer, die Linie überzutreten.

I find it difficult the line over-to-step

'I find it difficult to step over (cross) the line.' (in sports)

b. Ich finde es schwer, die Befehlungen des Kapitäns zu übertreten.

I find it difficult the orders of-the captain to contravene

'I find it difficult to contravene the captain's orders.'

The “separability” is plainly apparent in the finite present example given, and the present perfect and infinitive examples demonstrate the odd relationship these verbs have with the inflectional prefixes ge- and zu-. Common teaching practice is to explain this

alternation of the prefix’ position as a move of the prefix to the end when in matrix clauses in the present tense.⁹

The argument that these verbs are simply normal verbs coupled with reordered prepositional phrases also falls quickly. In German, the presence of a prepositional phrase is independent of the presence of a “separable-prefix” on the verb.¹⁰ This is easily demonstrated:

- (5) Das Ausland fängt nicht [PP an der Grenze] an.
the foreign-land begins not [on the border] [??]
‘Foreign lands don’t begin at the border.’

Another common approach is to equate these verbs to the similar phenomenon of phrasal verbs in English and Scandinavian languages, but this comparison is also unsatisfactory. Firstly, English phrasal verbs are limited to prepositions, as their selection of complements (up, out, on, etc.), while German “separable-prefix” verbs have no such restriction, often using verbal or adjectival forms as their complements (e.g., *stehen-bleiben*, *fertig-machen*). This evidence is only suggestive of a difference and still inconclusive, but there is more to support the distinction more concretely. The German verbs under consideration further differ from English phrasal verbs in their syntactic behavior. To demonstrate this, English *call up* is contrasted with German *aus-machen* ‘turn off’.

⁹ This explanation, however, does not fit the basic Chomskyan theoretical premise that transformations should only climb syntactic trees. While the English trend to climb to the left and not the right is not universally applicable, it happens that in syntactic trees of German, a rightward transformation from the position immediately before the verb stem’s surface position in present tense matrix clauses could still not be upward.

¹⁰ There is no direct dependence, but there is a marked frequency of collocation of prepositional phrases headed by the same preposition that is incorporated as the “separable verbal prefix”. (e.g., *Ich gehe bei der Bibliothek vorbei*.) The collocation of prepositional phrases that do not match the prefixes precludes any stronger tie from being made between them. Even so, the preponderance for matched collocation between PP head and “separable-prefix” is likely linked to the generative process that forms new “separable-prefix” verbs in the lexicon.

(6) call up

- a. I will call the doctor up.
- b. I will quickly call the doctor up.
- c. I will call the doctor up quickly.
- d. *I will call quickly the doctor up.
- e. *I will call the doctor quickly up.

(7) auf-machen ('open' something)

- a. Ich mache die Tür auf.
'I (open/am opening/will open) the door.'
- b. Ich mache die Tür schnell auf.
- c. Ich habe die Tür schnell aufgemacht.
- d. *Ich schnell habe die Tür aufgemacht.
- e. ?Ich habe schnell die Tür aufgemacht.
- f. *Ich habe die Tür aufgemacht schnell.
- g. *Ich schnell mache die Tür auf.
- h. ?Ich mache schnell die Tür auf.
- i. *Ich mache die Tür auf schnell.

In English, an adverbial adjunct *quickly* cannot come between the phrasal verb *call* and its prepositional complement *up*. On the other hand, the German adjunct *schnell* 'quickly' **must** come between the verbal position – occupied by *haben* when an auxiliary is used, or by the verb stem when there is no auxiliary – and the later position of the separable prefix.¹¹ That said, it is clear that, though outwardly similar, German “separable-prefix” verbs cannot be simply equated to the long-standing analysis of the English phrasal verb, and must be designated as their own natural syntactic class of verbs. This leaves the class of “separable-prefix” verbs without any described structure that is acceptable given the behavior and characteristics described above. In section 5, I

¹¹ The two examples that are marked as questionable in the German set suffer from an awkwardness of relative position of the adverbial adjunct *schnell* to the object complement *die Tür*, an issue separate from that of the adjunct's position in relation to the separable prefix.

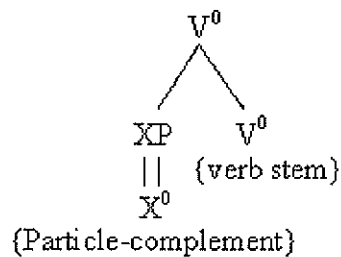
propose a solution to this problem that does not take the approach of analyzing this structure as a prefixed one, but rather as a lexicalized particle-complement structure.

5. Modeling a Particle-Complement Structure for the "Separable" Verb Class

An acceptable structural model for the class of verbs that is typically known as "separable-prefix" must both explain the prosodic, semantic, and syntactic behavior of the class as demonstrated above *and* mesh well with a broader context of verb phrase syntactic theory. With some modification for the SOV syntactic characteristics of German, the work of Chomsky (1994), Collins and Thráinsson (1996), and I-Adjunct theory provide the needed theoretical basis for a well-integrated particle-complement structure for this class of German verbs.

Chomsky (1994: 16) introduces the idea that a syntactic item can simultaneously be "both an X^0 and an XP." He names clitics as prime examples of such items, in that they have the theta-position of an XP, but also must carry a terminal head in order to be a phrasal unit at all. Such items cannot branch out into smaller constituents. In the case of the "separable-prefixes", which I assert are verbal XP complements rather than prefixes in the usual sense, the particle-complement of the verb is clearly lexicalized with the verb and dependent upon it, but does not undergo syntactic transformations with the verb stem. The phrasal structure of the complement-verb compound then should be as follows:

(8)¹² V^0 -Internal Structure of Particle-Complement Verbs in German



With this clitic-like structure, the particle-complement verbs' characteristics as outlined above are nicely explained. If it can be believed that there is any sort of

¹² I adopt the double-link notation "||" between XP and X^0 as a semiotic device borrowed from chemistry, where it would indicate a covalent (double) bond between atoms in a molecule, which ties them more strongly together. I use "||" to indicate the clitic-style non-branching projection proposed by Chomsky (1994) because the constituent binds the characteristics of the terminal node and the XP-projection inextricably.

connection between prosody and syntactic structure, then the unusual prosodic emphasis on the complement particle exhibited by this class can be linked to the greater syntactic “weight” that the particle gains from the full-fledged XP status it bears despite its subordination to a V^0 . That same “weighted” quality also seems to line up nicely with the fact that the particle-complement verbs have compositional meanings that seem almost evenly drawn from both the verb stem and the complement particle. Furthermore, since the particle enjoys full status as an XP, it can resist the attractions that draw the verb stem into syntactic transformations, thereby remaining anchored in its underlying position. Lastly, the block on branching under the XP node explains why there are no complex complement particles extant. Based on the observed behavior of the particle-complement verbal class above, the proposed V^0 -internal structure seems neatly appropriate.

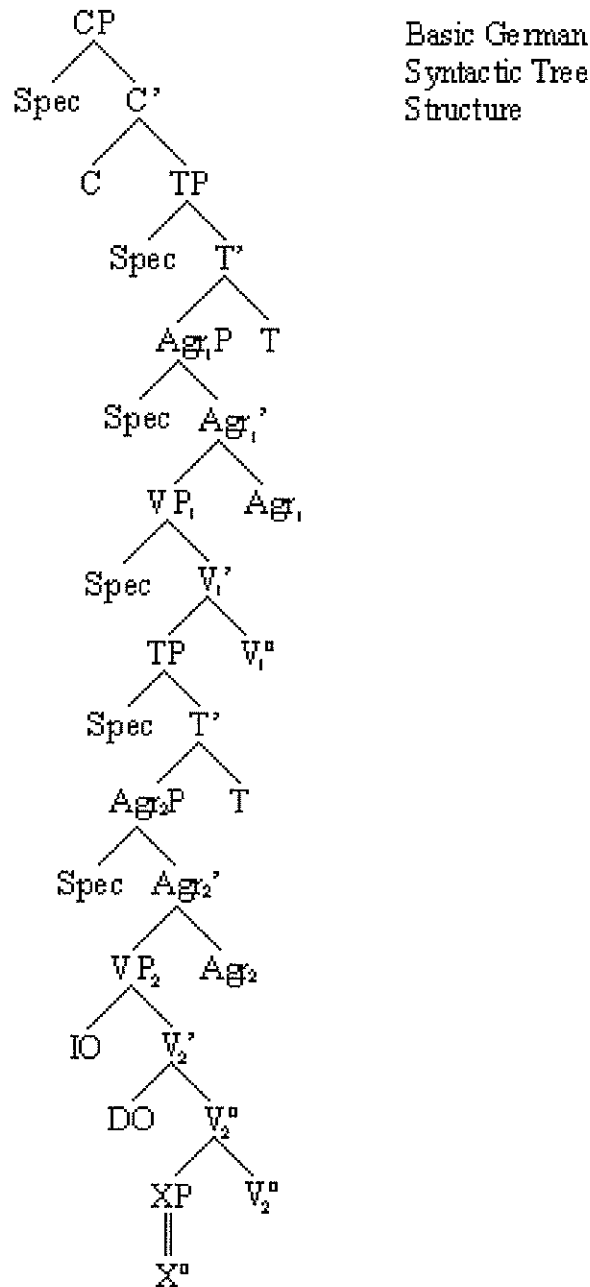
Before we can accept the structure, though, it has to fit into the larger syntactic context of a clause as well, and satisfy the requirements of the broader theoretical framework. A complicating factor with these particle-complement verbs in German is that all arguments come before the particle in every case, and the verb stem or auxiliary verb precedes the dative and accusative arguments in finite clauses. When there are object NPs present, they vary in order systematically, which suggests a great number of VP-internal transformations; therefore, it is prudent to consider the German VP’s argument structure. Collins and Thráinsson (1996) present a hybridized theory of NP-Object Shift based on data from Icelandic that combines theories of VP external functional projections with VP internal functional projections by plotting a recursive projection. Their composite object shift model works cleanly for Icelandic, but since Icelandic is an SVO language, their model requires some restructuring for German.¹³ Once the NP-Object Shift functional projections are restructured for an SOV clause in which all phrases are head-final with the exception of CP¹⁴, the full projection of the particle-complement verb in the verb phrase looks like that in (9) below, with Collins and

¹³ It should also be noted that their analysis of verb-particle constructions in Icelandic analogously applies to English and German phrasal verbs, but the class of particle-complement verbs is distinct from those, as is argued in section 4.

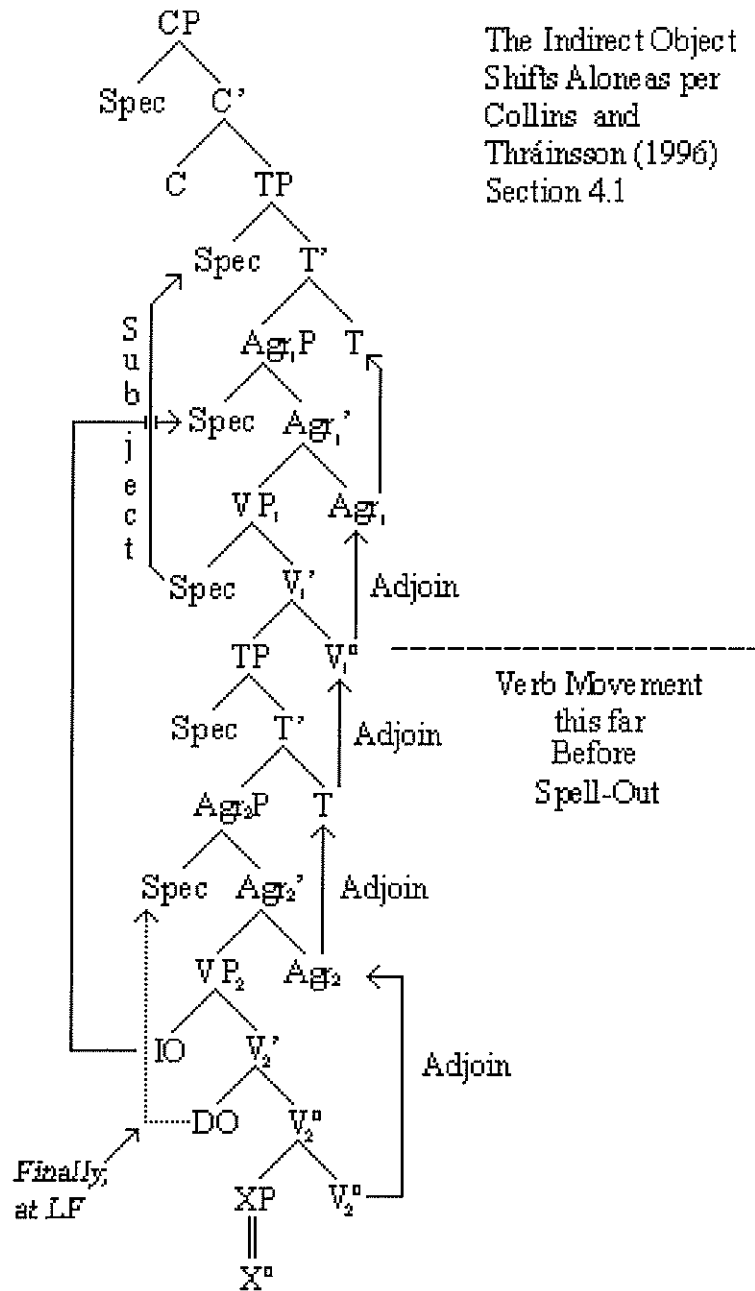
¹⁴ The Complementizer Phrase (CP) exception to the head-final rule in German explains the workings of the transformation of the verb into second position as being due to a strong attraction between C and V. This analysis of the German “V2 rule” has been established for some time.

Thráinsson's (1996) NP-Object shifts analogously intact, as demonstrated in (10) and (11), which illustrate when the Indirect Object shifts alone and when the Indirect Object and the Direct Object shift together, respectively.

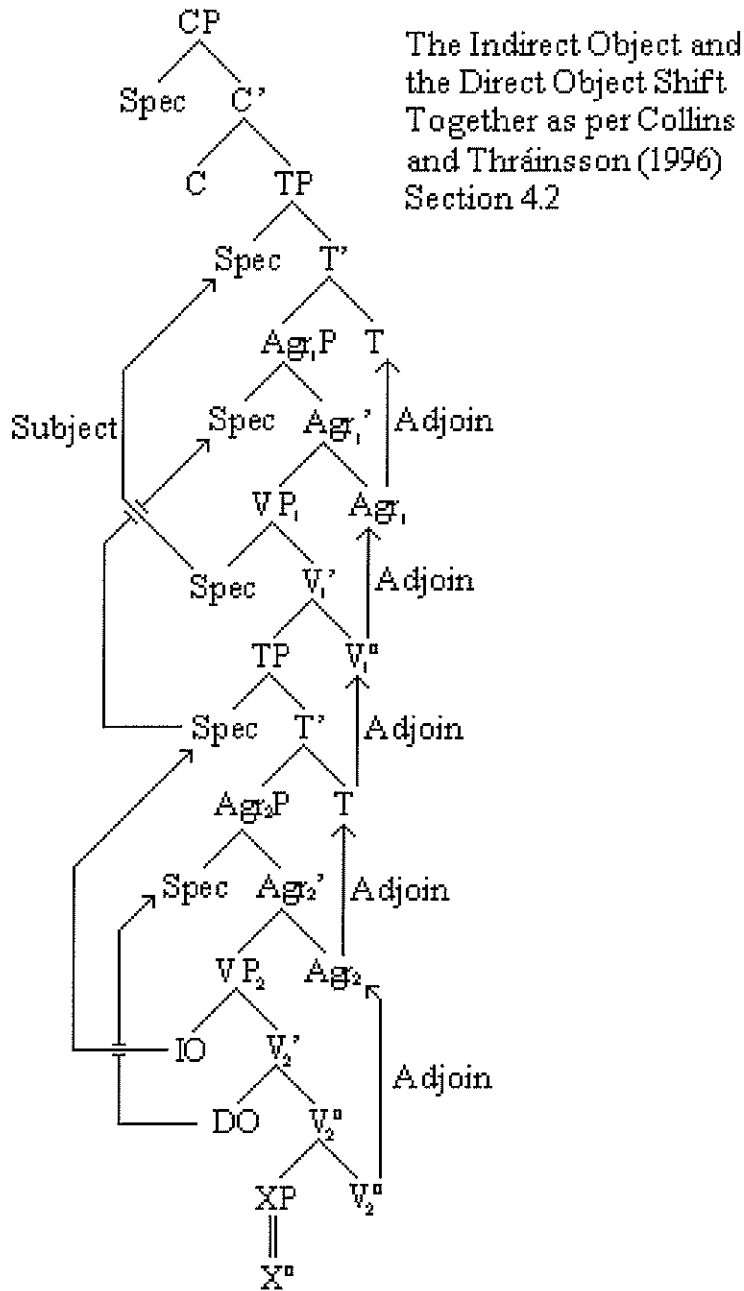
(9) [Adapted from Collins and Thráinsson (1996: 401)]



(10) [Adapted from Collins and Thráinsson (1996:401-4)]



(II) [Adapted from Collins and Thráinsson (1996:401-9)]



In this structure, the apparently odd intrusion of the inflectional affixes ge- and zu- is easily explained by transformation of the verb stem from the Agr₁ node into the T node, to which it adjoins. A complex I-Adjunct results, and when the affixes ge- and zu- are overt, they appear in their normal position, adjoined to the front of the relocated verb stem, but still produced after the particle-complement, which never moved from its

original position. With this formal model, the standard syntactic behavior of particle-complement verbs, the so-called “separable-prefix” verbs, becomes quite transparent.

6. Conclusions

The benefits of adopting the above interpretation are not limited to solving the many difficulties of the “separable-prefix verb” problem in German. What were taken in earlier work to be fatal counterexamples to the general pattern of this class of verbs actually serve to strengthen their status as a natural class, provided a scalar semantic classification on the concrete-abstract axis is adopted, and the generation of new verbs of the class is treated as a process similar to suppletion. Their unique prosodic, semantic, and syntactic characteristics together are clear testimony that they are their own class of verb distinct from similar constructions in related languages.

The proposed verbal complement structure accounts for each of the behaviors peculiar to the particle-complement class of verbs, and meshes nicely with contemporary syntactic theory. The most similar structure to the particle-complement verbs is actually that of clitics, in that they are both simultaneously entire phrases and terminal nodes, which allows them both types of syntactic behavior. Once an NP-Object shift functional projection is adapted for German’s SOV underlying word order, the formal model of a clause manages to demonstrate how verbal NP-Objects behave syntactically, what transformations a verb stem undergoes that lead to the verbal second-position rule in German finite clauses, and how the odd pattern of “prefix” -- inflectional affix -- verb stem occurs in with the help of I-Adjunction. It finally becomes clear that the single biggest hindrance to formalization of this verb class’s behavior has been the misnomer of “separable-prefix” itself.

Works Cited

- Brehmer, Karl Steik. 1985. *German Verbal Prefixes and Modern Generative Theories of Word Structure*. Unpublished manuscript, Princeton University, Princeton, New Jersey.
- Breitsprecher, Roland, Peter Terrell, Veronika Schnorr and Wendy V.A. Morris (eds.). 1998. *PONS Wörterbuch für Schule und Studium Deutsch-Englisch*. Ernst Klett Verlag, Stuttgart/Düsseldorf/Leipzig.
- Chomsky, Noam. 1994. *Bare Phrase Structure*. In *MIT Occasional Papers in Linguistics 5*. MITWPL, Department of Linguistics and Philosophy, MIT, Cambridge, Massachusetts.
- Collins, Chris and Höskuldur Thráinsson. 1996. *VP-Internal Structure and Object Shift in Icelandic*. In *Linguistic Inquiry* 27 (3), 1996, 391-444.
- Dressler, Wolfgang Ulrich. 1986. *Inflectional Suppletion in Natural Morphology*. In Elson (ed.) 1986, 97-111.
- Hagen, Vera. 2000. *From the Web to the Information Super-Highway: Metaphors Used to Talk about Information Technology*. Unpublished manuscript, Albert-Ludwigs-Universität Freiburg, Freiburg im Breisgau, Germany. Available online at http://home.t-online.de/home/vera_hagen/metaphor/index.htm
- Nübling, Damaris. 1998b. *Warum werden bestimmte Verben regelmäßig unregelmäßig? Prinzipien und Funktionen der Irregularisierung*. In *Germanisten. Tidskrift för svensk germanistik* 1-3, 1998, Year 3, 28-37.
- Nübling, Damaris. 1999. *Zur Funktionalität von Suppletion*. In Butt, Matthias/Fuhrhop, Nanna (eds.): *Varianten und Wortstruktur. Germanistische Linguistik* 141-142, 1998, 77-101.
- Ronneberger-Sibold, Elke. 1987. *Verschiedene Wege zur Entstehung von suppletiven Flexionsparadigmen. Deutsch gern – lieber – am liebsten*. In: Boretzky/Enninger/Stolz (eds.) 1987, 243-264.
- Ronneberger-Sibold, Elke. 1988. *Entstehung von Suppletion und Natürliche Morphologie*. In: *Zeitschrift für Phonetik, Sprachwissenschaft und Kommunikationsforschung* 41 (4) 453-462.
- Ronneberger-Sibold, Elke. 1990. *The Genesis of Suppletion through Morphological Change*. In W. Bahner et al. (eds.): *Proceedings of the Fourteenth International Congress of Linguists*. Berlin/GDR, August 10-15, 1987, Vol. (1) 628-631.

Werner, Otmar. 1977. *Suppletivwesen durch Lautwandel*. In G. Drachmann (ed.): *Akten der 2. Salzburger Frühlingstagung für Linguistik*, Tübingen, 269-83.

Werner, Otmar. 1987b. *Natürlichkeit und Nutzen morphologischer Irregularität*. In N. Boretzky et al. (eds.): *Beiträge zum 3. Essener Kolloquium über Sprachwandel und seine bestimmenden Faktoren*, Bochum, 289-316.

Why Early Immediate Constituents? The role of memory and locality

Gabriel Webster

gabeweb@u.washington.edu

The Early Immediate Constituents (EIC) theory of Hawkins (1990, 1994) has a strong claim to psychological validity because it successfully explains a wide range of word order phenomena within and across languages. Hawkins claims that the success of EIC is due to its ability to distinguish word orders that are easy to process from word orders difficult to process. EIC is defined entirely in syntactic terms: structures in which all daughters of a single mother node appear close together are easier to process. But EIC does not address the question, exactly what is it at the processing level that makes this so? A possible answer to this question is provided by the Syntactic Prediction Locality Theory (SPLT) of Gibson (1998), which explains many of the same phenomena as EIC by positing that constructed nodes slowly lose their activation over time, and must be reactivated in order for new nodes to attach to them. In this paper, I will adapt the model of working memory proposed by the SPLT for use with EIC, and in so doing will introduce an theory of syntactic processing which I will call Parsing EIC, or PEIC (pronounced [pik]). I argue that PEIC and the SPLT represent closely related theories of processing, and discuss how the PEIC parsing model should be constructed to capture the insights of both EIC and the SPLT: in rough terms, the SPLT contributes explanatory motivation for PEIC at the level of working memory, while EIC contributes the ability to explain many typological word ordering generalizations.

An attempt to mediate between two independently developed theories will of course have to overcome a certain amount of conflict. Motivating EIC in the terms of human working memory proposed by the SPLT results in subtle changes to EIC's predictions, but I argue that these changes are not likely to be empirically problematic.

- (2) a. ?The man put the valuable book that was extremely difficult to find on the table.
- _____
- b. The man put on the table the valuable book that was extremely difficult to find.
- _____

In English, the verb *put* takes an NP and a PP complement. When the two complements are of approximately equal length, the NP precedes the PP, as in (1a). If the NP is postposed, as in (1b), the acceptability of the sentences declines. However, when the NP complement is much longer than the PP, postposing the NP becomes preferable, making (2b) more acceptable than (2a). (2b) is a classic case of Heavy NP Shift (Ross, 1967).

EIC explains this preference in two steps. First, construction of the complement NP and PP nodes in (1-2) is assumed to be triggered by the appearance of their leftmost daughters. For NP, this is the word *the*; for PP, this is the preposition *on*. Hawkins defines a rule of *Mother Node Construction* to accomplish this:

(3) *Mother Node Construction* (MNC)

In the left-to-right parsing of a sentence, if any word of syntactic category C uniquely determines a phrasal mother node M, in accordance with PS rules of the grammar, then M is immediately constructed over C (Hawkins, 1994, p. 62).

Secondly, EIC states that the human sentence processor prefers word orders in which the *immediate constituents* (ICs), or daughters, of a single mother node M are constructed in as short a period of time as possible. This amount of time is measured as the total number of nodes that are constructed between the first IC and the last IC of M, but Hawkins often simply uses the number of words that pass as a rough measure of distance or time elapsed. All of the syntactic structure from the word that constructs the

¹ This overview is organized following that of Newmeyer (1998).

first IC of M to the word that constructs the last IC of M is called the *constituent recognition domain* (CRD) of that node. In the case of (1-2), the M in question is the matrix VP, whose daughters are V, NP, and PP; the CRDs for VP are bracketed in the examples. In all of the sentences, the first IC of the matrix VP is the V node constructed by the verb *put*; this marks the beginning of the CRD for VP in all of the sentences. In (1a), the CRD extends from *put* through the preposition *on* that constructs the PP node, since the PP is the last IC of the VP. This CRD consists of four words, *put the book on*. Hawkins proposes using a ratio of the number of ICs to the number of words in a CRD to measure relative processing ease. Using this metric, sentence (1a) has an IC-to-word ratio of $3/4 = 75\%$. In (1b), the last IC is the NP node, which is constructed by its leftmost daughter *the*. Thus, the CRD extends from *put* to the *the* of the NP, a distance of five words giving a ratio of $3/5 = 60\%$. This is somewhat worse than (1a), but still not too bad; the decline in acceptability is partly caused by a conventionalization in English that NP complements precede PP complements.² The ratio for (2a) is $3/11 = 27\%$, a much lower ratio due entirely to the much longer NP. But when the long NP is postposed in (2b), the ratio returns to a much higher $3/5 = 60\%$. It is the large difference in ratios in the sentences in (2) than makes postposing the NP more acceptable. With a small difference, not much processing benefit is to be gained by postposing the NP complement. With the large difference in (2), postposing the NP to the end of the sentence results in a large processing benefit, and (2b) is thus easier to process than (2a). Hawkins (1994) defines EIC as follows (p. 77):

² In this case, the conventionalization is a statement in the grammar that NP complements prefer to precede PP complements. It would be formalized by a requirement that the [V PP NP] word order must not only have a better IC-to-word ratio than the [V NP PP] order for that word order to be commonly produced, but that there is a threshold for the difference in IC-to-word ratios between the two orders above which [V PP NP] becomes common. In (1), the difference in IC-to-word ratios of the two sentences is 15 percentage points; the threshold above which [V PP NP] becomes common (both easier to process and more acceptable than the [V NP PP] order) is therefore above 0.15. This view contradicts the standard generative assumption that grammars cannot prefer, but rather can only accept or reject, strings of words. However, it potentially provides insight into language change, in which presumably one fixed word order does not change instantly to a different fixed word order, but rather goes through a stage of alternate possible word orderings, examples of which are found in Hawkins (1994).

leftmost daughter as in (5a) and examples (1-2). In EIC, whether the leftmost daughter or a non-leftmost daughter constructs the mother node has no effect on processing difficulty; EIC only prefers that the overall IC-to-word ratios be large. And in fact, (5a) and (5c) correspond to language types that are common, while (5b) and (5d) correspond to uncommon types. Thus, EIC provides an explanation for certain typological phenomena by claiming that languages tend to grammaticalize word orders that are easy to process.

EIC also includes a method for left-to-right (LR) calculation of IC-to-word ratios, and explicitly predicts that when overall IC-to-word ratios are equal, the LR IC-to-word ratio gives a tiebreaker metric of processing difficulty. For example, given an NP consisting of a noun, an adjective, and a subordinate clause (S) with a complementizer, there are twelve possible linear orders:

- | | | | | |
|-----|----|------------------|----|------------------|
| (6) | a. | [N Adj [Comp S]] | g. | [N [Comp S] Adj] |
| | b. | [Adj N [Comp S]] | h. | [Adj [Comp S] N] |
| | c. | [[S Comp] N Adj] | i. | [N [S Comp] Adj] |
| | d. | [[S Comp] Adj N] | j. | [Adj [S Comp] N] |
| | e. | [N Adj [S Comp]] | k. | [[Comp S] N Adj] |
| | f. | [Adj N [S Comp]] | l. | [[Comp S] Adj N] |

Hawkins argues that the S node is constructed by Comp. Accepting this argument, the three daughters of the mother NP node are constructed within a maximally optimal three-word CRD in (6a-d). In the remaining examples, the CRD always includes the embedded S node, and extends from the first word of the NP to the last word. If the embedded S is three words long, then the IC-to-word ratio for all of the word orders in (6e-l) is $3/6 = 50\%$. However, the LR IC-to-word ratio differentiates between them using the following logic: all other things being equal, word orders should be favored which provide access to a significant subset of the ICs of a mother node as quickly as possible. The LR IC-to-

word ratio is calculated by first calculating the IC-to-word ratio for each of the first n ICs in a phrase, and then averaging these. In example (6e), the IC-word ratio of the first IC, N, is $1/1 = 100\%$; that of the first two ICs, N Adj, is $2/2 = 100\%$; that of the first three ICs the whole phrase is $3/6 = 50\%$. The LR IC-to-word ratio is the average of these, or 83%. (6e-f) have LR IC-to-word ratios of 83.3%, (6g-j) have LR ratios of 63%. In the language sample of Lehmann (1984), languages of types (6a-d) are widely attested; types (6e-f) are attested but less common; of types (6g-j) only type (6j) is found as a marked variant; and types (6k-l) are nonexistent. Thus the LR IC-to-word ratio appears to accurately make finer distinctions than the normal IC-to-word ratio.

In addition to explaining effects of syntactic weight and many typological generalizations, EIC explains the processing difficulty of center-embedded and self-embedded structures and the Late Closure (Frazier, 1979) phenomenon. Furthermore, Hawkins (1994) defines a CRD as a type of *Structural Domain*, and he briefly discusses two other types which he calls *Relativization Domains* and *Movement Domains* that essentially encompass the syntactic structure between a filler and its gap, predicting that more complex domains will be more rare cross-linguistically, reflecting their processing difficulty. This insight, further developed in Hawkins (1999), explains why, for example, subject-extracted relative clauses are easier to process (and are more typologically common) than object-extracted relative clauses: object extraction involves a longer-distance filler-gap relationship and thus a more complex Relativization Domain. Thus EIC and its filler-gap analogs explain a wide range of linear word ordering phenomena across languages.

2.0 *Why EIC? The role of the SPLT*

EIC is an accurate, but relatively high-level, model of processing difficulty. EIC determines processing difficulty by calculating the IC-to-word ratios of CRDs in a phrase. It would be absurd to suggest that the human parser does the same thing,

calculating IC-to-word ratios during sentence processing and then determining the complexity of that sentence by looking at the ratios calculated. In that scenario, processing difficulty would literally be determined by a number rather than by anything inherent in the parsing process itself. Rather, it is certainly the case that an IC-to-word ratio is a *reflection* of the processing difficulty of a sentence, with the actual source of the processing difficulty lying elsewhere. That source, I argue, is the limits on human working memory proposed by Gibson (1998) in his Syntactic Prediction Locality Theory (SPLT).

In this section, 2.1 introduces the SPLT. Section 2.2 describes how the SPLT provides the explanatory force behind EIC, and in doing so introduces PEIC. Section 2.3 discusses how PEIC makes predictions that are slightly different from those of EIC. These small differences are not likely to conflict with the empirical evidence, and for at least one set of word order effects PEIC may offer an explanation that is superior to that of EIC.

2.1 The Syntactic Prediction Locality Theory

The SPLT (Gibson, 1998) proposes that each lexical item in a syntactic structure has an independent activation level.³ When a word is first encountered, it is activated to a high level and integrated into any existing syntactic structure. Activation levels decay as additional words are encountered. When a word is encountered that takes part in a head-dependent relationship with an earlier word, that earlier word must be reactivated in order for integration to take place. Thus, the further the distance between two words that will have to be integrated, the greater the amount of resources required to reactivate the decaying first word. Note, however, that since a lexical item must be reactivated to integrate a new word with it, this increased level of activation now makes it easier for

³ Gibson (1998) assumes that activation levels reflect not only syntactic activation, but also lexical frequency, plausibility, and so on. The PEIC model that I develop in this paper makes no claims about the degree to which activation level is influenced by non-syntactic factors.

words further on to also integrate with the same item, despite the long distance of the integration.

Gibson (1998) states that the SPLT assumes a constraint-based model of parsing (see e.g., MacDonald, Pearlmuter, and Seidenberg, 1994), which initially make may it seem incompatible with the rule-based EIC parsing model. However, no parsing algorithm is described by Gibson, and he does not explain why the model of working memory he describes is more compatible with a constraint-based parsing model than with a rule-based one. Furthermore, the assumptions made by Gibson (1998) about his parsing model (as I will discuss in section 3) appear to be compatible with the rule-based approach of EIC. Therefore, it seems appropriate to apply the SPLT model of working memory to EIC.

Although Gibson states that it is the activation of lexical items that decays over time, he assumes a standard phrase structure (such as $S \rightarrow NP VP$, $S \rightarrow Comp S$, etc.) for parsing, suggesting that the nodes whose construction is triggered by particular lexical items also have activation levels that decay. It is not the case, for example, that a verb actually attaches directly to the head noun of the verb's NP complement; rather, the VP node projected by the verb will attach directly to the NP node projected by the noun head (or determiner) of the complement. The nominal and verbal lexical items thus integrate indirectly, via their projections. My interpretation of Gibson (1998) is that a lexical head and its projections share an activation level (MacDonald et. al., 1994; Vosse and Kempen, 2000), for although new words must integrate with existing words via their projections, he specifically states (p. 11) that lexical heads must be reactivated to attach new lexical items. However, this interpretation raises thorny linguistic issues about which phrasal categories are projected from which lexical categories. For simplicity, I will assume that each node has an individual activation level, but this is not crucial to the analysis.⁴

⁴ In particular, a theory assuming that each X-bar projection has a single activation level is functionally equivalent to a theory which assumes a single, more-than-binary-branching maximal projection for each lexical item, as Hawkins (1994) does. This is because in the latter case, all attachments to a projection are

To quantify processing difficulty, Gibson defines an *energy unit* to be the amount of memory resources required to reactivate a node which has decayed while one new discourse referent was processed.⁵ Gibson measures reactivation energy in terms of new discourse referents because of evidence that syntactic integrations across new discourse referents are harder to process than integrations across first or second person referents, which presumably exist from the beginning of the sentence and thus don't need to be created (Gibson and Warren, 1998). Now, EIC uses number of nodes or words, rather than new discourse referents, to measure distance between two ICs of a phrase; however, it is clear that in rough terms, both metrics measure the amount of time that passes between construction of a node and attachment of new structure to it. In order to explicitly discuss the predictions of PEIC, in this paper I will use the term energy unit, or EU, to mean the amount of memory resources required to reactivate a node which has decayed during the processing of one word, rather than one new discourse referent. I assume that there exists some linguistic or temporal unit that allows both EIC and the SPLT to make the right predictions.

Gibson (1998) shows that this view of working memory ultimately explains a wide range of syntactic phenomena. These phenomena substantially overlap with those explained by EIC, and include syntactic heaviness effects, the processing difficulty of center-embedded structures, the greater processing difficulty of object-extracted than subject-extracted relative clauses, the lower complexity of cross-serial dependencies compared to center-embedded dependencies, and ambiguity effects such as those caused by preferences in positing gaps (the Active Filler Strategy of Frazier, 1987b). The empirical coverage of the SPLT strongly suggests that it and its characterization of human working memory, like EIC, are fundamentally correct.

literally all to a single phrasal node; therefore, the activation level of that node corresponds to the activation level of the entire projection under an X-bar approach.

⁵ I assume the version of the SPLT described in section 6 of Gibson (1998), which assumes that all nodes decay and must be reactivated to attach new structure to them. This holds of predicted nodes (see section 3.1 below) as well as non-predicted nodes.

2.2 PEIC: The SPLT explanation for EIC

Consider how the VPs of the sentences in examples (1a) and (2a-b), repeated here as (7), would be parsed under EIC:

- (7) a. The man_{VP}[put the book on the table].
 b. The man_{VP}[put the valuable book that was extremely difficult to find on the table].
 c. The man_{VP}[put on the table the valuable book that was extremely difficult to find].

In both (7a) and (7b), when the first word of the VP *put* is encountered, a VP mother node is constructed by Mother Node Construction (MNC) over the V node of *put*. According to the SPLT, this mother node M initially has a high activation level. The second word *the* constructs a NP node which is immediately attached to M, which remains at a high activation level. Following this attachment, processing the rest of the noun phrase involves attaching further structure to the NP node, but not to M. Thus, no other attachments need be made to M until the *on* of the second object constructs a PP node to attach to VP. Now, the SPLT says that a node's activation decays as additional words are encountered, and that a node must be reactivated to attach new structure to it. In example (7a), only one word (*book*) must be processed between the attachment of the NP node to M (triggered by *the*) and the attachment of the PP node to M (triggered by *on*). Because the activation of M has decayed during the processing of just one word, only 1 EU is required to reactivate it to attach the PP node of the second object. But in example (7b), eight words must be processed, and thus 8 EUs are required to reactivate it to attach the PP node. Now, if the order of the NP and PP complements are reversed as in (7c), only 2 EUs are now required. After the NP node of the direct object is attached to M, eight words remain to be processed, but since none of them require attaching any

further structure to M, it is no longer of any consequence that the activation of M decays significantly during the parsing of those final eight words.

In these examples, the IC-to-word ratio of the CRD of a phrase is a metric that reflects the overall amount of resources that must be spent to reactivate M. More generally and more explicitly, if the number of ICs is equal to the number of words in a CRD, then each consecutive word in the CRD triggers attachment of a node to M; there are no intervening words during which M's activation level can decay. Note that a CRD is defined to begin and end with words that construct ICs of M, with the first of those two ICs constructing M itself in examples like (7). Therefore, additional non-IC-constructing words can only be added between these two IC-constructing words, and these additional words cause decay of M's activation level. Now, M must always be reactivated for the final IC to be able to attach. Thus, every additional word beyond those that construct the ICs of M requires 1 EU of processing resources. This corresponds to the following equality:

$$(8) \quad \text{No. of ICs} / \text{No. of words in CRD} = \text{No. of ICs} / (\text{No. of ICs} + \text{EU})$$

The left-hand side of the equation is the IC-to-word-ratio. The right-hand side I will call the *IC-to-EU ratio*. This equality holds in the above example and in all cases where EIC and PEIC make the same predictions; in section 2.2, I will discuss cases in which the IC-to-word and IC-to-EU ratios are not the same.

In the examples in (7), M is constructed by its leftmost daughter IC. In phrases where M is constructed by a non-leftmost IC, it is one or more earlier-appearing ICs must be reactivated to attach to M, since the activation of these ICs decays as they wait for M to be constructed. Such an example is an English possessive phrase:

$$(9) \quad \text{The man in the royal garden's fingernails needed trimming.}$$

M in this case is the possessive phrase *the man in the royal garden s*, which I will call a DP headed by the D *s*. The first word of the phrase, *the*, triggers construction of an NP node, which is the first IC of M. The next two words (*man* and *in*) each construct a node (N and PP) that attaches to that NP, keeping it active. However, the next three words, *the royal garden*, attach to the PP constructed by *in*.⁶ During the processing of those words, the first NP node begins to decay. Next, *s* triggers construction of the M node DP, to which the NP IC *the man in the royal garden* must attach. To do this, however, it must first be reactivated. Just as with an M constructed by a leftmost IC, 1 EU is required for each word that intervenes between the construction of an IC and the construction of M by a later-appearing IC. In EIC, the IC-to-word ratio of a CRD remains the same no matter which IC constructs M; in our terms, this simply means that the activation levels of mother nodes and daughter nodes decay at the same rate. Thus, the IC-to-word ratio of a CRD can reflect the amount of decay in ICs constructed before M as well as in M itself.

2.3 *PEIC and its predictions*

One of the advantages of developing a lower-level explanation for EIC is that we can make more well informed predictions about how EIC should operate. It turns out that for some structural configurations, PEIC makes different predictions than EIC. In this section I discuss these differences, which I argue are minimal. Section 2.2.1 discusses differences between the predictions of EIC and PEIC for phrases with mother nodes constructed by a non-leftmost daughter. Section 2.2.2 discusses a flaw in Hawkins (1994) explanation of the LR IC-to-word ratio that PEIC may be able to help rectify.

⁶ I assume that *garden s*, although phonologically one word, is somehow split up for the purposes of syntactic parsing, not unlike *wanna* (*want to*) or *wuhjuh* (*what did you*).

2.2.1 Non-leftmost IC construction of M

One aspect of the SPLT's explanation for EIC that differs slightly from EIC's original formulation has to do with the construction of M by a non-leftmost IC and the resulting attachment to the earlier-constructed IC(s). Within this general case, there are two structural configurations for which the PEIC and EIC predictions differ.

The English possessive phrase discussed above exemplifies the first scenario. Using EIC, the CRD for DP in example (9) starts at the first *the* and continues through *s*, giving an IC-to-word ratio of $2/7 = 29\%$. However, in PEIC, the first IC of DP, NP, does not decay until after the word *in*, because the first three words *the*, *man*, and *in* all attached to NP, keeping it active. This means that the NP only decays during the words *the royal garden*, resulting in an IC-to-EU ratio of $2/(2+3) = 40\%$, which is higher than the EIC IC-to-word ratio. Example (9) is repeated below as (10) with the EIC CRD and the PEIC decay length for DP shown:

- (10) The man in the royal garden's fingernails needed trimming.
 EIC: _____
 PEIC: _____

Thus PEIC predicts less processing complexity than EIC for this example.

I believe that this difference will be minimal in most cases, for two reasons. Firstly, there is no difference for mothers constructed by leftmost daughters to which later daughters attach. This is because each such later daughter node is attached to the mother node as soon as it is constructed, with no period of time when the daughter, waiting for the mother to appear, could be reactivated by other attachments to it.

Secondly, Hawkins (1994) argues that many left-branching structures, which are those in which M is most likely to be constructed by a non-leftmost IC, have grammatical mechanisms such as case marking that move the mother-constructing word leftward. In fact, this must happen regularly in SOV languages if they are to be as easy to process as

SVO languages. If V constructs both VP and S in SOV languages, then the CRD for S will stretch from S across the O to V, whereas in SVO the CRD for S consists simply of SV. This longer CRD for S in SOV languages incorrectly predicts that they should be less frequent than SVO languages. However, if O constructs VP in SOV languages, then the CRD for S languages is now only SO (and that for VP stays OV), the same length as the CRDs for S and VP in SVO languages.⁷ This process further decreases the number of cases in which EIC and PEIC make different predictions. Evidence for this argument is provided by Siewierska and Bakker (1996), who report that 59% of verb-final languages have overt object case marking, while only 37% of V2 languages (SVO and OVS word orders, of which SVO is vastly more common) have overt object marking, a difference significant at the 0.05 level.

The second configuration involving non-leftmost IC construction of M for which EIC and PEIC make different predictions is a structure in which an M with three ICs is constructed by the rightmost IC. In this case, the activation of each of the first two ICs decays independently while waiting for M to be constructed. So for every word during whose processing the two ICs wait, an additional 2 EUs are required, as opposed to just 1 EU per word for a single IC. In EIC, however, the nature of the IC-to-word ratio means that every additional word is assumed to cause the same amount of decay; there is no way for a word to ever cause twice as much decay, as in the situation described above. Example (11) shows a CRD with the implied amount of decay in EIC, in PEIC with the leftmost IC constructing M, and in PEIC with the rightmost IC constructing M. *d*₁, *d*₂, and *d*₃ are the words which construct the ICs of M:

⁷ The view that O often constructs VP in SOV languages is compatible with experimental data suggesting that pre-verbal complements are not placed in a lookahead buffer but are rather immediately integrated into the syntactic structure (Kamide and Mitchell, 1999; Konieczny, Hemforth, Scheepers and Strube, 1997). In the SPLT, pre-verbal complements in Japanese predict their verbal head, which I argue in section 3.1.1 is equivalent to PEIC's approach.

- (11)
- | | |
|--|------------------|
| a. EIC: | d1 w w d2 w w d3 |
| b. PEIC (d1 constructs the M-constructing IC): | _____ |
| c. PEIC (d2 constructs the M-constructing IC): | _____ |
| d. PEIC (d3 constructs the M-constructing IC): | _____ + _____ |

In (11a), the IC-to-word ratio is $3/7 = 43\%$. The IC-to-EU ratio when the leftmost or middle IC constructs M (11b-c) is also $3/(3+4) = 43\%$, but when the rightmost IC constructs M (11d) the IC-to-EU ratio is $3/(3+7) = 30\%$. Note that d2 is one of the words during whose processing the IC constructed by d1 decays. Thus PEIC predicts greater processing difficulty for this type of sentence than does EIC.

Again, this difference is not likely to matter very much, for reasons similar to those given above for the first configuration. It only applies to phrases with at least three ICs with M constructed no earlier than by the third IC, with the frequency of these phrases further decreased by the fact that languages have a tendency to move leftward the word that triggers construction of M. For example, in the case of the possible orderings of [N Adj S] in a NP given in (6), this difference between EIC and PEIC only results in different predictions for processing difficulty in three of the twelve orders, even if we assume that no other node besides the head N ever constructs the mother node. These orders are repeated below:

- (6)
- d. [[S Comp] Adj N]
 - h. [Adj [Comp S] N]
 - l. [[Comp S] Adj N]

In two of three orders in (6) the increase in processing difficulty is slight. Assuming again that Adj and N are each one word long and S is three words long, PEIC predicts that (6d) will be only slightly harder to process than EIC predicts, because the S node constructed

by Comp decays during the processing of one word (Adj) before the mother node is built by N. But because (6d) has an IC-to-word ratio of 100%, it is still just 1 EU from optimal under PEIC. (6l) is also only slightly harder to process, but it goes from bad to worse: the S node constructed by Comp decays for four words instead of the three implied by its IC-to-word ratio. Only (6h) is predicted to be significantly more difficult to process by PEIC than by EIC: the Adj node now decays for four words instead of none, because the fact that Comp is adjacent to it does not matter in PEIC. Comp does not construct the mother NP node. In fact, PEIC predicts that (6h) should be just as difficult to process as (6l).

2.2.2 PEIC and LR IC-to-word ratios

PEIC helps to provide an explanation for the left-to-right calculation of IC-to-word ratios used for differentiating between the word orders in examples (6e-l). The PEIC explanation diverges from the predictions of EIC, but this is not necessarily a bad thing, since there is a flaw in the implementation of the motivating logic of the LR IC-to-word ratio as presented by Hawkins (1990, 1994, 1998). In this section, I argue that the PEIC explanation explains the data in (6) while eliminating this logical flaw.

Recall that the logic motivating the left-to-right IC-to-word ratio is that among non-optimal word orders, linear orderings should be favored that provide quick access to a significant subset of the ICs of a phrase; thus, among the non-optimal word orders of N, Adj, and S, orders in which two of the three ICs are immediately presented in quick succession should be favored. PEIC can explain this if it is assumed that two ICs constructed by consecutive words have the effect of increasing the activation level of M *above* the activation level required to attach further structure. For this to be possible, we must assume that the M is not fully active upon initial construction, and that attaching a new IC boosts the activation of M by a minimum amount. Under these assumptions, an M which is constructed by one IC and boosted to a higher activation level by an immediately following IC (such as (6e), [N Adj [S C]]) would have a higher activation

level after a given number of additional words had been processed than an M whose activation level was based solely on the constructing IC, and would thus require fewer EUs when the next attachment to it is made. Equal efficiency is predicted for a word order in which consecutive words build ICs with the second IC constructing M (such as (6f), [Adj N [S C]]), since the activation of the first IC has not yet decayed when it is attached to the newly constructed M node. When M is constructed by the second IC, attaching the fully active first IC to it raises the activation level of M above its initial state.

In example (6), these assumptions predict that the word orders (6e-h) will be typologically less frequent than orders (6a-d), but more frequent than orders (6i-l). The logical motivation given by Hawkins (1994) for using LR IC-to-word ratios also makes this prediction, but the formal definition of the calculation of the LR IC-to-word ratio does not. This difference in prediction rises from a flaw in the way that the logical motivation for LR IC-to-word ratios is implemented in its defined method of calculation.

To see this flaw, consider the word order [N [Comp S] Adj] from example (6g) above. According to the stated logic of Hawkins (1994), this word order should be fairly optimal since it provides access to two of the three ICs of NP, N and Comp, in the first two words, just like the attested (6e-f). But according to the formal definition of the LR IC-to-word ratio, (6g) has a LR IC-to-word ratio of 63% while (6e-f) have a ratio of 83%. The stated logic of the LR IC-to-word ratio is not implemented in the definition, for the following reason: the LR IC-to-word ratio is defined to be calculated by averaging the IC-to-word ratios of each of the first n ICs in a phrase, even though IC-to-word ratios should be calculated on CRDs, not on entire ICs. That is, in example (6g) the IC-to-word ratio for the first two daughters, N S, should be calculated on the CRD for those two daughters, which is just the two words N Comp. This would give a LR IC-to-word ratio of 83%, the same as in (6e-f). Instead, it is defined to be calculated on *all* of the nodes dominated by the two daughters, including those outside of the CRD of those daughters (the words dominated by the S sister of Comp), giving a LR IC-to-word ratio of 63%.

Why is it that Hawkins (1994) calculates overall IC-to-word ratios based on the CRD of a phrase's daughters, but calculates LR IC-to-word ratios based on the full ICs of daughters of that phrase? The answer is that although it is logically suspect, it gets the right results: (6e-f) are word orders that appear in the sample of Lehmann (1984), while (6g) as well as (6h), the other order affected by this problem, do not. However, it is interesting to note that (6h) is precisely the only order for which processing is predicted to be significantly more difficult by PEIC than by EIC; its absence in the sample is thus explained. Thus the only discrepancy between the PEIC account of the relative frequencies of the orderings in (6) and the frequencies of Lehmann (1984) is the unpredicted lack of languages with the word order of (6g). Lehmann's sample consists of 83 languages, which for examining the possible word orders of the present construction is actually somewhat small. To see this, consider an ideal, perfectly distributed sample of 83 languages. Since PEIC predicts that word orders (6a-d) are easy to process and that with orders (6e-g) are harder to process but still acceptable, types (6a-d) should be significantly more common than types (6e-g) to be able to conclude that the two types indeed have different processing properties. Thus, each of types (6e-g) should probably appear no more than about 9 times each, with types (6a-d) appearing at least 14 times each. So even with a perfect sample, less than 10 instances of (6g) languages would be predicted. In reality, a perfect language sample is impossible to construct (for discussion, see Newmeyer, 1998), and wide variation in language type frequencies can be expected. Therefore, the absence of language type (6g) in the sample of Lehmann (1984) is plausibly simply a sampling error.

3.0 *Developing a compatible PEIC*

EIC and the SPLT begin with essentially the same principle: the human parsing mechanism prefers word orders that keep related elements of syntactic structures close together. But in discussing the ramifications of their models, Hawkins (1994) and Gibson

(1998) diverge in their assumptions about the parsing model that implements this shared efficiency principle. In this section I will describe the principal differences between the models of parsing assumed by EIC and the SPLT, and attempt to resolve these differences in PEIC. The goal of this section is not to describe a fully specified model of sentence processing, nor is it to review the evidence for parsing algorithm details on which the SPLT and EIC agree. Rather, the goal is to point out the key areas in which the two approaches differ and to resolve these differences, thus clearing the way for a PEIC model that successfully integrates the SPLT and EIC.

This section is organized as follows. Section 3.1 looks at the widespread use of prediction in the SPLT and its virtual absence in EIC, and argues that this difference is not as significant as it may seem. I show that widespread prediction is not necessary for PEIC to explain syntactic complexity phenomena. Section 3.2 discusses the issue of lexical ambiguity, focusing on subcategorization ambiguity and syntactic category ambiguity. I argue that for the latter (but not for the former), the SPLT's assumption of a parallel parser is the correct approach. Importantly, since syntactic category ambiguities are usually resolved within one or two words, the amount of time during which multiple simultaneous analyses have to be maintained is limited.

3.1 *The role of syntactic prediction*

The SPLT assumes widespread syntactic prediction, where *prediction* can be defined as construction of a node before all daughters of that node have been seen. EIC also uses syntactic prediction, but only predicts nodes when such prediction can be done with certainty. In this section, I demonstrate that the types of prediction used by the SPLT and EIC are fundamentally equivalent in terms of complexity predictions. However, EIC often uses *retrodiction* where the SPLT uses prediction, which reduces the need for parallel parsing and increases efficiency. PEIC combines prediction and retrodiction in a fashion that is compatible with, but more efficient than, the SPLT. Finally, I argue that

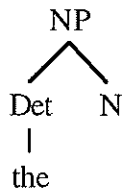
Gibson's (1998) claim that the prediction of the top-level verb is cost free is problematic in a number of respects.

3.1.1 Prediction in EIC and the SPLT

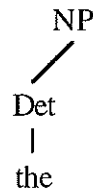
In the SPLT, encountering the word *the* causes a syntactic prediction of a following noun. This is functionally a *left-corner* parsing strategy (Aho & Ullman 1972): encountering the leftmost daughter of a phrase-structure rule causes the mother node and all sister nodes of that daughter to be constructed. In the case of *the*, the structure in (12a) is built. (With an X-bar grammar, the predicted noun is actually an N in order to account for any adjectives intervening between the determiner and the noun.) Then, when a noun is encountered, the predicted node is first reactivated, if necessary; then the noun is attached to the predicted N node.

PEIC also makes a prediction based on sentence-initial *the*, but it is a somewhat different prediction than the SPLT. In PEIC, encountering the word *the* triggers construction of the mother NP node, but not of the sister N node, as shown in (12b). This is a prediction, despite the lack of N node construction, simply because not all of the NP has been seen; PEIC is thus predicting the remainder of the NP by building the mother NP node. When a noun is then encountered, the mother NP node is reactivated, if necessary, and the noun is then attached to it.

(12a)



(12b)



Note that for these two types of prediction, the amount of reactivation necessary in the SPLT and in PEIC is exactly the same. In the SPLT, the predicted N node decays

exactly as much as the mother NP node does in PEIC, because the nodes are constructed at the same time (when *the* is encountered) and reactivated at the same time (when the noun is encountered). Thus, this difference between PEIC and the SPLT has no effect on the complexity predictions of the two models. However, this difference results in two differences between the two models in other areas.

The first difference between SPLT prediction and PEIC prediction is that of how a predicted node is licensed; that is, how does the parser establish that it is grammatical for one piece of structure to attach to another? Consider the example of the verb *put*. In the SPLT, encountering the verb *put* triggers construction of two predicted sister nodes, NP and PP. When an NP or PP is later constructed, the SPLT licenses their attachment to the VP headed by *put* by virtue of their having been predicted. If, for example, an AdjP had been encountered after *put*, its ungrammaticality would be captured by the fact that there would be no predicted AdjP node for it to attach to. In other words, the SPLT licenses its arguments by predicting them. In PEIC, on the other hand, the NP and PP sisters of *put* would not be predicted, and licensing them has to occur via some other means, most likely by storing subcategorization information in the mother VP node, and checking with that node when an NP or PP (or AdjP) is encountered to see if an attachment is legal. The important point here is that both licensing methods get the right results, although I will argue in sections 3.1.2 and 3.2.1 that the second licensing method is preferable.

The second difference between SPLT and PEIC prediction derives from the guiding philosophy behind the set of parsing principles defined by Hawkins (1994) for EIC. This philosophy, which I will term *certainty construction*, is that nodes should only be constructed when it can be done with certainty that it is the right choice to make. Because being able to predict nodes with absolute certainty is quite rare in natural language, among the parsing principles of Hawkins (1994) only Sister Node Construction predicts nodes, and in practice it very seldom does so. For example, encountering the word *the* triggers construction of an NP because no other node can dominate a D node.

However, creating an NP node does not trigger construction of any node above it, since NP could be dominated by S, VP, PP, and so on. Even the context-sensitive information that the NP is encountered in sentence-initial position does not help, because a sentence-initial NP could be dominated by S, DP (as in example (10) above), another NP (in the event of coordination), or in the event of object NP topicalization, some sort of TopP (E, in Hawkins terms). Gibson (1998) assumes that the SPLT predicts a matrix verb upon encountering a sentence-initial *the*, despite the fact that this prediction is not certain.⁸ In this sense, the SPLT is more aggressive in its predictions than PEIC.

The SPLT can make uncertain predictions because Gibson (1998) assumes a parallel parser (Kurtzman, 1985; Gorrell, 1987; Gibson, 1991; MacDonald, Pearlmutter, and Seidenberg, 1994; Vosse and Kempen, 2000). In a parallel parser that makes left-corner predictions, every possible distinct prediction made by a category results in a new candidate analysis. Thus the prediction of a matrix verb is just one of several predictions made by the SPLT upon encountering a sentence-initial *the*. In this sense, parallel parsing allows more aggressive predictions to be made, because the correct prediction is guaranteed to be among all the predictions made.

This type of logic can be dangerous, however. One criticism that can be leveled against parallel parsing models is that it is computationally expensive to maintain several analyses in memory at once. The more aggressive, or uncertain, the predictions made by a model are, the greater the number of possible predictions and the more simultaneous analyses there will be. Thus a parallel parser should actually be *more* restrictive, not less, in the predictions it is allowed to make, to compensate for the greater computational complexity of allowing multiple simultaneous analyses. The SPLT is in this sense undesirably computationally costly.

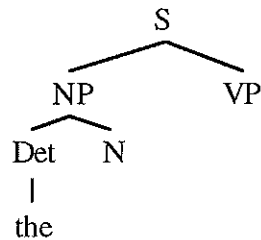
⁸ I assume that prediction of the matrix verb is actually construction of a VP node, to which the matrix verb attaches. Prediction of VP upon encountering sentence-initial *the* is actually an example of *arc-eager* left-corner parsing (Abney and Johnson, 1991). In arc-eager left-corner parsing, a category does not need to see all of its daughters before making its own left corner predictions; in this case, the category NP does not see its N daughter before predicting its own VP sister.

3.1.2 Prediction and retrodiction as equivalent

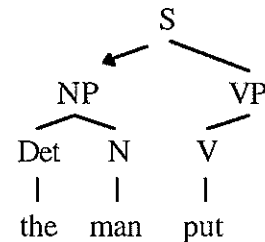
EIC offers a way to avoid the use of aggressive predictions without changing measurements of structural complexity; in this way, the parser is made more efficient without losing any explanatory power. In the example of the PEIC parsing of left-branching structures in (9), I noted that the number of EUs required to construct an M with two ICs was the same no matter which IC constructed M: if the first IC constructs M, then M will have to be reactivated to attach the second IC; if the second IC constructs M, then an equal number of EUs will be required to reactivate the first IC in order to attach it to M.

As discussed in the previous section, the SPLT assumes that construction of the subject NP of a sentence triggers prediction of the matrix verb; this is illustrated in (13a). EIC and PEIC, in contrast, assume that the matrix verb of a sentence constructs S, to which the subject NP is then attached. This is shown in (13b), where the arrow indicates the attachment of the structure generated by the verb *put* to the previously existing structure:

(13a)



(13b)



The left-corner parsing strategy used by the SPLT results in construction of S and prediction of the VP node. PEIC, on the other hand, builds this structure in what is essentially a *right-corner* fashion, with the rightmost daughter VP constructing the mother node S. I will therefore say that in PEIC the constructed S node *retrodicts* the subject NP. Retrodiction, as I use the term, is the act of a word or phrase placing

requirements on the structure that precedes it; as such, it is just the opposite of prediction.

Because of the equivalence in EUs required, prediction and retrodiction are equivalent for structures that are binary branching (but not in ternary structures, as example (11d) shows) As such, retrodiction offers an efficient solution to the problem of the aggressive prediction of VP made by the SPLT. PEIC thus differs from the SPLT in its use of retrodiction, but the two theories remain compatible in this regard.

3.1.3 Prediction cost of the top-level verb

The SPLT assumes that a sentence-initial *the* triggers prediction of the top-level verb. This would appear to imply that processing difficulty should increase as the distance between a sentence-initial *the* and the top-level verb increases, since more EUs will be needed to reactivate the predicted VP node in order to attach the top-level verb to it. However, Gibson (1998) cites evidence that more complex, and thus longer, subject noun phrases are in fact *not* more difficult to process than short ones (Hakes et. al., 1976; Gibson and Thomas, 1997, cited in Gibson, 1998). To account for these data, Gibson (1998) proposes that there is no cost associated with the prediction of the top-level verb. This means that the verb predicted by, say, sentence-initial *the*, does not decay as time passes.

In PEIC, the notion of a cost-free top-level verb must be implemented slightly differently. This is because EIC assumes that the top-level verb constructs S, to which the subject NP then attaches. Because no VP node is predicted, there is no node whose activation level can be assumed not to decay. Instead, in PEIC the notion of a cost-free top-level verb can be implemented by positing that a top-level, non-decaying S node already exists at the point that parsing begins. Then, when the subject NP is constructed, it is attached to this pre-existing S node, as is the top-level VP when it is constructed by the top-level verb. Under this scheme, PEIC makes the same complexity predictions as the SPLT.

On the EIC side, a non-decaying S node predicts that CRDs for S that stretch from the word constructing the subject NP to the word constructing the top-level VP should not matter in terms of word order. However, there are many constructions in EIC in which the size of the CRD for S *must* matter. I present two examples in this section, that of the correlation between OV word order and overt object case-marking already discussed in section 2.2.1, and that of heavy object preposing in Japanese.

One consequence of the assumption that the size of the CRD for S does not matter is an explanation why SOV languages, in which the S and the V are separated by O, are not less frequent than SVO languages. However, this explanation undermines the explanation given in section 2.2.1 for the same facts, since there is no longer an explanation for the correlation between SOV word order and object case marking. In other words, the fact that OV languages correlate with languages with case-marked NPs is explained if the construction of VP can move leftward in OV languages to reduce the size of the CRD for S. If the S node does not decay, then there is no motivation to move the mother-constructing daughter of VP leftward, and thus no explanation for the OV-case marking correlation.

Furthermore, S must decay in order for PEIC to explain many word order phenomena explained by EIC. For example, in Japanese, Hawkins (1994) shows that the longer an object is, the most likely it is to be preposed before the subject:

- (14) a. Mary-ga [kinoo John-ga kekkonsi-ta to]_S it -ta.
 Mary ACC yesterday John ACC marry PAST that say PAST
 Mary said that John got married yesterday.
- b. [Kinoo John-ga kekkonsi-ta to]_S Mary-ga it-ta.

In (14a), the CRD for S stretches from the first *ga*, which constructs (via the PP (or NP_[+nominative]) *Mary-ga*) the S mother node, to the complementizer *to* which constructs (via the S of the complement clause) the matrix VP second IC of S. Thus in PEIC, 5 EUs

are required to reactivate the matrix S node to attach the VP. The CRD for VP is just two words, the complementizer *to* and the verb *it(-ta)*. In (14b), preposing the complement clause before the subject has the effect of reducing the CRD for S to the three words stretching from the complementizer *to* to the *ga* of *Mary-ga*, requiring a single EU. If the S node does not decay, then there is no longer any explanation for why heavy objects prepose before the subject. Note that in (14b), the CRD for VP actually increases: now it stretches from the complementizer *to*, which constructs S, to the *ga* of *Mary-ga*, which constructs S, requiring 1 EU.⁹ So if the CRD for S were irrelevant, then the word order in (14a) should actually be preferred to that in (14b).

In addition to the above example from Japanese, Hawkins (1994) gives examples from Korean, Turkish, German, and English that also crucially depend on the size of the CRD for S. Based on this evidence, I cannot accept the notion that the top-level verb is cost free. Of course, the experimental data cited by Gibson (1998) cannot be ignored. However, given the evidence that the S node does decay in PEIC, I conclude that the locus of explanation for the data of Hakes et. al. (1976) and of Gibson and Thomas (1997) lies elsewhere, and is a matter for future research.

3.2 Lexical ambiguity

A parallel parser such as the SPLT can easily handle instances of lexical ambiguity by positing separate structures for each possible reading of an ambiguous word. However, I have argued in the previous section that PEIC avoids making uncertain predictions because of a desire to avoid parallel parsing wherever possible. How, then, does PEIC deal with lexical ambiguity? In this section I discuss two kinds of lexical ambiguity. Subcategorization ambiguity occurs when a word, typically a verb, has multiple possible subcategorization frames. Syntactic category ambiguity occurs when a single word can be

⁹ This analysis assumes a discontinuous VP in (14b) as the result of extraposition. Hawkins (1994:140-149) argues that EIC is compatible with a flat S (no VP) analysis, but that a discontinuous VP analysis gets better results overall. EIC does not support a movement analysis (adjunction of the S to the top-level S).

interpreted as belonging to two separate syntactic categories.¹⁰ I conclude that parallelism is not required for PEIC to handle subcategorization ambiguity. For syntactic category ambiguity, however, I argue that three alternate strategies to parallelism, the delay strategy of Frazier and Rayner (1987), the Statistical Lexical Category Module of Corley and Crocker (2000), and the nondeterministic probabilistic serial model of Lewis (2000), are inadequate. Therefore, PEIC, like the SPLT, uses parallel parsing to handle syntactic category ambiguity. Fortunately, the fact that most instances of syntactic category ambiguity are disambiguated within one or two words means that the amount of parallel parsing in PEIC remains very restricted.

3.2.1 *Subcategorization ambiguity*

In examples (1-2), the verb *put* was assumed to simply require a following NP and PP. But three minutes brainstorming reveals at least five possible subcategorization frames for *put*:

- (15) a. The man put the book on the table. (NP PP)
 a. The man put the baby down. (NP Part)
 b. The man put down the baby. (Part NP)
 c. The man put all the books together. (NP Adj)
 d. The man put up with his incessant ranting.¹¹ (PP)

In a model of parsing that allows prediction such as the SPLT, the most obvious way to deal with such examples of subcategorization ambiguity is to construct, upon encountering a verb, parallel structures for each possible subcategorization frame of the verb. Of course, each individual prediction is highly uncertain. I have argued in section

¹⁰ A discussion of semantic ambiguity, although a rich topic, is beyond the scope of this paper.

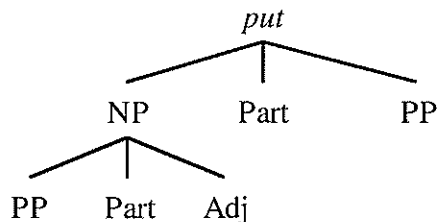
¹¹ It is true that *to put up with* is a highly idiomatic expression. However, a listener cannot recognize an idiomatic expression until *after* the structure for the expression has been built. Thus, idiomatic

3.1.2 that PEIC does not make such uncertain predictions; rather, a VP node is constructed upon encountering a verb, and new possible ICs of the VPs are licensed at the time of their construction by checking with the potential VP mother node.

For subcategorization ambiguity, this licensing scheme is too unsophisticated. To see this, consider parsing the VP in (15a). Encountering *put* triggers construction of VP, and the next word *the* triggers construction of NP. At this point, the NP checks with the VP to see if it can attach. It can, but the problem is that it can attach as the first complement of three distinct subcategorization frames: (15a), (15b), and (15d). Since PEIC does not build parallel analyses for the three possible following constituents (PP, Part, or Adj), what mechanism will encode the fact that the newly attached NP is the first constituent of one of three possible subcategorization frames?

The answer is to replace the traditional notion of a subcategorization frame with that of a subcategorization *tree* (similar to the phoneme tree for word recognition that is described by Klatt, 1979). The tree for all the possible subcategorization frames in (15) is given in (16):

(16)



Using a subcategorization tree, one node in the tree is marked as the current node, with the daughters of the current node being the possible following constituents. When *put* is encountered, the marker is set at the *put* node at the root of the tree. Then, encountering an NP after *put* causes the marker to move down from the *put* node to the NP node in the

expressions must have a representation equal to that of non-idiomatic structure during processing, at least for initial syntactic structure building.

tree, and the possible following constituents are the daughters of the NP node PP, Part, or Adj which remain encoded in a single representation. Any semantic information specific to particular frames is encoded in the leaves of the tree, since each leaf node corresponds to exactly one frame. Using subcategorization trees allows PEIC to handle subcategorization ambiguity without prediction or parallel parsing.

3.2.2 *Syntactic category ambiguity*

A second type of syntactic ambiguity occurs when a word is categorically ambiguous, as in the following example from Frazier and Rayner (1987):

- (17) a. The warehouse fires numerous employees each year.
 b. The warehouse fires harm some employees each year.

In this example, the word *fires* is ambiguous between a noun and a verb. Language is rife with examples of syntactic category ambiguity, but by and large resolving such ambiguity is handled unproblematically by the human sentence processor.¹²

The existence of syntactic category ambiguity poses a problem for the certainty construction philosophy of EIC. Certainty construction requires categorically ambiguous words to not be mother node constructors, since such mother node construction cannot be done with certainty. For example, Hawkins (1998) states that in EIC, a verbal *to* in English does not construct a VP node, since this *to* is identical to the preposition *to* (p. 769). The problem with this approach becomes obvious in a sentence such as (18):

- (18) Ducks fly.

¹² The infamous exceptions to unproblematic syntactic ambiguity resolution are *garden path* sentences such as the following:

- (i) The man who hunts ducks out on Sundays.

In (18), both words of the sentence are categorically ambiguous between a noun and a verb. If certainty construction were strictly true, then no structure for this sentence could ever be built, because neither word uniquely determines a mother node. Thus EIC does not offer an answer to the syntactic category ambiguity problem.

The parallel parser of the SPLT handles syntactic category ambiguity completely unproblematically by proposing simultaneous analyses for each category of the ambiguous word. PEIC could conceivably handle such ambiguity in the same way. However, I have argued in the preceding sections that parallelism in a parser should be constrained as much as possible due to its computational expense. Thus before concluding that PEIC is also ranked parallel, I will review the alternate proposals that have been made. One such proposal is that resolution of ambiguity is delayed until disambiguating material has been encountered (Frazier and Rayner, 1987). A second proposal is that a separate lexical disambiguation module in the form of a bigram part-of-speech tagger handles syntactic category ambiguity (Corley and Crocker, 2000). Finally, a parser might be nondeterministic, choosing different analyses to pursue on different occasions, given the same input (Lewis, 2000).

The delay strategy of Frazier and Rayner (1987) posits that for syntactic category ambiguities that are disambiguated by a later-appearing word, as in example (17), no decision about the ambiguous word's category is made until that later word is encountered. To test this hypothesis, Frazier and Rayner used an eye-tracking experiment with sentences like those in (17), where the ambiguous word *fires* is disambiguated by a following word, along with similar sentences where the ambiguous word is disambiguated by the previous syntactic structure, such as the following:

In (i), the word *ducks* is the matrix verb of the sentence, but is misinterpreted by the human sentence processor as a noun. However, garden path sentences are quite rare in normal language use.

- (19) a. This warehouse fires numerous employees each year.
 b. These warehouse fires harm some employees each year.

In (19a), the singular demonstrative pronoun *this* requires that *fires* be a verb, while in (19b) *these* requires *fires* to be a noun. Frazier and Rayner found that for sentences like those in (17), reading times were shorter during *warehouse fires* and longer for the rest of the sentence than for sentences like those in (19). They concluded that when a lexical category ambiguity is disambiguated by preceding context as in (19), the word is immediately integrated into the existing syntactic structure, requiring computation that slows down reading. However, if an ambiguous word is not disambiguated by previous context as in (17), no integration is performed until disambiguating information arrives, thereby delaying the computation due to integration until after the ambiguous words, thus explaining the faster reading times for the ambiguous words in (17) and the slower reading times for the (disambiguating) remainder of the sentence.

The delay strategy has been criticized by MacDonald (1993), who argued that the pronouns *this* and *these* are deictic, referring the reader to a previously mentioned discourse object. Using these pronouns without such an existing discourse object is infelicitous, which results in confusion on the part of the reader that results in longer reading times. MacDonald conducted an experiment that partly consisted of varying the type of determiner used (*the* versus *this/these*) in purely unambiguous sentences, and found that reading times were indeed longer for the subject noun phrases in *this/these* sentences than in *the* sentences, even when there was no categorically ambiguous word present in those sentences.

Apart from MacDonald's (1993) criticism, there is a fundamental problem with the delay strategy as Frazier and Rayner (1987) describe it. In particular, it is unclear how a parser could determine exactly when the delay strategy should be applied except by trying to integrate all categories of a newly encountered ambiguous word with the existing syntactic structure which is exactly the computation that the delay strategy is

designed to avoid! To see this, consider that in (17) and (19), whether the word *fires* is integrated into the existing syntactic structure depends on whether this structure disambiguates between the noun and verb readings of *fires*.¹³ How do we determine whether this structure is disambiguating or not? The only apparent answer is to take each category of *fires* and try to integrate it into the existing structure. If only one category successfully integrates, then the previous structure is disambiguating; if both categories integrate, then the previous structure does not help and the delay strategy should be used. But at this point, structures for each reading of *fires* have already been built, and have been built in parallel.¹⁴ To throw these away, only to build them again when the disambiguating word arrives would be ridiculously inefficient, particularly because the disambiguating word for the sentences in (17) is the word that immediately follows *fires*.

Furthermore, according to the delay strategy a category for an ambiguous word occurs only upon encountering disambiguating material. Since such material is not necessarily the word directly following the ambiguous word as it is in (17), how do we determine what the disambiguating material is? Again, the only apparent solution is to build all possible structures in parallel, and see whether one reading of the ambiguous word does not result in a valid syntactic structure.

¹³ Frazier and Rayner claim that in these sentences, *warehouse* is ambiguous between a noun in (15b) and (17b) and an adjective in (15a) and (17a). However, this analysis ignores the facts of noun compounding in English. Firstly, such an analysis cannot capture the ambiguity of phrases like *French teacher*, which is either an Adj N (teacher from France) or a N N (teacher of French). Secondly, phrases consisting of multiple true adjectives followed by a noun (*the big old red bus*) are strictly right-branching. To assume that all non-final nouns in a noun compound are adjectives would require an equally right-branching structure and would thus be unable to capture the fact that some noun compounds are not strictly right-branching: *[[teacher committee] meeting]*, *[[leadership skills] seminar]*, *[[product fulfillment] cycle]*, and so on. Thus in these sentences, the categorically ambiguous word is *fires*.

¹⁴ Building each structure serially, rather than in parallel, is problematic in cases where, for example, the previous structure is disambiguating and the correct category of the ambiguous word is integrated (successfully) first. At this point, the parser still does not know whether the existing structure is compatible with the second category, so it must discard (part of) the first structure in order to try to integrate the second category. If the second category doesn't integrate, then the first, now disambiguated, structure must be immediately rebuilt. I am not comfortable endorsing a parsing model that is so blatantly inefficient, particularly when the cost associated with maintaining one word's worth of extra syntactic structure in memory while a second structure is built is likely to be minimal.

To implement the delay strategy by immediately attempting to build parallel structures for each possible category of an ambiguous word is to undermine not only the delay strategy itself but also the serial parser that it is designed to operate within (Frazier, 1987a). However, it is unclear how else the delay strategy could work. Frazier and Rayner (1987) do not discuss the issue, and thus appear to assume some sort of oracle that knows whether a particular structure is disambiguating without actually checking that structure against the ambiguous word. I have no suggestions for how such an oracle might operate that would not defeat the motivation for delaying, and I thus reject the delay strategy as a method for dealing with syntactic category ambiguity.

A second approach to syntactic category ambiguity is that of Corley and Crocker (2000), who propose that lexical disambiguation takes place in its own module, distinct from syntactic processing. This module takes the form of a bigram part-of-speech tagger, in which the category chosen for an ambiguous word depends entirely on two kinds of frequency-based probabilities: the probabilities that a word appears as each of its possible categories, and category-to-category transitional probabilities, that is, the probability, given a word of a particular syntactic category C_1 , that the following word is of syntactic category C_2 . Corley and Crocker present evidence that both types of frequencies play a role in explaining syntactic category disambiguation data.

However, two objections can be made that question the psychological plausibility of Corley and Crocker's model, one aesthetic and one empirical. Corley and Crocker rightly believe that a modular architecture is to be preferred over an interactive architecture, to the extent that modularity is consistent with the experimental data. However, it does not follow from this that adding additional modules to a model increases the attractiveness of the model. In particular, Corley and Crocker posit distinct modules for lexical disambiguation and for syntactic structure building. Each of these modules uses a completely distinct set of processing mechanisms. However, it would also be possible, for example, to envision a syntactic module which uses parallel parsing to handle both syntactic category ambiguities as well as purely syntactic ambiguities such as

attachment. This parallel parsing module is more parsimonious in that a single set of mechanisms handles both lexical disambiguation and the construction of syntactic structure. And since such a module would still rely on purely syntactic information, it is not subject to Corley and Crocker's criticism that an interactive model may be more computationally complex than a modular model because it does not restrict the amount of information brought to bear on decision-making.¹⁵

A second objection to a lexical disambiguation module comes from experimental data that shows that manipulating the properties of a secondary interpretation of an ambiguous sentence has effects on comprehending the primary interpretation (Kurtzman, 1985; Gorrell, 1987; Pearlmuter and Mendelsohn, 1999, cited in Gibson and Pearlmuter, 2000). These results argue strongly for a parallel parsing model. Lewis (2000), an advocate of serial models, concedes that a deterministic serial model, in which the same input always results in the same output, cannot account for these results, but claims that they are consistent with a nondeterministic probabilistic serial model in which the sentence processor chooses to pursue different interpretations of the same input on different occasions. Neither of these models is compatible with that of Corley and Crocker (2000), whose model is deterministically probabilistic: the same sequence of words will always be assigned the same sequence of syntactic categories, even though the model uses probabilities to calculate these categories. Thus, there is no way for Corley and Crocker's lexical disambiguation module to account for the data showing that the secondary interpretation can affect the primary interpretation of a sentence.

As for the plausibility of Lewis (2000) nondeterministic model, Pearlmuter and Mendelsohn (1999) argue that their data are not compatible with a nondeterministic probabilistic serial model. Furthermore, a nondeterministic model will initially choose the

¹⁵ In fact, I am not arguing for an autonomous syntactic module; I am merely pointing out that even assuming a modular architecture, Corley and Crocker's model is not very parsimonious. Furthermore, Corley and Crocker make the common mistake of assuming that in an interactive model, *all* decision-making processes have access to *all* possible information. This assumption ignores Crain and Steedman's (1985) observation that interaction may be restricted such that some, but not all, information from higher levels of processing may influence decisions made at lower levels (Crain and Steedman's *weakly*

correct interpretation less frequently than a deterministic model. To see this, consider a syntactic category ambiguity in which category A occurs 70% of the time, and category B appears 30% of the time. A deterministic model can achieve a 70% accuracy rate by always choosing A. A nondeterministic model is guaranteed to have less than a 70% accuracy rate: if, for example, the nondeterministic model chooses A 70% of the time and B 30% of time, then there are four possibilities:

(20)

| Processor chooses: | Correct category: | Percent of occasions: |
|--------------------|-------------------|-----------------------|
| A | A | $0.7 * 0.7 = 0.49$ |
| A | B | $0.7 * 0.3 = 0.21$ |
| B | A | $0.3 * 0.7 = 0.21$ |
| B | B | $0.3 * 0.3 = 0.09$ |

As can be seen from the table, 49% percent of the time the processor will choose the category A correctly, and 9% of the time will chose category B correctly, giving a total accuracy rate of 58%, much lower than the deterministic strategy of always choosing A. More generally, if in this ambiguity the processor chooses category A x percent of the time, then the accuracy rate is equal to $0.7x + 0.3(1-x) = 0.4x + 0.3$. Since the result is a linear equation, the highest accuracy rate is achieved by setting x as high as possible, namely to 1.0 (100% of the time), which results in the 70% accuracy rate given above. This holds for any nonequal frequencies of A and B. Thus, while a nondeterministic probabilistic serial model may or may not be consistent with the empirical data, it would certainly be strange for the human sentence processor to adopt a nondeterministic strategy that is both more complex and less accurate than a deterministic model.

Because of the problems with the delay strategy, the lexical disambiguation module, and a nondeterministic probabilistic serial model, combined with the experimental

interactive model). This type of model would not be as computationally complex as the fully interactive model that Corley and Crocker criticize.

evidence in favor of parallelism cited above, I conclude that PEIC, like the SPLT, uses parallel parsing to handle syntactic category ambiguity. Interestingly, both Frazier and Rayner (1987) and Corley and Crocker (2000) point out that syntactic category ambiguities are most often resolved within one or two words, using the highly local nature of such ambiguity as evidence to support their respective models. In fact, this locality of ambiguity also supports a parallel model, because it means that while categorically ambiguous words trigger construction of parallel structures, all but one of these structures will normally be pruned away within one or two words. Combined with the fact that a parallel parsing model certainly shares as much common structure between analyses as possible (as in e.g., the chart parser of Kay, 1980/1985), the criticism that parallel parsing is overly computationally complex is largely eliminated.

Conclusion

In this paper, I have argued that the Early Immediate Constituents theory of Hawkins (1994) and the Syntactic Prediction Locality Theory of Gibson (1998) actually represent two closely related approaches to sentence processing. In very rough terms, EIC represents a higher level of modeling and explanation than the SPLT. While EIC and the SPLT both explain cross-linguistic word order and complexity phenomena, the explanatory focus of EIC is to use syntactic primitives to provide insight into cross-linguistic word order generalizations, while that of the SPLT is to use the primitives of working memory to motivate a wide range of complexity effects in English. Because of this difference in the level of descriptive and explanatory insight, deriving from these two approaches the single PEIC model of sentence processing results in a model that is more end-to-end than either individual approach in that it claims that the limitations of working memory explicitly explain the emergence of typological generalizations.

Newmeyer (1998) argues that EIC is an example of *external explanation* for grammatical theory. That is to say, EIC explains certain aspects of grammar, while remaining distinct from grammar itself. In the same way, in PEIC working memory acts

as an external explanation for the structure of the parser. Working memory is not a part of the parsing mechanism, but provides an explanation for why parts of it behave as they do. This is clearly a desirable result, because it is the beginning of a chain in which each coherent linguistic subsystem is motivated by the consequences of a lower-level system. This type of explanation thus begins to provide us with an overall picture of the creation of human language.

To be able make this claim is very exciting, but in a sense also entirely expected. Hawkins and Gibson conduct their primary research in the fields of language typology and experimental psychology, respectively. However, this difference in research focus does not change the fact that there is a single human sentence processing system, and that therefore any model of this system that is fundamentally correct must be compatible with any other correct model, whether these models come from the same or from different linguistic subfields. From this point of view, relating approaches from different subfields provides the most insight, since the resulting model will offer a unified explanation for empirical data in both subfields. This is exactly the explanatory power offered by PEIC.

References

- Abney, Steven P., and Mark Johnson (1991). Memory requirements and local ambiguities of parsing strategies , *Journal of Psycholinguistic Research* 20(3):233-250.
- Aho, Alfred V., and Jeffrey D. Ullman (1972). *The Theory of Parsing, Translation, and Compiling, Volume 1: Parsing*. Englewood Cliffs, New Jersey: Prentice Hall.
- Corley, Steffan, and Matthew S. Crocker (2000). The Modular Statistical Hypothesis: Exploring Lexical Category Ambiguity , in Matthew S. Crocker, Martin Pickering, and Charles Clifton, Jr. (Eds.), *Architectures and mechanisms for language processing*. Cambridge: Cambridge University Press, 135-160.

- Crain, Stephen, and Mark Steedman (1985). On not being led up the garden path: the use of context by the psychological syntax processor , in David R. Dowty, Lauri Karttunen, and Arnold M. Zwicky (Eds.), *Natural language parsing: Psychological, computational, and theoretical perspectives*. Cambridge: Cambridge University Press, 320-358.
- Frazier, Lyn (1979) On comprehending sentences: syntactic parsing strategies , Indiana University Linguistics Club, Bloomington, Indiana.
- Frazier, Lyn (1987a). Sentence Processing: A Tutorial Review , in Max Coltheart (Ed.), *Attention and Performance XII: The psychology of reading*. Hove, East Sussex: Lawrence Erlbaum Associates.
- Frazier, Lyn (1987b). Syntactic processing evidence from Dutch , *Natural Language and Linguistic Theory* 5:519-559.
- Frazier, Lyn and Keith Rayner (1987). Resolution of Syntactic Category Ambiguities: Eye Movements in Parsing Lexically Ambiguous Sentences , *Journal of Memory and Language* 26:505-526.
- Gibson, Edward (1991). *A Computational Theory of Human Linguistic Processing: Memory Limitations and Processing Breakdown*. Ph.D. dissertation, Carnegie Mellon University.
- Gibson, Edward (1998). Linguistic complexity: locality of syntactic dependencies , *Cognition* 68:1-76.
- Gibson, Edward, and Neal J. Pearlmutter (2000). Distinguishing Serial and Parallel Parsing , *Journal of Psycholinguistic Research* 29(2):231-240.
- Gibson, Edward, and J. Thomas (1997). *Processing Load Judgements in English: Evidence for the Syntactic Prediction Locality Theory of syntactic complexity*. Manuscript, MIT, Cambridge, Mass.
- Gorrell, Paul (1987). *Studies of Human Syntactic Processing: Ranked-Parallel versus Serial Models*. Ph.D. dissertation, University of Connecticut.

- Greenberg, Joseph H. (1963). Some universals of language with special reference to the order of meaningful elements , in Joseph Greenberg (Ed.), *Universals of Language*, Cambridge: MIT Press, pp. 73-113.
- Hakes, David T., Judith S. Evans, and Linda L. Brannon (1976). Understanding sentences with relative clauses , *Memory and Cognition* 4:283-296.
- Hakwins, John A. (1990). A Parsing Theory of Word Order Universals , *Linguistic Inquiry* 21(2):223-261.
- Hawkins, John A. (1994). *A performance theory of order and constituency*. Cambridge: Cambridge University Press.
- Hawkins, John A. (1998). Some issues in a performance theory of word order , in Anna Siewierska (Ed.), *Constituent Order in the Languages of Europe*. New York: Mouton de Gruyter, 729-780.
- Hawkins, John A. (1999). Processing complexity and filler-gap dependencies across grammars , *Language* 75:244-285.
- Kamide, Yuki, and Don C. Mitchell (1999). Incremental pre-head attachment in Japanese parsing , *Language and Cognitive Processes* 14:631-662.
- Kay, Martin (1980/1985). Algorithm Schemata and Data Structures in Syntactic Processing , CSL-80-12, Xerox Corporation, reprinted in Barbara J. Grosz, Karen Sparck Jones, and Bonnie Lynn Webber (Eds.), *Readings in Natural Language Processing*. Los Altos: Morgan Kaufmann, 35-70.
- Kimball, John (1975). Predictive analysis and over-the-top parsing , in John Kimball (Ed.), *Syntax and Semantics, Volume 4*. New York: Academic Press, 155-179.
- Klatt, Dennis H. (1979). Speech perception: a model of acoustic-phonetic analysis and lexical access , *Journal of Phonetics* 7:279-312.
- Konieczny, Lars, Barbara Hemforth, Christoph Scheepers, and Gerhard Strube (1997). The role of lexical heads in parsing: evidence from German , *Language and Cognitive Processes* 12:307-348.

- Kurtzman, Harold S. (1985). *Studies in Syntactic Ambiguity Resolution*. Ph.D. dissertation, MIT.
- Lehmann, Christian (1984). *Der Relativsatz*. T bingen: Gunter Narr Verlag.
- Lewis, Richard L. (2000). Falsifying Serial and Parallel Parsing Models: Empirical Conundrums and An Overlooked Paradigm , *Journal of Psycholinguistic Research* 29(2):241-248.
- MacDonald, Maryellen C. (1993). The Interaction of Lexical and Syntactic Ambiguity , *Journal of Memory and Language* 32:692-715.
- MacDonald, Maryellen C., Neal J. Pearlmutter, and Mark S. Seidenberg (1994). Lexical Nature of Syntactic Ambiguity Resolution , *Psychological Review* 101(4):676-703.
- Pearlmutter, Neal J., and A. Mendelsohn (1999). Serial versus parallel sentence comprehension , submitted manuscript.
- Newmeyer, Frederick J. (1998). *Language Form and Language Function*. Cambridge, Mass.: MIT Press.
- Pritchett, Bradley (1992). *Grammatical Competence and Parsing Performance*. Chicago: University of Chicago Press.
- Ross, John Robert (1967) *Constraints on variables in syntax*. Ph.D. dissertation, MIT.
- Siewierska, Anna, and Dik Bakker (1996). The distribution of subject and object agreement and word order type , *Studies in Language* 20(1):115-161.
- Vosse, Theo, and Gerard Kempen (2000). Syntactic structure assembly in human parsing: a computational model based on competitive inhibition and a lexicalist grammar , *Cognition* 75:105-143.

Segmental Analysis of Beijing Mandarin Rhymes in Feature Geometry

Kening Li

kening@u.washington.edu

In the phonological inventory of Beijing Mandarin, there are thirteen surface vowels that occur in thirty-four surface rhymes optionally with one of the three glides /j/, /w/ and /ɥ/, and one of the three consonantal sonorants /n/ /ŋ/ and /ɹ/. However the actual number of vowels that are phonemically contrastive is only five. The actual phonetic realizations of the five phonemic vowels in the rhymes can be well predicted from the surrounding segments. In this paper, the feature geometry model proposed by Clements and Hume (1995) is briefly reviewed and used to explain how the surface phonetic vowels can be derived from the underlying phonemic representations in each rhyme. The place features of the adjacent glides or consonants spread to the vowels, either adding a feature node to the vowel or replacing an original node of the vowel. Generally, regressive assimilation is more dominant than progressive assimilation when the vowel is flanked by two segments in the rhyme.

1. Introduction

1.1 Beijing Mandarin

Beijing Mandarin is a subdialect of Beijing Mandarin spoken in the area of Beijing, capital of the People's Republic of China. Its phonology is the basis of the phonology of the so-called "common speech" widely used in public media, school education and teaching of Chinese as a second language.

Generally speaking, in Beijing Mandarin, like in other Chinese dialects, one morpheme corresponds to one syllable. The syllable structure of Beijing Mandarin is relatively simple, and can be generalized as (C) V(C) where the V part may contain a main vowel with a glide (/j/, /ɥ/ or /w/) at either side or even both sides (e.g. /jaw/ and /waj/) and the coda consonant is restricted to /n/ /ŋ/ or /ɹ/. Each syllable bears one of the four lexical tones (tone I to tone IV) or a neutral tone which doesn't have a fixed

pitch value. The tradition of Chinese linguistics divides each syllable into 3 parts: initial, final and tone. “Initial” refers to the syllable onset consonant and “final” refers to the remainder of the syllable minus the tone. The final may be further broken down into medial, main vowel and ending. “Medial” refers to one of the three glides at the left side of the main vowel, and “ending” refers to anything that follows the main vowel, which can be a glide or a consonant (Norman, 1988). In this paper, however, I would like to adopt the more common terms used in the field of linguistics and call initials and rhymes initial consonants and rhymes respectively. “Medial” and “ending” in their particular references are not used here either. The following is the inventory of initial consonants and rhymes in Beijing Mandarin.

(1) Initial Consonants (phonemic representations)

| | Labial | Labio-dental | Dental | Alveolar | Retroflex | Palatal | Velar |
|-----------|--------------------|--------------|----------------------|----------|----------------------|---------|--------------------|
| Stop | p ^h , p | | t ^h , t | | | | k ^h , k |
| Fricative | | f | s | | ʂ | | x |
| Affricate | | | ts ^h , ts | | tʂ ^h , tʂ | | |
| Nasal | m | | n | | | | |
| Liquid | | | | l | ɭ | | |
| Glide | *ɥ | | | | | j | *w |

*w: This is a voiced labial-velar approximant

*ɥ: This is a voice labial-palatal approximant

(2) Rhymes (phonetic representations):

z/z̄ ɤ a ej aj ow aw ən an ɤŋ aŋ əɿ
 i jɛ ja jow jaw in jɛn iŋ jaŋ
 u wɔ wa wej waj wən wan uŋ waŋ
 y ɥɛ yn ɥɛn

Thirteen surface vowels appear in the rhymes above. But as I mention above, the vowels in the rhymes listed in (2) can be reduced to a relatively small number of phonemes. As to the exact number of the phonemes and what they are, different people have different opinions. Hartman (1944) suggests there are three phonemic vowels: /i/ /e/ and /a/. Hockett (1947) even reduces the three-vowel system to two: /e/ and /a/. More recently Xue (1986) proposes a three-vowel system /i/ /ə/ and /a/, Norman (1988) and Bedell (1984) propose a five-vowel system /i/, /y/, /u/, /a/ and /ɤ/, and Cheng (1973) proposes a six-vowel system /i/, /i/, /u/, /ü/, /a/ and /ɤ/. I agree with Norman and Bedell's five-vowel analysis and propose the five phonemic vowels as /i/ /u/ /y/ /a/ and /ɤ/. The first three are high vowels, /ɤ/ is a mid vowel and /a/ is a low vowel. The phonemic status of the five vowels can be illustrated by the following minimal set: /i/ 'profit, benefit', /y/ 'green' /u/ 'road' /ɤ/ 'happy' and /a/ 'pungent, hot' (Norman 1988). All the five syllables have the same tone. A minimal set of six words each containing one of the six vowels proposed by Cheng (1973) does not exist. (3) shows the five phonemic vowels in Beijing Mandarin.

(3) i y u
 ɤ
 a

Among the thirteen surface vowels, only /i/, /z/, /z̥/, /u/, /ü/, /a/ and /ɤ/ can occur in the simplest open syllables whose structure is CV without glides. /z/ and /z̥/ are treated as allophones of /i/, and they are in complementary distribution (Norman 1988). Now the rhymes in (2) are repeated in (4) with their underlying representations. (The corresponding phonetic representations are put in the parenthesis below for the purpose of comparison)

(4)

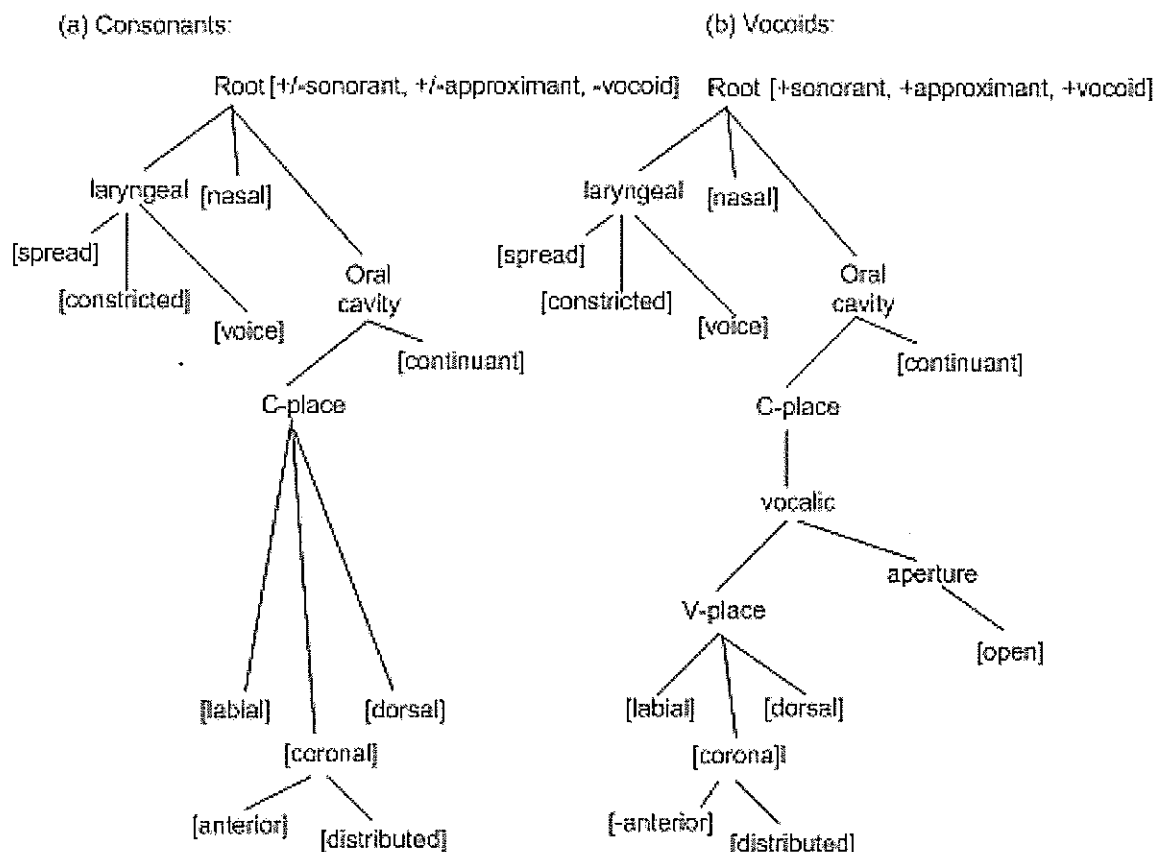
| | | | | | | | | | | | |
|--------|------|------|-------|-------|-------|-------|-------|-------|------|-------|------|
| i | ɿ | a | ɿj | aj | ɿw | aw | ɿn | an | ɿŋ | aŋ | ɿɿ |
| (z/z̥) | (ɿ) | (a) | (ej) | (aj) | (ow) | (aw) | (ən) | (an) | (ɿŋ) | (aŋ) | (əɿ) |
| i | jɿ | ja | | | jɿw | jaw | in | jan | iŋ | jaŋ | |
| (i) | (jɿ) | (ja) | | | (jow) | (jaw) | (in) | (jɿn) | (iŋ) | (jaŋ) | |
| u | wɿ | wa | wɿj | waj | | | wɿn | wan | uŋ | waŋ | |
| (u) | (wɿ) | (wa) | (wej) | (waj) | | | (wɿn) | (wan) | (uŋ) | (waŋ) | |
| y | ɥɿ | | | | | | | ɥan | | | |
| (y) | (ɥɿ) | | | | | | | (ɥɿn) | | | |

In the remainder of this paper, I will show how feature geometry theory can be used to derive all the thirteen surface vowels from the five underlying phonemes. The phonetic realization of the vowel is highly predictable from the environment, i.e. the surrounding glides and consonants in the syllable. In section 1.2, I would like to give a brief overview of the theory of feature geometry and introduce the model I will use in this paper.

1.2 *Theory of Feature Geometry*

Speech sounds can be described by a set of distinctive features. The theory of Feature Geometry is concerned with the internal organization of these features. It is widely accepted that distinctive features are not totally independent of each other and yet are not equally related to each other. Some features tend to group together in certain phonological rules, behaving as a single unit. These features are regarded as dependents under a single node. The problem the theory of Feature Geometry tries to solve is what these nodes are and how these nodes are organized. Various linguists have provided various approaches. The approach I take in this article is the model proposed by Clements and Hume (1995). I will also adopt some relevant conclusions in Clements' article in 1991 which didn't appear in the article of Clements and Hume (1995). The following figure demonstrates the Clements and Hume (1995)'s model:

(5)



In the following sections, I will use this model to show that (1) in the syllable containing the sequence of a retroflex or a palato-alveolar initial consonant and /i/, the oral cavity node of the consonant will spread to the root of the vowel, replacing its original oral cavity node; (2) in the complex rhyme (I will define it in the following section) where the main vowel is next to one or two segments, the dependent of the V-place node of the vocalic segment or its V-place node as a single unit, or the dependents of the C-place node of the consonantal segment will spread to the main vowel, either adding a new dependent node under its original V-place node or replacing its original V-place node completely; (3) some other processes are involved in the derivation of the underlying form to its surface form.

Before I go into the detailed analysis, I would like to provide the specifications of all the surface vowels in Mandarin. Each vowel can be distinguished by different combinations of the dependent nodes under V-place node, and furthermore, different degrees of openness under aperture node. Clements (1995) proposes a binary value of the

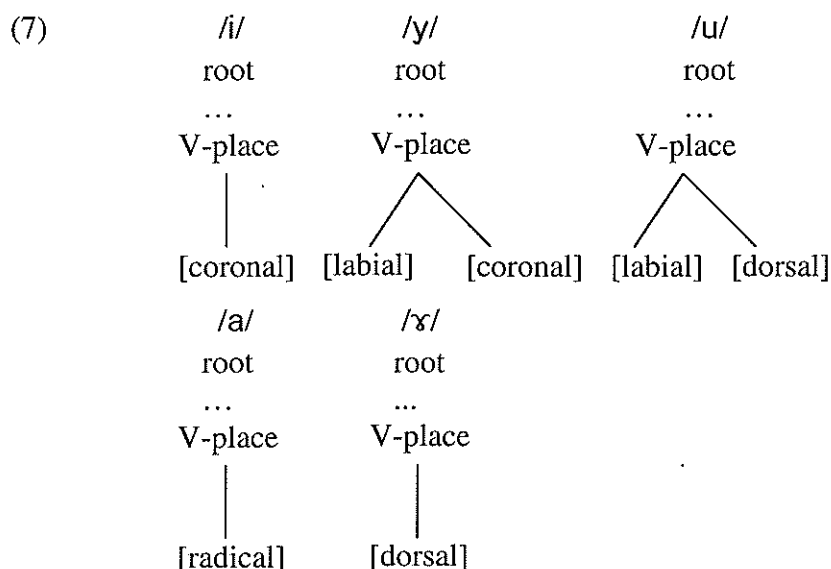
feature [open] which can occur in two height registers (2 tiers) to represent various degrees of vowel height. With this device, two vowels with the same place specifications can be distinguished by different aperture specifications. Below is the chart listing the specifications of all the surface vowels in Beijing Mandarin:

(6)

| | i | u | y | ɑ | ɤ | e | ɛ | a | o | ɔ | ə | ʐ | ʑ |
|---------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Labial | - | + | + | - | - | - | - | - | + | + | | - | - |
| Coronal | + | - | + | - | - | + | + | - | - | - | | + | + |
| Dorsal | - | + | - | + | + | - | - | - | + | + | | - | - |
| radical | - | - | - | + | - | - | - | + | - | - | | - | - |
| Higher tier open | - | - | - | + | - | - | + | + | - | + | | - | - |
| Lower tier open | - | - | - | + | + | + | - | + | + | - | | - | - |

The place specifications of the vowels follow Clements' proposal in 1991 except [ɤ], [ə], [ʐ] and [ʑ]. Since [ɤ] is a back unrounded vowel, I specify it as [dorsal]. [ə] is a mid central vowel in neutral position. Clements (1991) believes that "central unrounded vowels such as [ɨ] and [ə] have no place features..., ...they are maximally unmarked..."

It seems plausible to assume that it is underspecified. [ʐ] and [ʑ] are two syllabic vowels and both are high. Although in the chart above they have the same specifications, they are distinguished by different dependent nodes under the node [coronal]. What exactly these dependent nodes are is not important to current purpose, though. Both [ɑ] and [a] have a place feature [radical]. This also follows Clements' proposal (1991) although there is no [radical] node in the above model. I assume that it is also attached under the V-place node. The five phonemic vowels with their place specifications are represented as follows in terms of the feature geometry model in (5):



The feature specifications of the three glides */j/*, */ɥ/* or */w/* are conveniently assumed to be the same as the three high vowels */i/*, */y/* and */u/* respectively. As for the three consonants, */n/* and */ɲ/* are specified as [coronal] under their C-place node since they are alveolar sounds, and */ŋ/* is given a [dorsal] node under its C-place node since it is a velar sound (Hall, 1997). */n/* and */ɲ/* can be distinguished by nodes other than C-place.

2 Data Analysis: Vowels in the Rhymes of Beijing Mandarin

2.1 Simple Rhymes

Here by simple rhymes I mean rhymes only containing a vowel. As mentioned above, there are only seven surface vowels that can form this kind of rhyme. They are the five phonemic vowels plus [ʐ] and [ʑ]. Since the five phonemic vowels are realized as themselves in the surface forms, there are no derivations involved. [ʐ], [ʑ] and [i] are three allophones of */i/*, with [ʐ] only occurring with dental sibilants */s/*, */ts^h/* and */ts/*, [ʑ] only with retroflex sibilants */ʂ/*, */tʂ^h/* and */tʂ/*, and [i] elsewhere. It seems that */i/* is the only one among the five phonemic vowels that undergoes the assimilation to sibilants. Assuming the underlying vowel is */i/*, I propose that the oral cavity node of the initial

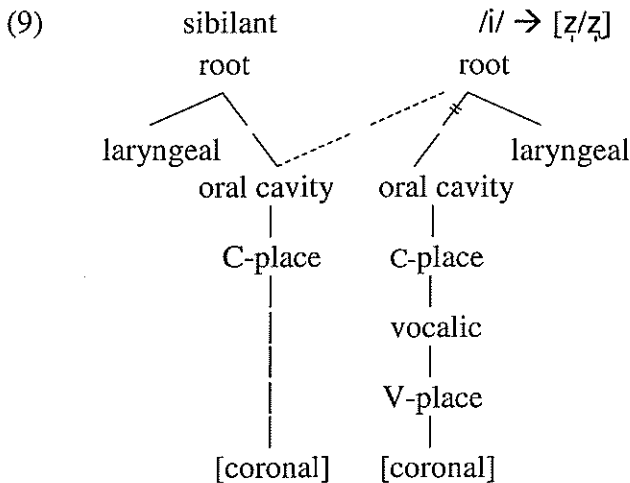
sibilant spreads to the root of the following /i/, replacing its original oral cavity node.

This assimilation process is formulated as the following rule:

(8) Sibilant Assimilation Rule:

When /i/ follows a sibilant consonant, the oral cavity node of the sibilant will spread to the root of /i/ and delink the original oral cavity node of it.

This rule is represented in term of feature geometry as follows:



Both the two series of sibilants and [i] are specified [coronal] under V-place node, thus the OCP is violated. The problem of OCP violation can be solved by proposing that the oral cavity node attached to [i] is replaced by the oral cavity node of the sibilant, as illustrated above. It is not hard to understand why /i/ is the only vowel of the five that undergoes this process. /u/ /a/ and /ɤ/ are not specified as [coronal], so nothing needs to be done to avoid the OCP violation. Although /y/ is another vowel which is specified as [coronal], its co-occurrence with sibilants doesn't exist in Beijing Mandarin. After the rule in (8) is applied, /i/ loses its original oral cavity features but keeps its laryngeal feature intact, thus still voiced.

2.2 Complex Rhymes

As opposed to simple rhymes, complex rhymes mean rhymes containing a main vowel plus one or two other segments, either a glide or a consonant. I would like to organize these rhymes into various groups by their components. These groups are: VC, VG, GV, GVG and GVC (V refers to the main vowel, C refers to the final consonantal ending and G the glide).

2.2.1 Rhymes of VC sequence

The following chart lists the possible rhymes of VC sequence. (Phonetic representations are given in the parentheses next to the underlying representations. “-” indicates such combination is not available. The same notation will be used in the following sections.)

(10)

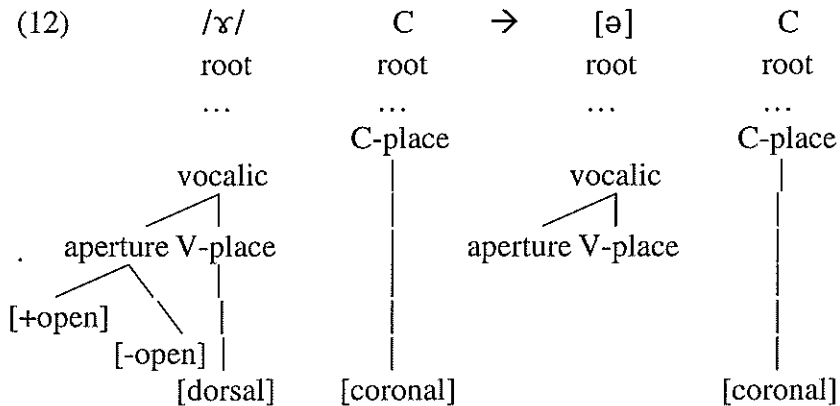
| | n | ŋ | ɹ |
|---|---------|---------|---------|
| i | in (in) | iŋ (iŋ) | - |
| u | - | uŋ (uŋ) | - |
| y | yn (yn) | - | - |
| ɻ | ɻn (əɻ) | ɻŋ (ɻŋ) | ɻɹ (əɹ) |
| a | an (an) | aŋ (aŋ) | - |

In this group, there are nine existing rhymes. Apparently only three of them undergo assimilation, which are /ɻn/ ([əɻ]), /ɻɹ/ ([əɹ]) and /aŋ/ ([aŋ]). When /ɻ/ is followed by coronal nasal /n/ or coronal liquid /ɹ/, it loses all its specified features under aperture node and V-place node, realized as the underspecified [ə]. I name this rule as *Reduction Rule*.

(11) χ -Reduction Rule

When / χ / is followed by a [coronal] consonant it will lose all the dependent nodes of its aperture node and V-place node.

This rule is represented in term of feature geometry as follows:



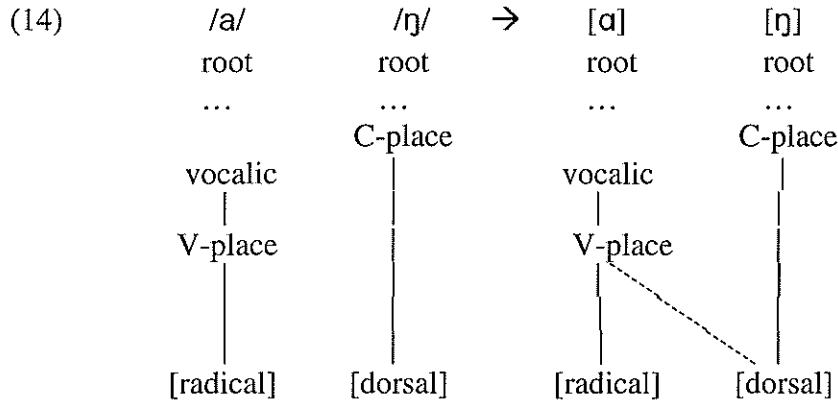
/ χ / is a [dorsal] vowel so the tongue position is relatively back. In anticipating a front sound, the tongue moves forward in advance, ending up in the position of [ə]. Although there is no feature spreading, the rule in essence can be considered to be an assimilation rule. We will see later that the rule in (11) needs to be modified.

Another rule is needed to derive the surface form [ɑŋ] from /aŋ/. Obviously the choice between [ɑ] and [a] is conditioned by the following nasal. The underlying low vowel is realized as the back [ɑ] when followed by the back nasal [ŋ], and as front [a] when followed by the front nasal [n]. The first process can be stated as rule (13) below:

(13) Dorsal Spreading Rule

When the vowel /a/ is followed by the velar nasal /ŋ/, the [dorsal] node of the velar nasal will spread to the V-place node of the vowel.

This rule is represented in term of feature geometry as follows:



Apparently no assimilation rule is needed to the form /an/, but I would like to regard it as the result of an assimilation too. There is perhaps a language specific restriction on the existence of the low front vowel [æ] (specified as [radical] and [coronal] by Clements (1991)) in Beijing Mandarin, which prevents /n/ spreading its [coronal] feature to the preceding low vowel. Therefore the low vowel cannot go forward beyond the mid vowel /a/.

2.2.2 Rhymes of VG sequence

The following chart lists the possible rhymes of VG sequence.

(15)

| | j | ɥ | w |
|---|--------|---|--------|
| i | - | - | - |
| u | - | - | - |
| y | - | - | - |
| ɤ | ɤj(ej) | - | ɤw(ow) |
| a | aj(aj) | - | aw(aw) |

In this group, there are only four possible combinations. All of them undergo some change from the underlying form to the surface form except /aj/. As in the case of

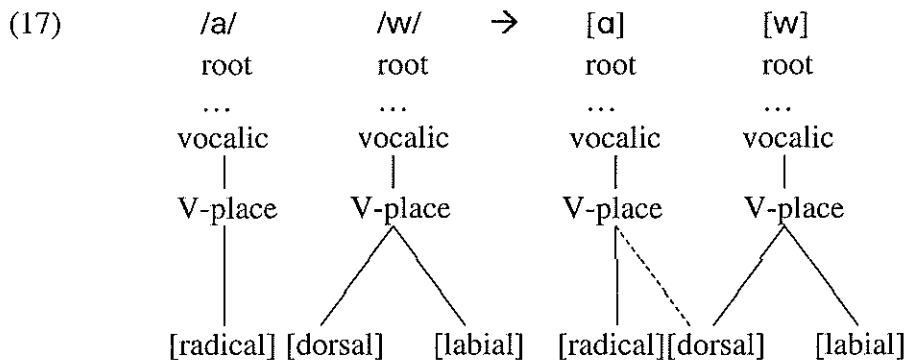
/an/, I also assume /j/ has some assimilating effect on /a/, but fails to realize it as [æ] due to a language specific restriction.

The surface form [aw] is easy to account for. Rule (13) is applied to the underlying form /aw/ with a little modification. The modified Dorsal Spreading Rule is as follows:

(16) Dorsal Spreading Rule:

When the vowel /a/ is followed by a segment specified with [dorsal], the [dorsal] node of that segment will spread to the V-place node of /a/.

Thus, the derivation of /aw/ is represented as below:



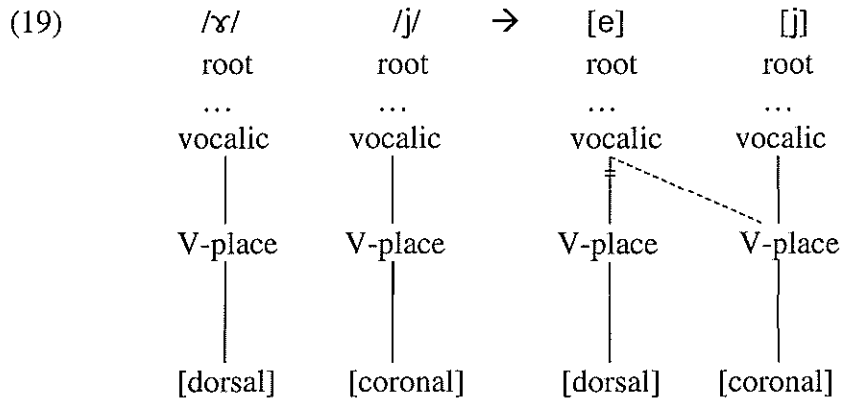
This rule will be expanded further later.

The derivation of /ɤj/ is a different situation. Not only a new place feature is added to the vowel but also this new feature replaces its original place feature. A rule is formulated as follows:

(18) V-place Spreading Rule:

The V-place node of /j/ will replace the V-place node of /ɤ/ when they are adjacent.

This rule is represented in terms of feature geometry as follows:

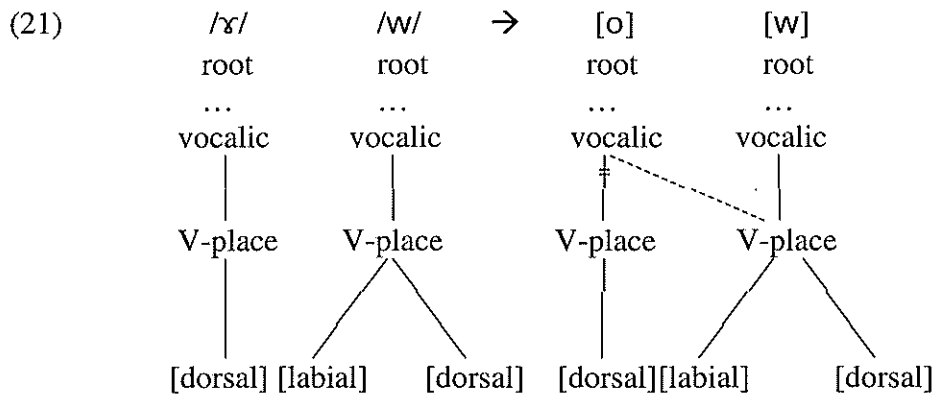


Rule (18) is expanded to (20) to account for the derivation of $/\varepsilon w/$.

(20) V-place Spreading Rule:

When the glide $/j/$ or $/w/$ is adjacent to $/\varepsilon/$, the V-place node of the former will replace the V-place node of the latter.

The derivation of $/\varepsilon w/$ can be shown in (21):



The reason why $/w/$ spreads both [dorsal] and [labial] features to $/\varepsilon/$, but only [dorsal] feature to $/a/$ is probably due to the rareness of low rounded vowels cross linguistically.

2.2.3 Rhymes of GV sequence

The following chart lists the possible rhymes of GV sequence.

(22)

| | i | u | y | ɤ | a |
|---|---|---|---|--------|--------|
| j | - | - | - | jɤ(jɛ) | ja(ja) |
| ɥ | - | - | - | ɥɤ(ɥɛ) | - |
| w | - | - | - | wɤ(wɔ) | wa(wa) |

Among the five possible combinations here, four undergo assimilation. To derive the surface form [wɑ], I need to expand the Dorsal Spreading Rule in (16) a little more.

The expanded Dorsal Spreading Rule is represented in (23) below:

(23) Dorsal Spreading Rule:

When /a/ is adjacent to a segment specified with [dorsal], the [dorsal] node of that segment will spread to the V-place node of /a/.

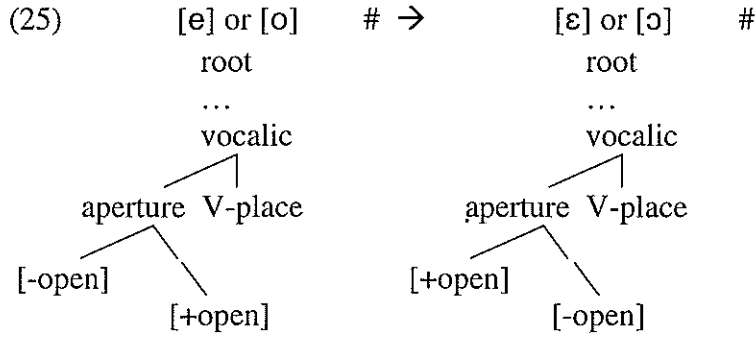
With rule (23), all the surface sequences of the vowel [ɑ] and the glide /w/ or the nasal /ŋ/ can be derived.

The derivation process of /jɤ/ to [jɛ] and /wɤ/ to [wɔ] involves two steps. First, V-place Spreading Rule in (20) is applied and the V-place node of the vowel is replaced by that of the glide; the intermediate form [jɛ] and [wɔ] will be derived. Next, there needs to be a lowering rule, which changes the syllable final [ɛ] and [ɔ] into [ɛ̃] and [ɔ̃] respectively. This rule is formulated as follows:

(24) Mid Vowel Lowering Rule

When [ɛ] or [ɔ] is in the syllable-final position, it is lowered to [ɛ̃] or [ɔ̃] respectively.

This rule is represented in terms of feature geometry as follows:

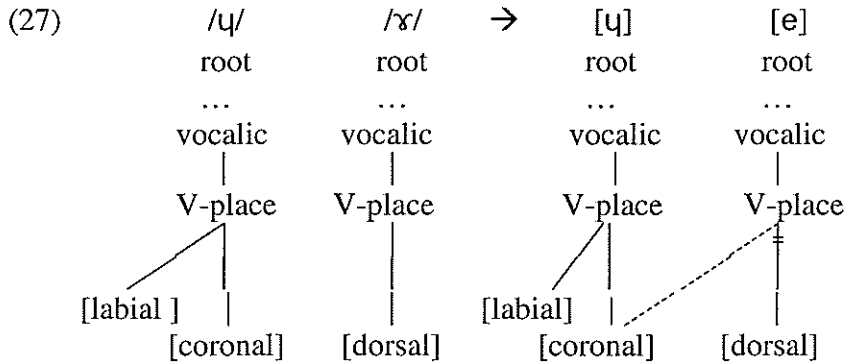


For the derivation of the surface rhyme [ɥɛ], we need to take into consideration the peculiarities of the glide /ɥ/. Among the three glides, /ɥ/ has the lowest frequency with respect to composing syllables. Unlike the other two glides /j/ and /w/, which spread the whole V-place node to the adjacent /ʁ/, /ɥ/ only spreads one of its dependent nodes [coronal] to /ʁ/ and delinks the [dorsal] node of /ʁ/ at the mean time. Probably there is a restriction on the existence of front mid rounded vowels in Beijing Mandarin. I formulate a separate rule to describe this process:

(26) Coronal Spreading Rule

When /ɥ/ is followed by the vowel /ʁ/, one of its place feature nodes [coronal] will replace the [dorsal] node attached under the V-place node of /ʁ/.

This rule is represented in term of feature geometry as follows:



But [ɥɛ] is only an intermediate outcome; [ɛ] needs to be lowered to [ɛ̃]. The Mid Vowel Lowering Rule, will be in turn applied to [ɥɛ̃], giving the final outcome [ɥɛ̃].

2.2.4 Rhymes of GVG Sequence

The following chart lists the possible rhymes of GVG sequence.

(28)

| | i | u | y | ɤ | a | i | u | y | ɤ | a | i | u | y | ɤ | a | |
|---|---|---|---|-------|-------|---|---|---|---|---|---|---|---|-------|-------|-----|
| | j | | | | | ɥ | | | | | w | | | | | |
| j | - | - | - | - | - | - | - | - | - | - | - | - | - | - | jɤw | jaw |
| | | | | | | | | | | | | | | (jow) | (jaw) | |
| ɥ | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| w | - | - | - | wɤj | waj | - | - | - | - | - | - | - | - | - | - | - |
| | | | | (wej) | (waj) | | | | | | | | | | | |

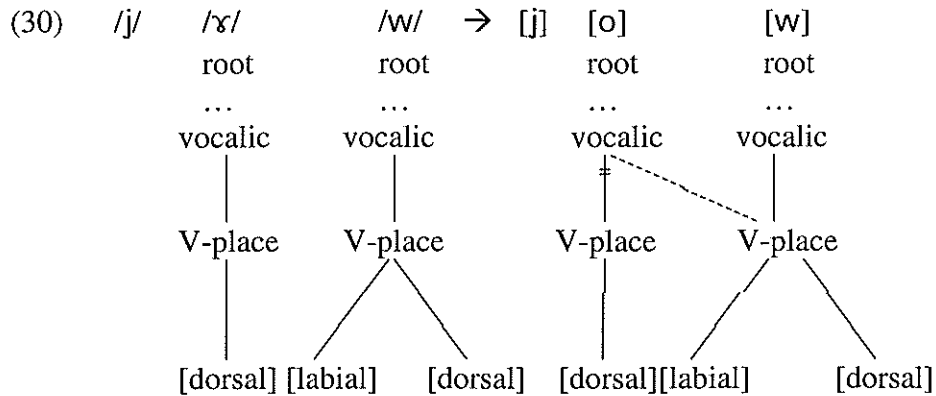
Among the four possible surface forms, three are different from their corresponding underlying forms. Only /waj/ surfaces as [waj] with no change. The preceding [dorsal] glide doesn't trigger the Dorsal Spreading Rule here. As will be verified by other examples, in Beijing Mandarin, regressive assimilation is more dominant than progressive assimilation. When both regressive assimilation and progressive assimilation are possible, the former wins out. In /waj/, /j/ imposes stronger influence than /w/. Therefore, it is realized as [waj] instead of [wɥj]. I would like to formulate a general principle on assimilation and assume all the rules formulated must comply with it:

(29) Principle of Assimilation:

When both regressive assimilation and progressive assimilation are possible, the regressive assimilation prevails over progressive assimilation.

For /jaw/, the Dorsal Spreading Rule in (23) is applied to it, and /a/ is realized as [ɑ]. Again the preceding [coronal] glide cannot prevent this, which follows the principle in (29). The explanation of the fact that /wɤj/ is realized as [wej] and /jɤw/ as [jow] is

simple. Only one rule will suffice, namely the V-place Spreading Rule. The V-place node of the glide will spread to the Vocalic node of the vowel /ɤ/, delinking its original V-place node at the mean time. Again, the preceding glide doesn't impose any effect in this process. To illustrate this, I show the derivation of /jɤw/ as an example below:



2.2.5 Rhymes of GVC Sequence

The following chart lists the possible rhymes of GVC sequence.

(31)

| | i | u | y | ɤ | a | i | u | y | ɤ | a | i | u | y | ɤ | a |
|---|---|---|---|--------------|--------------|---|---|---|---|--------------|---|---|---|---|---|
| | n | | | | | ŋ | | | | | ɹ | | | | |
| j | - | - | - | - | jan (jɛn) | - | - | - | - | jaŋ (jaŋ) | - | - | - | - | - |
| ɥ | - | - | - | - | ɥan (ɥɛn) | - | - | - | - | - | - | - | - | - | - |
| w | - | - | - | wɤn (wɛn) | wan (wan) | - | - | - | - | waŋ (waŋ) | - | - | - | - | - |

There are six rhymes altogether with the structure GVC, two of which ending with /ŋ/, four ending with /n/ and none with /ɹ/. /ɹ/ is a very special phoneme in Beijing Mandarin and the only place it occurs as a syllable ending is after /ʁ/ realized as [ə].

/wan/ is realized as [wan]; no rule is needed and /w/ doesn't have any effect. For the two rhymes /jan/ and /wan/, the Dorsal Spreading Rule applies to them and the front /a/ is realized as the back [ɑ]. Now only three rhymes ending with /n/ are left to be accounted for.

An existing rule can be used to explain the derivation of [wən] from /wɹn/, namely the ɹ-Reduction Rule. The derivation is exactly the same as that of /ɹn/ realized as [ən] discussed above. The Principle of Assimilation prevents the preceding glide /w/ imposing any effect on the derivation.

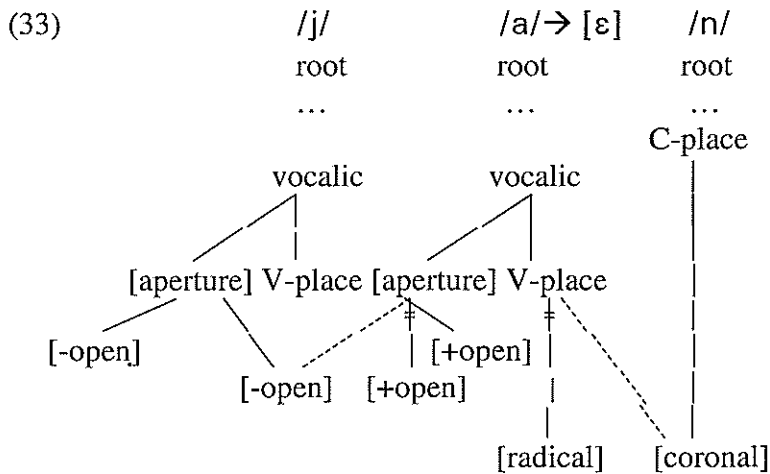
The two rhymes /jan/ and /ɹan/ can be grouped together. The underlying vowel in them is given as /a/. The reason why I propose /a/ instead of /ɹ/ as the underlying phoneme is that first, historically these two rhymes came from the earlier forms with [a] as the main vowel; secondly for quite a few native speakers of Beijing Mandarin the pronunciations of these two rhymes are still preserved as [jan] and [ɹan] respectively. In my dialect, for example, I pronounce the first one as [jən] but the second one as [ɹan]. In general, [a] and [ɛ] can be regarded as in free variation in these two rhymes. Other scholars (Hartman 1944, Hockett 1947 and Cheng 1973) also propose that the underlying vowel is /a/ in the two rhymes. Here /a/ is flanked between a [coronal] nasal and a [coronal] glide. As seen from above, with only one coronal segment next to it doesn't change it. A plausible explanation for why /a/ is fronted and also raised to [ɛ] seems to have something to do with the fact that here /a/ is surrounded by two [coronal] sounds (and one of them is a high glide), which doesn't happen in any other rhymes, so there might be a strong fronting effect and also raising effect which moves /a/ to the position

of a front mid vowel. A new rule is needed to generalize it. I'll call this rule Low Vowel Raising Rule.

(32) Low Vowel Raising Rule

When /a/ is between a [coronal] glide and a [coronal] nasal, it will be realized as [ɛ].

This rule is represented in terms of feature geometry as follows:



Note that here I propose that the place node [coronal] of the nasal spreads to the V-place node of the vowel, delinking the [radical] node of /a/, and at the same time the [-open] node on the second tier under the [aperture] node of the glide spreads to the [aperture] node of the vowel, delinking its original [+open] node at that tier automatically. But these two processes cannot proceed independently.

2.2.6 Further Discussion

In section 2.2.1 to 2.2.5, I discussed all the complex rhymes in Beijing Mandarin. Seven rules altogether are proposed to derive the surface forms from the underlying representations. To draw a conclusion, assimilation is responsible for the realizations of the rhymes. Generally speaking, the main vowel assimilates to the adjacent glide or consonant by taking from them the place feature which is not specified for itself. In terms of feature geometry, this is represented by spreading the place node of the glide or the consonant to the main vowel. Since the three place features [labial] [coronal] and [dorsal]

(with various combinations) are the main features that specify the three glides and the consonants, they are naturally the features that are spreading. From the charts above, two prominent characteristics about the combinations of the three parts that compose a rhyme can be observed. First, the majority of the potentially possible combinations that don't actually exist involve the co-occurrence of the glides and the three high vowels. Second, in the possible rhymes, those containing /i/, /u/ and /y/ are most stable, not susceptible to assimilation rules while those containing /ɤ/ and /a/ tend to undergo the assimilation easily. It's not hard to understand the first characteristics. Since the three high vowels and the three glides have exactly the same representations in terms of this model of feature geometry, OCP would be the main constraint that blocks their co-occurrence. There are also some language peculiar constraints in effect. For example, no existence of the combination of /j/ and /u/ is something peculiar to Beijing Mandarin instead of something universal. The second characteristics can be explained by the general observation that the vowel only takes the feature it doesn't have itself. Since the three high vowels /i/, /y/ and /u/ are always equipped with the feature that are spreading, they are not as likely to undergo the assimilation as the other two non-low vowels /ɤ/ and /a/, which are equipped with [dorsal] and [radical] respectively. When /ɤ/ is adjacent to /w/, it will take the [labial] feature from /w/ because it doesn't have it itself. When /a/ is followed by /ŋ/ it will take its [dorsal] feature because it is not specified as [dorsal] itself. Similarly, the form /in/, /yn/, /uŋ/ and /ɤŋ/ don't undergo assimilation because the vowel in them is specified with the feature that is ready to be spread by the following nasal. Obviously, this generalization cannot cover all the data listed above like the rhyme [iŋ], [ɥɛ] and [ɑw] where the vowel, not as expected, doesn't take all the place features from the adjacent segment that it doesn't have itself. This indicates that the general principle that the vowel will take the features it doesn't have from the adjacent segment is subject to other language universal or language specific constraints.

3 Conclusion

This article tries to give an explanation to the realizations for the vowels in all the rhymes of Beijing Chinese in terms of feature geometry theory. I assumed in this paper that in Beijing Mandarin there are only five phonemic vowels. The analysis above has shown that all the surface vowels in the rhymes are derived from the place assimilation, and height assimilation sometimes, of the underlying vowels to their neighboring segments. Both regressive assimilation and progressive assimilation can proceed independently, but regressive assimilation prevails over progressive assimilation when they compete within one rhyme. The proposals for C-place node, oral cavity node, V-place node, aperture node and their organizations in Clements and Hume's model of feature geometry have been shown to be able to capture the segmental phonology of Beijing Mandarin very well. Seven rules and one principle are generalized. To conclude this paper, I would like to summarize all the rules and principle in (34)-(41) below:

(34) Sibilant Assimilation Rule

When /i/ follows a sibilant consonant, the oral cavity node of the sibilant will spread to the root of /i/ and delink the original oral cavity node of it.

(35) \varkappa -Reduction Rule

When / \varkappa / is followed by a [coronal] consonant it will lose all the dependent nodes of its aperture node and V-place node.

(36) Dorsal Spreading Rule

When /a/ is adjacent to a segment specified with [dorsal], the [dorsal] node of that segment will spread to the V-place node of /a/.

(37) V-place Spreading Rule

When the glide /j/ or /w/ is adjacent to / \varkappa /, the V-place node of the former will replace the V-place node of the latter.

(38) Mid Vowel Lowering Rule

When [e] or [o] is in the syllable-final position, it is lowered to [ɛ] or [ɔ] respectively.

(39) Coronal Spreading Rule

When /ɥ/ is followed by the vowel /ɤ/, one of its place feature nodes [coronal] will replace the [dorsal] node attached under the V-place node of /ɤ/.

(40) Low Vowel Raising Rule

When /a/ is between a [coronal] glide and a [coronal] nasal, it will be realized as [ɛ].

The application of all these rules must comply with the following principle:

(41) Principle of Assimilation:

When both regressive assimilation and progressive assimilation are possible, the regressive assimilation prevails over progressive assimilation.

References:

- Bedell, George 1984, *Chinese*, Ms., UCLA.
- Cheng, Chin-Chuan 1973, *A Synchronic Phonology of Beijing Mandarin*, Monographs on Linguistics Analysis 4, Mouton the Hague Paris.
- Clements, G. N. 1991, *Place of Articulation in Consonants and Vowels: A Unified Theory*, unpublished ms. Cornell.
- Clements, G. N. & Hume, Elizabeth 1995, *The Internal Organization Of Speech Sounds*, in the *Handbook Of Phonological Theory*, edited by John Goldsmith, Oxford Blackwell.
- Hall, Alan T. 1997, *The Phonology of Coronals*, John Benjamins Publishing Company Amsterdam/Philadelphia
- Hartman, Lawton M III 1944, *The Segmental Phonemes of the Peiping Dialect*, *Language* 20:28-42.
- Hockett, Charles F. 1947, *Peiping Phonology*, *Journal of the American Oriental Society* 67: 253-267
- Norman, Jerry 1988, *Chinese*, Cambridge University Press
- Xue, Fengsheng 1986, *Analysis of Beijing Phonological System*, Beijing Language Institute Press

Table of Contents

| | |
|--|-----|
| Initial clusters and minimality in Yakima Sahaptin..... (Sharon Hargus and Virginia Beavert) | 1 |
| Quality sensitive stress reconsidered..... (Sharon Hargus) | 25 |
| Glides in Korean syllables..... (Yungdo Yun) | 57 |
| German particle complement verbs in modern morphological syntactic theory: contering the “separable-prefix” misnomer..... (John H. G. Scott) | 99 |
| Why Early Immediat Constituents? The role of memory and locality... (Gabriel Webster) | 118 |
| Segmental analysis of Beijing Mandarin rhymes in Feature Geometry.. (Kening Li) | 159 |