CHAPTER 4

AUGMENTATION OF PSYCHOLINGUISTICALLY STRONG POSITIONS

4.1 Introduction

The strong positions discussed in Chapter 3 have a special phonological status because of their phonetic salience. As demonstrated most thoroughly by Beckman (1998; see also Beckman 1997; Casali 1996, 1997), there are also positions that have the status of phonologically strong positions, and the concomitant ability to resist positional neutralization, because of their *psycholinguistic* salience — namely, the root and the morphological word (MWd)-initial syllable.[1]

The theory developed in Chapter 2 predicts that these psycholinguistically strong positions (abbreviated *Ψstr*), being strong positions, should be eligible for positional augmentation constraints, and **M/str** constraints for these positions are in fact attested (examples are discussed in §4.2). The theory also predicts that, because only psycholinguistically strong positions are subject to the Segmental Contrast Condition (§2.4), there should be fewer **M/Ψstr** than **M/Φstr** constraints attested (where *Φstr* are phonetically strong positions such as stressed syllable, long vowel, and onset/released consonant). Specifically, psycholinguistically strong positions are particularly important in the initial stages of word recognition, so there is substantive pressure against the neutralization of contrasts in those positions — even neutralization of the prominence-enhancing kind — because it would be inefficient for word recognition if too many contrasts were neutralized in these important positions. This substantive pressure is formalized as the Segmental Contrast Condition, a filter that rules out **M/Ψstr** constraints if their satisfaction would have the effect of neutralizing contrasts of the kind that are relevant for early-stage word recognition.

Indeed, empirically, the psycholinguistically strong positions do not exhibit the same wide range of augmentation effects that the phonetically strong positions show. For example, although there is a [*PEAK/X]/σ́ constraint subhierarchy (§3.2.1.3), there is no evidence of an analogous [*PEAK/X]/σ_1 subhierarchy. The *PEAK/X constraint subhierarchy qualifies as prominence-enhancing (§2.3.2.2), and it can obviously be relativized to a syllable-sized domain given [*PEAK/X]/σ́, so the existence of a [*PEAK/X]/σ_1 subhierarchy would be compatible with **M/str** constraint construction and the Prominence Condition. Nevertheless, [*PEAK/X]/σ_1 is not attested. Other examples of **M/Ψstr** constraints that satisfy the Prominence Condition but are not empirically attested include HEAVYσ/σ́ and HAVECPLACE/Root; see chart (47) in §2.3.3 for a general comparison of attested **M/Ψstr** and **M/Φstr** constraints.

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[1]Beckman (1997, 1998) proposes that the relevant "initial" syllable for positional faithfulness constraints is the root-initial syllable. See §4.4 for discussion.

The Segmental Contrast Condition correctly predicts that empirically attested **M/Ψstr** constraints like HAVESTRESS/Root (§4.2.2) are legitimate constraints, because stress (even when lexically contrastive) does not play the same role in early-stage word recognition that segmental contrasts play, and so augmenting even a psycholinguistically strong position with this property does not hamper the recognition of words. But something like the *PEAK/X subhierarchy is relevant for segmental features rather than prosodic properties. Requiring initial syllables to have highly sonorant nuclei (as by a positional [*PEAK/X]/σ_1 subhierarchy) would reduce the number of segmental contrasts that are available in initial syllables, so this is the kind of constraint that the Segmental Contrast Condition rejects.

Finally, there is one case in which an **M/Ψstr** constraint is able to pass the Segmental Contrast Condition despite reference to a contrast that is relevant for early-stage word recognition: when satisfaction of the constraint would affect the left edge of the initial syllable. This aspect of the Segmental Contrast Condition also reflects substantive considerations, because the satisfaction of such constraints aids in demarcating the beginnings of words, and the segmentation (i.e., separation) of words in the speech stream is an important and difficult part of speech perception (see §4.3.4). **M/Ψstr** constraints that pass the Segmental Contrast Condition on these grounds include ONSET/σ_1 (§4.2.1.1) and the [*ONSET/X]/σ_1 subhierarchy (§4.2.1.2).

The proposal summarized above has been presented in Chapter 2. The goal of the current chapter is to support this proposal, and explore some of its implications, by discussing in more depth various matters relating to the Segmental Contrast Condition and the augmentation of psycholinguistically strong positions. §4.2 presents case studies of languages in which **M/Ψstr** constraints are active; some of these case studies also have implications for subsyllabic structure and for details of the formulation of *ONSET/X constraints. §4.3 reviews evidence from psycholinguistic studies in support of the claims made in Chapter 2 about the substantive basis for the Segmental Contrast Condition: that the positions initial syllable and root have a particularly important status in lexical organization and early-stage word recognition; that the stressed syllable does not have the same status (although it is important for other aspects of speech perception); and that information about prosodic properties such as stress and perhaps also tone is not used to constrain early-stage word recognition in the same way that segmental features are used. §4.4 examines the claim that "initial syllable" is best understood as "morphological-word-initial syllable," considering alternatives (particularly "root-initial syllable" (Beckman 1998) and "prosodic-word-initial syllable") and showing that the choice of MWd-initial syllable is the most consistent, theoretically and empirically, with the general pattern of attested initial-syllable augmentation effects. Conclusions are presented in §4.5.

4.2 Exemplification of M/Ψstr constraints

This section demonstrates that augmentation constraints relativized to psycholinguistically strong positions play a crucial role in phonological patterning. Languages exemplifying initial-syllable augmentation constraints and root augmentation constraints are discussed in §4.2.1 and §4.2.2 respectively. §4.2.3 then examines the typology of attested

M/Ψstr constraints and shows how the Segmental Contrast Condition (discussed more thoroughly in §4.3) restricts augmentation constraints for psycholinguistically strong positions.

4.2.1 Positional augmentation in initial syllables

The initial syllable (σ_1) is identified by Beckman (1995, 1997, 1998) as a strong position. Phonologically, there is good evidence that the initial syllable has special status, since there are many languages in which it resists processes of positional neutralization (see, e.g., Trubetzkoy 1939; Steriade 1993; Beckman 1995, 1997, 1998; Casali 1996, 1997). The external justification that Beckman (1997, 1998) gives for the special status of the initial syllable is its importance in speech perception and language processing. (The discussion in §4.3 below argues that it is specifically an importance in *early-stage* word recognition that is crucial).

Since it is a strong position, the initial syllable is predicted to undergo positional augmentation in addition to resisting positional neutralization. This section presents examples of augmentation constraints that are relativized to this position: ONSET/σ_1 (§4.2.1.1) and the [*ONSET/X]/σ_1 constraint subhierarchy (§4.2.1.2, where some theoretical implications for syllable structure are also discussed).

Beckman (1997, 1998) proposes that what "initial syllable" means is *root*-initial syllable, a choice that is consistent with the phonological patterns that she examines. The initial-syllable augmentation effects discussed here, on the other hand, are most compatible with the designation of "morphological word (MWd)-initial syllable" as the relevant strong position. Explicit discussion of this choice, and of the broader implications of various possible definitions of "initial syllable", is postponed until §4.4 below, since the purpose of the current section is to present natural-language examples of augmentation phenomena in initial syllables.

4.2.1.1 Obligatory onsets in initial syllables: ONSET/σ_1

In some languages, the requirement that syllables must have onsets holds more strictly of initial syllables than of other syllables; onsetless syllables are tolerated medially, but not initially. The special demand for initial onsets is accounted for with an initial-syllable-specific version of the general augmentation constraint ONSET (the particular formulation of ONSET given here was introduced in §2.3.2.3.2; the positional restrictor *if-then* clauses that correspond to each strong position were introduced in §2.3.3).

(1) ONSET/σ_1 — For all syllables *x*, if *x* is the leftmost syllable whose head is affiliated with MWd *m*, then $a \neq b$

where *a* is the leftmost segment dominated by syllable *x*
b is the head of syllable *x*

Since the constraint ONSET/σ_1 is relativized to the strong position initial syllable, no violations are incurred by a medial syllable that lacks an onset. Languages that tolerate medial hiatus but not initial vowels have the ranking in (2).

(2) ONSET/σ_1 >> FAITH >> ONSET

General ONSET is ranked low, which allows vowel-initial syllables generally, but specific ONSET/σ_1 is ranked high, ensuring that all initial syllables do have onsets.

This section discusses two languages that have a specific onset requirement for initial syllables, Arapaho (Salzmann 1956) and Guhang Ifugao (Newell 1956, Landman 1999). Other languages that require onsets in initial syllables, but not in all syllables, include Hausa (Greenberg 1941), Guaraní (Gregores & Suarez 1967), and Tabukang Sangir (Maryott 1961).

According to Salzmann (1956), the Northern Arapaho dialect of Arapaho (Algonquian) is an example of a language that tolerates onsetless syllables medially, but not word-initially. Examples of medial syllables without onsets are given in (3).

(3) Medial onsetless syllables (Salzmann 1956:53-4)[2]

čé.či.no.húː.o	'chicken hawk (obviative)'
noh.ʔó.eː.sei.hí.hiʔ	'firefly'
wo.ʔó.uː.soː	'kitten'

However, in initial position, onsetless syllables are not tolerated: vowels "are found only medially and finally, thus contrasting with consonants which are found also initially" (Salzmann 1956:51). All words start with one of the consonantal phonemes /b,t,k,č,θ,s,x,h,n,w,y/.[3]

[2]Medial hiatus is not tolerated when the adjacent vowels are identical (this is presumably an OCP effect). For example, Salzmann (1956:53) states that in a sequence of like vowels VV́, a tonal pattern in which the vowels are heterosyllabic, "the two vowels are peaks of two separate syllables marked with a y-like or h-like transition in the case of i, and an h-like transition in the case of the other three vowels [[e,u,o] — JLS]."

[3]/ʔ/ is also a phoneme of the language, but Salzmann (1956:50) notes that word-initial /ʔ/ occurs in his corpus only in two interjections.

(4) No vowel-initial words (Salzmann 1956:51, 53)

bétee	'(human) heart'
kétee	'is it your heart?'
čis	'nighthawk'
seeníwuú	'lizards'
xooó	'skunk'
héθ	'dog'
nówoʔ	'fish'
wótoʔ	'(human) nape'

*otoʔ
*owotoʔ

Because word-internal syllables can be vowel-initial (3), the constraint ONSET is dominated by faithfulness constraints such as MAX-SEG (which penalizes deletion) and DEP-SEG (which penalizes epenthesis) (5).

(5) Segmental correspondence (faithfulness) constraints
(after McCarthy & Prince 1995)

MAX-SEG Every input segment has an output correspondent

DEP-SEG Every output segment has an input correspondent

The interaction among ONSET, MAX-SEG, and DEP-SEG is shown in (6).

(6) Medial onsetless syllables are tolerated

/čéčinohúːo/	MAX-SEG	DEP-SEG	ONSET
☞ a. čé.či.no.húː.o			*
b. čé.či.no.húː.ʔo		*!	
c. čé.či.no.húː__	*!		

However, as seen in (4) above, a stricter requirement holds of initial syllables: they must have onsets. No vowel-initial forms are allowed. Languages like Arapaho (and Guhang Ifugao; see below) thus present an interesting contrast to the more common pattern, found for example in Axininca Campa (Payne 1981; Spring 1990; McCarthy & Prince 1993ab), in which onsetless syllables are tolerated *only* in initial position. In languages like Axininca, alignment constraints dominate ONSET (McCarthy & Prince 1993ab), so that disrupting the alignment of the input material with the left edge of the prosodic word by means of epenthesis is worse than tolerating an onsetless syllable. This can be seen in (7), where failure to epenthesize an onset medially is fatal (7a), but epenthesizing an initial onset is also fatal (7b).

(7) Initial onset epenthesis blocked in Axininca Campa (adapted from McCarthy & Prince 1993a:119)

/i-N-koma-i/ 'he will paddle' (epenthetic segments are in boldface)

/i-N-koma-i/	ALIGN-L (Stem, PrWd)	ONSET	DEP-SEG
a. iŋ.ko.ma.i		**!	
b. **t**iŋ.ko.ma.**t**i	*!		**
☞ c. iŋ.ko.ma.**t**i		*	*

By contrast, Arapaho-type languages seem to go out of their way to disrupt edge-alignment. Because these languages *require* onsets in initial position, an alignment-based analysis will not work. What can account for the Arapaho pattern is a constraint that specifically mandates the presence of an onset in the initial syllable: ONSET/σ_1 (8). If this constraint dominates at least one faithfulness constraint, then initial syllables will always surface with an onset (9).

(8) ONSET/σ_1 For all syllables *x*, if *x* is the leftmost syllable whose head is affiliated with MWd *m*, then $a \neq b$

where *a* is the leftmost segment dominated by syllable *x*
b is the head of syllable *x*

(9) Initial syllables always have onsets (hypothetical input)

/otoʔ/	ONSET/σ_1	MAX-SEG	DEP-SEG	ONSET
a. otoʔ	*!			*
(☞) b. **h**otoʔ			*	
(☞) c. _toʔ		*		

Whether (9b) or (9c) — or indeed some other candidate not shown here — is the actual output that the grammar of Arapaho would produce for the hypothetical input /otoʔ/ will depend on the ranking relationships among MAX-SEG, DEP-SEG, and other faithfulness constraints, which cannot be precisely determined here. What matters for this discussion is that the faithful, onsetless candidate is less harmonic than other candidates, so an output with an onsetless initial syllable will never surface.

Guhang Ifugao (Newell 1956; Landman 1999) is another language that shows the effects of the ONSET/σ_1 constraint.[4] Onsetless syllables do occur in the language, as seen in (10). (The syllable breaks for the first five examples are given explicitly by Newell (1956:535); other examples are syllabified in accordance with his description of syllable structure. Note that either vowel in a VV sequence may bear stress, a fact which supports separate syllabification.)

(10) Medial onsetless syllables (Newell 1956:535, 538)

ʔi.áb.baʔ	'I will carry (on back)'
bú.uŋ	'an Ifugao necklace'
ma.ŋá.an	'remove'
ma.ga.á.tan	'clean (by cutting)'
ba.bá.i	'female'
ha.í.tan	'whetstone'
hé.ep	'sunflower'
bu.ma.nú.ot	'smolder'
ma.ni.go.áʔ	'I'm looking for'

However, vowel-initial syllables are not permitted in word-initial position (11).

(11) Initial onsets are obligatory (Newell 1956:534-6)

(a)	tin.ní.go	'saw'
	gád.deŋ	'goat'
	mun.báŋ.ŋad	'return'
	ŋí.lig	'yard'
	lu.má.hu	'hot'
	hi.dí	'there (far)'
	ya.gu.yá	'why'
	wá.da	'there is'
	ʔu.húp	'late, long time'
	ʔíŋ.ŋi	'baby girl'
	ʔad.dá.ya	'sky'

[4]Landman (1999) takes a different approach to Guhang Ifugao, proposing a constraint, MORPHEME-CONTIGUITY, that penalizes contiguity violations (including epenthesis, deletion, and metathesis) inside morphemes but is not violated by epenthesis at morpheme edges.

(b) *uhup
*iŋŋi
*addaya

Just as for Arapaho, an analysis that accounts for the facts of Guhang Ifugao is one in which ONSET/σ_1 outranks (at least one of) the faithfulness constraints MAX-SEG and DEP-SEG (12).

(12) Initial syllables always have onsets (hypothetical input)

/uhup/	ONSET/σ_1	MAX-SEG	DEP-SEG	ONSET
a. u.hup	*!			*
(☞) b. ʔu.hup			*	
(☞) c. _hup		*		

Again, as for Arapaho, the evidence introduced here does not determine whether onsetless initial syllables are repaired by means of (consonant) epenthesis or (vowel) deletion; the choice between (12b) and (12c) will depend on the relative ranking of the faithfulness constraints. (Landman (1999) suggests that there is evidence, from orthographic practice and comparison with related languages, that glottal-stop epenthesis is the chosen "repair" for a potential onsetless initial syllable, so (12b) may be the actual output.)

The languages examined in this section, Arapaho and Guhang Ifugao, are languages with mandatory onsets only in initial syllables. Such languages provide evidence for the positional augmentation constraint ONSET/σ_1. In such a language, ONSET/σ_1 outranks at least one of the faithfulness constraints that would otherwise protect initial onsetless syllables, such as DEP-SEG or MAX-SEG. However, the general ONSET constraint is dominated by all relevant faithfulness constraints; as a result, non-initial syllables may remain onsetless.

The following section examines phenomena that motivate another family of positional augmentation constraints for the strong position σ_1: the [*ONSET/X]/σ_1 subhierarchy.

4.2.1.2 High-sonority onsets banned in initial syllables: [*ONSET/X]/σ_1

In certain languages, initial-syllable onsets that are high in sonority, such as glides or liquids, are not allowed.[5] To account for languages with special onset-sonority restrictions for

[5] In such languages, initial onsetless syllables may be tolerated. This is to be expected, since ONSET and *ONSET/X are formally independent and the ranking between them is not universally fixed (§2.3.2.3.3).

initial syllables, it is necessary to recognize a specific version of the *ONSET/X constraint subhierarchy relativized to initial syllables, [*ONSET/X]/σ_1.

This section examines three different sonority-sensitive restrictions on initial-syllable onsets: a ban on rhotic and glide onsets in initial syllables, a ban on all liquid onsets in initial syllables, and a ban on specifically rhotic onsets in initial syllables. These three types are exemplified by Campidanian Sardinian (§4.2.1.2.1), by Mongolian, Kuman, Guugu Yimidhirr, and Pitta-Pitta (§4.2.1.2.2), and by Mbabaram (§4.2.1.2.3) respectively.

The general *ONSET/X subhierarchy, a universally ranked set of constraints banning onset consonants of particular levels of sonority, was discussed in §2.3.2.3.3. The initial-syllable-specific version of this constraint subhierarchy is given in (13).

(13) [*ONSET/X]/σ_1 For every segment *a* that is the leftmost pre-moraic segment of some syllable *x*, if *x* is the leftmost syllable whose head is affiliated with MWd *m*, then $|a| < X$

where $|y|$ is the sonority of segment *y*
X is a particular step on the segmental sonority scale

The particular values assigned to *X* in (13), and therefore the specific formulations of the individual constraints that make up the subhierarchy, depend on the composition of the segmental sonority hierarchy. The sonority hierarchy assumed here is that shown in (14) (see §2.3.2.2 for discussion). Some of the languages discussed in this section, Campidanian Sardinian (§4.2.1.2.1) and Mbabaram (§4.2.1.2.3), further support the division of the class of liquids into rhotics and laterals, because they prohibit rhotics but allow laterals as the onsets of initial syllables.

(14) Segmental sonority scale (consonantal portion)

glides > rhotics > laterals > nasals > voiced obstruents > voiceless obstruents

When this sonority scale is applied to the constraint formulation in (13) above, the following universal subhierarchy is derived (where *D* and *T* are abbreviations for voiced and voiceless obstruents respectively).

(15) [*ONS/GLI]/σ_1 >> [*ONS/RHO]/σ_1 >> [*ONS/LAT]/σ_1 >> [*ONS/NAS]/σ_1
>> [*ONS/D]/σ_1 >> [*ONS/T]/σ_1

The analyses proposed in this section also have implications for the formulation of general and positional *ONSET/X constraints. Languages in which syllable-initial glides are syllabified as true onset consonants must ban initial glides when they ban initial liquids, because of the universal ranking [*ONS/GLI]/σ_1 >> [*ONS/RHO]/σ_1 >> [*ONS/LAT]/σ_1. An example of a language that follows this pattern is the Sestu dialect of Campidanian Sardinian (§4.2.1.2.1).

Thus, languages that ban word-initial rhotics (or liquids generally) while tolerating word-initial glides, such as Mongolian, Kuman, Guugu Yimidhirr, Pitta-Pitta, and Mbabaram, provide evidence that not all syllable-initial glides are structurally onsets. This point will be taken up at the end of the onset-sonority discussion, in §4.2.1.2.4.

4.2.1.2.1 Initial glide and rhotic onsets banned in Campidanian Sardinian

In the Sestu dialect of Campidanian Sardinian (Bolognesi 1998),[6] there is a prohibition against initial onsets that consist solely of a glide or of the liquid [r]. Sestu Campidanian thus provides an example of a language that bans both liquid (rhotic, in this case) and glide onsets together. This subsection first gives an overview of the relevant data and then presents an analysis that makes crucial use of the positional augmentation constraints [*ONSET/GLI]/σ_1 and [*ONSET/RHO]/σ_1.

Where initial [r] would have been expected in Sestu and other Campidanian dialects, given the diachronic or loanword source of a particular word, the liquid is instead preceded by a low vowel (and is usually geminate).[7]

(16) Potential [r]-initial words have prothetic vowels (Bolognesi 1998:42)

(a) Regular outcomes of diachronic change from Latin/Romance

ar̲ːɔza	'rose'	< Latin *rosa*
ar̲ːiu	'river/creek'	< Latin *rivus*
ar̲ːana	'frog'	< Latin *rana*
ar̲ːuβiu	'red'	< Latin *rubeum*
ar̲ːɔða	'wheel'	< Latin *rota*

(b) Loanwords from Italian

ar̲ːikːu	'rich'	< Italian *ricco*
ar̲ːaðiu	'radio'	< Italian *radio*

However, syllable-initial [r] is possible in syllables that are not word-initial (17a),[8] and [r] can appear as part of a complex onset (17b), even in word-initial syllables.

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[6]Thanks to Paul de Lacy for bringing this example and reference to my attention.

[7]According to Bolognesi (1998), the initial [a] is optional for some recent loanwords from Italian.

[8]Bolognesi (1998:27) explicitly states that /r/ does not show any allophonic alternations. However, he sometimes — although not consistently — gives intervocalic /r/ as a surface tap [ɾ] in his phonetic transcriptions. Forms shown here follow Bolognesi's transcriptions.

(17) Licit occurrences of onset [r]

(a) Onset [r] in non-initial syllables (Bolognesi 1998:37, 39, 496, 498)

dʒɛner̠u	'son-in-law'
dzir̠u	'jar'
aŋkɔr̠a	'still'
pur̠u	'also'
nar̠aða	'call-3SG-PST'

(b) [r] in complex onsets (Bolognesi 1998: 31, 44, 45, 496, 497, 502)

tr̠onu	'thunder'
tr̠iŋku	'scar'
pr̠ɛnu	'full'
gr̠andu	'great'
fr̠isku	'fresh air'
atːr̠u	'other'
sɛmpr̠i	'always'

Sestu Campidanian also disallows glide-initial words, again with the exception of certain very recent loanwords like *yoghurt* [joɣurtu] and *whisky* (no transcription given). According to Bolognesi (1998:44), word-initial [j] is relatively uncommon in the Campidanian dialects in general, occurring in about four forms. But Sestu disallows initial [j] even in these forms. There is a prothetic [a] in two of the four cases where other Campidanian dialects have initial [j] (34a). (In the other two cases, the initial consonant is an affricate in Sestu (34b) or the Sestu form is not given (34c).)

(18) Forms with initial [j] (Bolognesi 1998:44)

	Sestu form	*Other Campidanian dialects*	*Gloss*
(a)	ajaju	jaju	'grandfather'
	ajaja	jaja	'grandmother'
(b)	dʒu	juu	'yoke'
(c)	*<not given>*[9]	josːu	'down'

[9]The Sestu form corresponding to [josːu] 'down' is not given in Bolognesi's (1998:44-5) explicit discussion of initial glides, and it does not appear in either of the two long Sestu texts transcribed in Bolognesi's appendix.

As for initial [w], Bolognesi (1998:44) states that it occurs in word-initial position only in the single loanword *whisky*.

In addition to the forms in (18a), word-medial glide onsets appear in a few other forms.

(19) Word-medial glide onsets (Bolognesi 1998:44-5)

maj̲u	'May'
ej̲a	'yes'
koj̲a	'wedding'
faw̲aɲtʃu	'liar'

Thus, like [r], glides can be syllable onsets as long as they are not in initial position. But glides differ from [r] in one respect: in Sestu, glides do not appear with another onset consonant, so that there are *.CrV.* sequences but not *.Cw/jV.* sequences. (This point becomes important in the discussion of syllabic positions for glides in §4.2.1.2.4 below.)

> Rising diphthongs are allowed by syllable structure in some dialects of Campidanian, but they are normally prohibited in Sestu and other central dialects. As a consequence the "Standard" Campidanian word '*kwaɖːu* ('horse') is realized as *ku*'*aɖːu* in the Sestu dialect: /u/ is short and unstressed, but distinctly longer than the corresponding glide. (Bolognesi 1998:24)[10]

In contrast to [r] and the glides, which do not appear in initial position, [l] can appear as a word-initial onset in Sestu Campidanian.

(20) Onset [l] in word-initial syllables (Bolognesi 1998:43-4)

luʒi	'light'
ledʒu	'ugly'
latːi	'milk'
luðu	'mud'

To summarize the patterns seen in the data introduced above: Sestu Campidanian does not tolerate glides or [r] as independent onsets in initial syllables. However, these consonants

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[10]Rising diphthongs do appear from time to time in Bolognesi's (1998) phonetic transcriptions of the running texts. For example, the form /familːia/ is given as [(v)amilːi̲a], as expected, on p. 30, but as [(fː)amilːj̲a], with an apparent rising diphthong, on p. 45 (in both examples, sandhi processes have affected the word-initial fricative). Since Bolognesi so explicitly states that Sestu does not have rising diphthongs, presumably the unexpected glides in the transcriptions are to be taken as some sort of rapid-speech contraction.

can be onsets of medial syllables, which indicates that the sonority-based restrictions in question hold specifically of initial syllables. Finally, while [r] can form part of an onset cluster even in initial syllables, rising diphthongs (or complex onsets involving glides) are not permitted. The remainder of this subsection presents an analysis of initial-syllable onsets in Sestu, accounting for the special ban on high-sonority elements with constraints from the [*ONSET/X]/σ_1 constraint subhierarchy.

The consonants that may not be initial onsets in Sestu Campidanian are the glides, [j,w], and the rhotic [r]. This pattern can be accounted for if the constraints [*ONSET/GLI]/σ_1 and [*ONSET/RHO]/σ_1 are ranked above at least one of the faithfulness constraints.

(21) [*ONSET/GLI]/σ_1 For every segment *a* that is the leftmost pre-moraic segment of some syllable *x*, if *x* is the leftmost syllable whose head is affiliated with MWd *m*, then |*a*| < GLI

where |*y*| is the sonority of segment *y*

[*ONSET/RHO]/σ_1 For every segment *a* that is the leftmost pre-moraic segment of some syllable *x*, if *x* is the leftmost syllable whose head is affiliated with MWd *m*, then |*a*| < RHO

where |*y*| is the sonority of segment *y*

Because Sestu words that correspond to glide- or [r]-initial words in other dialects or languages generally have initial [a] (and even very recent loanwords from Italian that begin with [r] have optional variants with an epenthetic [a]; Bolognesi 1998:43), it appears that the faithfulness constraint crucially dominated by these initial-syllable markedness constraints is DEP-SEG, which penalizes epenthesis.

The constraints [*ONSET/GLI]/σ_1 and [*ONSET/RHO]/σ_1 must also dominate ONSET/σ_1 (as well as general ONSET), or the onsetless syllable created by [a]-epenthesis would not be tolerated. DEP-SEG must dominate ONSET/σ_1 as well, or an epenthetic onset would appear with the epenthetic [a]. The interactions among these constraints are shown in (22).

(22) Initial glides and [r] avoided

(a) [ajaju] 'grandfather'

/jaju/	[*ONS/GLI]/σ_1	[*ONS/RHO]/σ_1	DEP-SEG	ONSET/σ_1
a. jaju	*!			
☞ b. **a**jaju			*	*
c. **ta**jaju			**!	

(b) [arːɔða] 'wheel'[11]

/rɔða/	[*ONS/GLI]/σ_1	[*ONS/RHO]/σ_1	DEP-SEG	ONSET/σ_1
a. rɔða		*!		
☞ b. **a**rːɔða			*	*
c. **ta**rːɔða			**!	

Although DEP-SEG is dominated by [*ONSET/GLI]/σ_1 and [*ONSET/RHO]/σ_1, it dominates the other constraints in the subhierarchy, including [*ONSET/LAT]/σ_1.

(23) [*ONSET/LAT]/σ_1 For every segment *a* that is the leftmost pre-moraic segment of some syllable *x*, if *x* is the leftmost syllable whose head is affiliated with MWd *m*, then |*a*| < LAT

where |*y*| is the sonority of segment *y*

Therefore, initial liquid onsets (and less sonorous initial segments) appear faithfully in output forms.

(24) Initial [l] surfaces: [luʒi] 'light'

/luʒi/	[*ONS/GL]/σ_1	[*ONS/R]/σ_1	DEP-SEG	[*ONS/L]/σ_1
☞ a. luʒi				*
b. **a**luʒi			*!	

Since all relevant faithfulness constraints dominate [*ONSET/LAT]/σ_1, but [*ONSET/RHO]/σ_1 crucially dominates at least one of the faithfulness constraints, the two constraints [*ONSET/RHO]/σ_1 and [*ONSET/LAT]/σ_1 must be recognized as distinct members of the [*ONSET/X]/σ_1 hierarchy. A unitary [*ONSET/LIQ]/σ_1 constraint, that makes reference to rhotics

[11] While the constraints introduced thus far are sufficient to account for the glide-initial cases, something more will need to be said about the [r]-initial cases, given that a form like /rɔða/ surfaces as [arːɔða], with gemination of the liquid. Some constraint must be active that prefers a candidate with gemination over the more faithful candidate *[arɔða]. Intuitively, one suspects that there may be an opaque interaction here — perhaps an underlyingly word-initial [r] resists being realized as a flap even though it is intervocalic on the surface, and gemination is the strategy chosen to avoid flaps, if indeed flaps are mandatory in intervocalic environments; see footnote 8.

and laterals together, cannot capture the pattern of permissible initial onsets seen in Sestu Campidanian. (The same point can be made about Mbabaram, discussed in §4.2.1.2.3 below.)

A final point to note is that, because the formulation of *ONSET/X constraints makes them relevant only for the leftmost (pre-moraic) segment of the syllable, [*ONSET/RHO]/σ_1 correctly fails to penalize initial *Cr*- clusters, which are attested in Sestu Campidanian. The leftmost element of a syllable such as [tro] in (25) is [t], not [r], so it does not violate [*ONSET/RHO]/σ_1 as the syllable [ro] would do.

(25) Initial *Cr*- onsets are allowed: [tronu] 'thunder'

/tronu/	[*ONS/GLI]/σ_1	[*ONS/RHO]/σ_1	DEP-SEG
☞ a. tronu			
b. **a**tronu			*!
c. t**a**ronu			*!

As noted above, however, Sestu does not allow rising diphthongs; that is, syllables like *[tja] or *[twa] are prohibited. These syllables satisfy [*ONSET/GLI], just as the attested syllable [tro] satisfies [*ONSET/RHO], because the glide is not leftmost in the syllable. Therefore, another constraint must be responsible for ruling out such syllables. This point is considered again in §4.2.1.2.4 below, where various matters pertaining to glides and onsets are addressed.

In conclusion, the initial-syllable-specific constraint subhierarchy [*ONSET/X]/σ_1 accounts for the prohibition of initial [j,w,r] in Sestu Campidanian. [*ONSET/GLI]/σ_1 and [*ONSET/RHO]/σ_1 are ranked above a faithfulness constraint, so glide and [r] onsets are avoided. However, [*ONSET/LAT]/σ_1 and all lower-ranked constraints in the [*ONSET/X]/σ_1 hierarchy are dominated by all relevant faithfulness constraints, so that other consonants, including [l], are permissible initial onsets.

4.2.1.2.2 Initial liquid onsets banned

This section discusses four languages with a different kind of initial-syllable onset sonority restriction. Mongolian, Kuman, Guugu Yimidhirr, and Pitta-Pitta, each discussed in Walsh Dickey 1997, ban all liquid onsets — including laterals as well as rhotics — in initial syllables. (Unlike Sestu Campidanian, these languages do allow word-initial glides. The implicational relationship between liquids and glides as admissible onsets is discussed in §4.2.1.2.4 below.)

First, the crucial initial-syllable restrictions in each language are presented. Then, an analysis is proposed that accounts for these languages with the positional augmentation constraints [*ONSET/RHO]/σ_1 and [*ONSET/LAT]/σ_1.

In (Khalkha) Mongolian, as in most Altaic languages, there is a ban on liquids in word-initial position (Poppe 1970, Ramsey 1987),[12] although they may appear medially and finally (26). Ramsey (1987:205) describes [l] as a dental lateral, and [r] as a dental "flap or trill".

(26) Medial and final liquids (Ramsey 1987:205-7)

daḻae	'sea'
zuṟag	'picture'
üüḻ	'cloud'
xaṟ	'black'
emeeḻ	'saddle'
teŋgeṟ	'sky'

Other consonants[13] may appear initially (27). Vowel-initial words are also permitted (28).

(27) Initial consonants (Ramsey 1987:205-9)

teŋger	'sky'
baatar	'hero'
gar	'hand'
ʃönö	'night'
xüxe	'blue'
zuraba	'painted'
maxa	'meat, fish'
jaba	'go!'

(28) Vowel-initial words (Ramsey 1987:205-9)

ulaan	'red'
emeel	'saddle'
onoqu	'to understand'
axa	'elder brother'

Thus, the class of liquids is systematically excluded from the word-initial onset position in Mongolian.

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[12]According to Ramsey (1987:206), the ban on initial [r] is absolute, but initial [l] does occur in a small number of loanwords. This difference between [r] and [l] may well reflect rhotics' higher sonority.

[13]Ramsey (1987:205) states that [w] occurs only in loanwords, but he does not indicate whether or not [w] is a possible initial onset.

Another language in which initial liquids are banned is Kuman (Papuan; Trefry 1969, Lynch 1983, Blevins 1994). In this language, as analyzed by Lynch (1983 [cited in Blevins 1994]), there are two contrastive liquids, a velar lateral [ʟ] (which can coalesce with a following [i] to form an alveolar lateral [l]), and an alveolar flap [ɾ] that is in complementary distribution with [t]. No liquid segment occurs word-initially in Kuman; the [ɾ]~[t] phoneme surfaces as [t] whenever it is word-initial (although [ɾ] appears prevocalically in all other cases), and [ʟ]~[l] does not appear in initial position at all. However, both liquids occur medially and finally (29).

(29) Medial and final liquids (Trefry 1969:2-5; Blevins 1994:321)

meɾ̲e	'many'
pɾ̲iɾ̲o	'hear! (DU IMP)'
boɾ̲umai	'blood'
suaɾ̲a	'one'
iɾ̲	'cold'
piɾ̲aʟ̲endi	'warm'
jaʟ̲o	'plant! (SG IMP)'
jal̲o < /jaʟ+io/	'plant! (PL IMP)'
biʟ̲e	'broken'
gaʟ̲puʟ̲a	'hat'
jaʟ̲	'man'

As in Mongolian, initial glides (30) and vowel-initial words (31) are possible in Kuman (Trefry 1969:12-13).

(30) Initial glides (Trefry 1969:2-3, Blevins 1994:321-4)

jaɾaʟka	'I will plant'
jobuʟo	'bone-3SG'
juo	'bring! (SG IMP)'
wam	'fat'
winaʟe	'claw'
wagai	'good'

(31) Vowel-initial words (Trefry 1969:13-14)

i	'this'
iɾ	'cold'
olto	'long'
amuʟ	'pandanus'
amniʟo	'milk'

Once again, it is the class of liquids that is excluded from initial-syllable onsets.

Two more examples of this pattern are the Australian languages Guugu Yimidhirr and Pitta-Pitta, which ban word-initial liquids while permitting other consonants in word-initial position (Dixon 1980: Ch. 6). (Unlike Mongolian and Kuman, however, these two languages do not allow onsetless syllables; see footnote 5.)

In Guugu Yimidhirr (Dixon 1980:162-3), there is an apical lateral [l] and two rhotics, the apico-alveolar trill [r] and the retroflex approximant [ɻ]. However, none of these liquids are possible in initial position — even though Guugu Yimidhirr, unlike some Australian languages, does allow the non-liquid apicals [d,n] in initial position.

(32) Consonant inventory of Guugu Yimidhirr (Dixon 1980:162)
(Shaded segments are banned from word-initial position.)

Apical		*Laminal*		*Peripheral*[14]	
d		d̪	ɟ	g	b
n		n̪	ɲ	ŋ	m
l					
r	ɻ				
		j		w	

In Pitta-Pitta (Dixon 1980:160-161), all apico-alveolar consonants are banned from word-initial position (dashed box in (33)), so naturally there are no initial apico-alveolar liquids. However, this language has a number of additional liquids at other places of articulation, and none of those liquids are possible initial onsets either. That is, in addition to a place-based ban on initial apico-alveolars, Pitta-Pitta also has a general ban on initial liquids.

[14]Dixon (1980) groups labial and velar consonants together as "peripheral" consonants because they typically pattern as a class in Australian languages.

(33) Consonant inventory of Pitta-Pitta (Dixon 1980:160)
(Shaded segments are banned from word-initial position.)

Apical			*Laminal*		*Peripheral*	
	d	ɖ	d̪	ɟ	g	b
	n	ɳ	n̪	ɲ	ŋ	m
	l	ɭ	l̪	ʎ		
	r	ɻ				
ɾ						
			j		w	

Thus, both Guugu Yimidhirr and Pitta-Pitta also exclude specifically liquids from the set of possible initial onsets.

These four languages that systematically ban liquid onsets in initial syllables — Mongolian, Kuman, Guugu Yimidhirr, and Pitta-Pitta — can be accounted for with a ranking in which the positional augmentation constraint [*Onset/Lat]/σ_1 dominates at least one relevant faithfulness constraint. (Since [*Onset/Rho]/σ_1 dominates [*Onset/Lat]/σ_1 universally, both rhotics and laterals are thus impossible onsets.[15]) If [*Onset/Rho]/σ_1 and [*Onset/Lat]/σ_1 outrank at least one (relevant) faithfulness constraint, then the lowest ranked of such faithfulness constraints, $\mathbf{F}_n$, will be violated when necessary to avoid a liquid onset in the initial syllable. Depending on what faithfulness constraint stands in the place of $\mathbf{F}_n$ in a particular language, several strategies for avoiding initial liquids are possible.

If $\mathbf{F}_n$ is Dep-Seg, then epenthesis will occur to ensure that the input initial liquid is not an initial-syllable onset in the output (34). In §4.2.1.2.1 above, Campidanian Sardinian was argued to be a language with this kind of ranking: vowels are epenthesized when otherwise initial onsets would be unacceptably high in sonority.

[15]Of course, [*Onset/Gli]/σ_1 universally outranks [*Onset/Rho]/σ_1, since glides are higher in sonority than rhotics. But as noted above, the four languages discussed in this section do not prohibit word-initial glides. In §4.2.1.2.4, a connection is drawn between the fact that a ban on liquid (or only rhotic) onsets does not always entail a ban on syllable-initial glides and the fact that syllable-initial glides are not always structural onsets, but may sometimes be onglides within the nucleus.

(34) Initial liquid onset avoided by epenthesis

/rana/	[*ONS/R]/σ_1	[*ONS/L]/σ_1	MAX-SEG	IDENT[*f*]	DEP-SEG
a. rana	*!				
☞ b. **e**rana					*
c. ana			*!		
d. tana				*!	

If $\mathbf{F}_n$ is MAX-SEG, then initial liquid onsets will be deleted (35).

(35) Initial liquid onset avoided by liquid deletion

/rana/	[*ONS/R]/σ_1	[*ONS/L]/σ_1	DEP-SEG	IDENT[*f*]	MAX-SEG
a. rana	*!				
b. **e**rana			*!		
☞ c. ana					*
d. tana				*!	

Finally, if $\mathbf{F}_n$ is IDENT[*f*] for some feature *f*, then the optimal output for a form with an initial liquid is one that has changed the *f* specification for the liquid so that it surfaces as a non-liquid. This is the ranking that is relevant for Kuman [ɾ], which according to Blevins (1994) surfaces as [t] in word-initial position (as well as pre-consonantally).

(36) Initial liquid onset avoided by altering the liquid

/rana/	[*ONS/R]/σ_1	[*ONS/L]/σ_1	DEP-SEG	MAX-SEG	IDENT[*f*]
a. rana	*!				
b. **e**rana			*!		
c. ana				*!	
☞ d. tana					*

Although for some of the languages surveyed in this section it is not possible to tell precisely which repair strategy is chosen for avoiding initial liquid onsets, it is clear that in each language the positional augmentation constraints [*ONSET/RHO]/σ_1 >> [*ONSET/LAT]/σ_1 are ranked above at least one faithfulness constraint; initial liquid onsets do not surface.

4.2.1.2.3 Initial rhotic onsets banned in Mbabaram

The third pattern of initial-syllable onset sonority restrictions to be discussed here is that found in Mbabaram (Australian; Dixon 1991). This pattern is related to both of the patterns just discussed. Like Sestu Campidanian (§4.2.1.2.1), Mbabaram bans rhotics from initial onset position while allowing laterals. But unlike Sestu, and like the four languages discussed in §4.2.1.2.2, Mbabaram allows word-initial glides.

Mbabaram has three liquids in its consonant inventory: the apico-alveolar lateral [l], the 0alveolar tap or trill [r], and the retroflex [ɽ], "which may be a tap, a trill, or a rhotic continuant" (Dixon 1991:356). However, while the lateral may appear word-initially (37), both of the rhotics are banned from that position (Dixon 1991:359).[16]

(37) Word-initial laterals in Mbabaram (Dixon 1991:398-401)

lim	'good, fresh, satisfied'
lɔːr	'whip-tail kangaroo'
libɔ́ɽ	'eye'
lugúl	'long way'
lábɨ-	'leave (something in a place)'
láŋgil	'light'

As noted, word-initial glides do appear in Mbabaram, but further discussion of this fact and its implications is postponed until §4.2.1.2.4.

[16]One might ask whether there could be a confounding factor, unrelated to sonority differences, when languages ban initial rhotics but not initial laterals. Several kinds of rhotics, including taps and trills, occur preferentially between vowels, so there may be independent constraints unrelated to the *ONSET/X hierarchy that prevent these kinds of rhotics from surfacing in word-initial position. However, the fact that Mbabaram [ɽ] can be realized as a continuant in addition to its realization as a tap or trill, and yet is still banned from word-initial position, indicates that it really is *[ONSET/RHO]/σ_1, and not simply a ban on initial taps and trills, that is active in this language.

(38) Word-initial glides in Mbabaram (Dixon 1991:398-401)

jɨ	'I (subject)'
ju	'fish'
ja-ɽ$^{\text{ə}}$	'give-PAST'
jigír	'itchy'
jargúl	'woman'
wiːr	'head hair'
wɛ	'mouth, teeth'
wuː	'mother'
wɔ	'west'
walŋá	'girl'
wuɽgún	'boy'

The fact that Mbabaram disallows initial rhotics shows that [*Onset/Rho]/σ_1 outranks some faithfulness constraint (such as Dep-Seg, Max-Seg, or Ident[*f*]).

(39) Initial rhotics banned in Mbabaram (hypothetical input)

/ramba/	[*Ons/Rho]/σ_1	Dep-Seg	Max-Seg	Ident[*f*]
a. ramba	*!			
(☞) b. **a**ramba		*		
(☞) c. amba			*	
(☞) d. damba				*

Again, there is not enough information to tell whether the actual output for this kind of input would be (39b),[17] (39c), or (39d), but crucially, it is not (39a).

Laterals, unlike rhotics, are permissible initial onsets. Therefore, all relevant faithfulness constraints, such as Dep-Seg, Max-Seg, and Ident[*f*], represented here by Faith, must dominate [*Onset/Lat]/σ_1.

[17] Mbabaram is an "initial-dropping" language (Dixon 1991:351), which gives it an atypical phonological system for an Australian language. For example, most Australian languages require all syllables to have onsets, but Mbabaram tolerates the word-initial vowel [a]. (Arrernte, discussed in Chapter 3, is another initial-dropping language, but the two languages are geographically separated and, along with still other languages, are argued by Dixon (1980) to have undergone similar diachronic changes independently.)

(40) Initial laterals allowed in Mbabaram

/laŋgil/	[*ONS/RHO]/σ_1	FAITH	[*ONS/LAT]/σ_1
☞ a. laŋgil			*
b. **a**laŋgil		*!	
c. aŋgil		*!	
d. daŋgil		*!	

The above analysis of Mbabaram initial-syllable onsets concludes the set of case studies presented to exemplify constraints from the [*ONSET/X]/σ_1 subhierarchy. Before closing the discussion of **M/σ_1** constraints (§4.2.1.3), however, this section addresses one final topic: the conclusions that can be drawn on the basis of these case studies about the formulation of [*ONSET/X] constraints — in particular, how an additional possible syllabic position for pre-peak glides can allow a syllable to begin with a glide without violating [*ONSET/GLI].

4.2.1.2.4 Implications for syllable structure and onset-related constraints

This section discusses certain implications that the results of the [*ONSET/X]/σ_1 case studies have for constraint formulations and for subsyllabic structure. The crucial question is the structural position of syllable-initial glides. A distinction has been made in the literature between glides that are true consonantal onsets, and those that precede the syllable peak but are included within the nucleus (Kaye & Lowenstamm 1984; Davis & Hammond 1995; Harris & Kaisse 1999). The proposal developed here is that [*ONSET/GLI](/σ_1) is violated by true onset glides, but not by nuclear onglides; this allows glides to "escape" onset sonority restrictions in certain languages.

As seen above, languages like Mongolian, Kuman, Guugu Yimidhirr, and Pitta-Pitta avoid liquid onsets in initial syllables, but they allow words to begin with glides. The avoidance of initial liquids was analyzed by means of a ranking in which the positional augmentation constraints [*ONSET/RHO]/σ_1 >> [*ONSET/LAT]/σ_1 dominate at least one relevant faithfulness constraint. As a result of this ranking, any initial liquid in the input will fail to surface as such — depending on the ranking among the faithfulness constraints, the liquid will be deleted or changed into a non-liquid segment, or a prothetic vowel will appear.

However, the constraints [*ONSET/RHO]/σ_1 >> [*ONSET/LAT]/σ_1 do not exist in isolation. They are part of the [*ONSET/X]/σ_1 constraint subhierarchy, whose component constraints are in a universally fixed ranking that is derived from the segmental sonority scale (§2.3.2.3.3). In particular, the constraint [*ONSET/GLI]/σ_1 always dominates [*ONSET/RHO]/σ_1. By transitivity of ranking, this entails that whenever [*ONSET/RHO]/σ_1 dominates some faithfulness constraint **F**, [*ONSET/GLI]/σ_1 also dominates **F**. So if a language avoids initial liquid onsets through vowel prothesis (meaning that DEP-SEG is dominated by [*ONSET/RHO]/σ_1 >> [*ONSET/LAT]/σ_1), the prediction is made that initial glide onsets will be avoided through prothesis as well.[18]

(41) A ban on liquids entails a ban on glides

(a)

/la/	[*ONS/RHO]/σ_1	[*ONS/LAT]/σ_1	DEP-SEG
a. la		*!	
☞ b. **e**la			*

(b)

/ja/	[*ONS/GLI]/σ_1	[*ONS/RHO]/σ_1	[*ONS/LAT]/σ_1	DEP-SEG
a. ja	*!			
☞ b. **e**ja				*

How, then, is it possible for a language to avoid initial liquid onsets while nevertheless tolerating initial glides? This apparent contradiction can be resolved if it is recognized that not all syllable-initial glides are truly onsets, as in (42a). Some such glides are actually part of the

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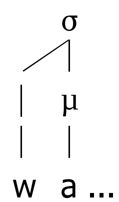
[18]Another situation in which a language would satisfy [*ONSET/RHO]/σ_1 >> [*ONSET/LAT]/σ_1 while nevertheless violating [*ONSET/GLI]/σ_1 might arise if the low-ranking faithfulness constraint whose violation was compelled by [*ONSET/RHO]/σ_1 >> [*ONSET/LAT]/σ_1 were a faithfulness constraint for a feature that was crucial to the identity of a liquid but not to that of a glide. For example, imagine a language in which underlying word-initial liquids are avoided because they surface as [n] (a pattern that is actually seen in Korean, but for all (non-ambisyllabic) syllable onsets, not just word-initial onsets). This would indicate that featural faithfulness constraints such as IDENT[nasal] and IDENT[lateral] are ranked below [*ONSET/RHO]/σ_1 >> [*ONSET/LAT]/σ_1. If IDENT[consonantal] (as well as MAX-SEG and DEP-SEG) outranks [*ONSET/GLI]/σ_1, initial glides will surface unchanged even though initial liquids are altered, because glides cannot become lower in sonority without changing from [-cons] to [+cons], but liquids are already [+cons] and will remain so even if they change into lower-sonority segments.

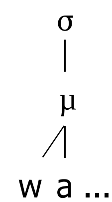
However, the problem of initial glides in languages that ban only initial liquids is a more general problem that requires a general explanation; feature alteration is not always the way that languages choose to avoid initial liquid onsets. For example, the Iglesias dialect of Campidanian Sardinian avoids initial liquid onsets (as does Sestu) but allows initial glides (unlike Sestu) (Bolognesi 1998:44). Crucially, initial liquid onsets are avoided through prothesis. There is no explanation intrinsic to the featural composition of glides as to why prothesis would be blocked before glides and not before liquids.

nucleus; in other words, they are dominated by a mora, as shown in (42b). (Glides that form part of the nucleus but precede the peak, as in (42b), will be called *nuclear onglides*.)

(42) (a) True onset



(b) Nuclear onglide



This structural distinction is possible to maintain under a version of moraic theory in which onset consonants are directly affiliated with the syllable node (Hayes 1989; McCarthy & Prince 1986). Failure to be dominated by a mora then becomes the structural diagnostic for a true onset; as seen below, the structural difference between the glides in (42a) and (42b) can be exploited in the formulation of constraints.

Supporting evidence for the claim that languages distinguish between true consonantal onset glides and nuclear onglides can be found in French (Kaye & Lowenstamm 1984), Spanish (Harris & Kaisse 1999; see also Harris 1983, Hualde 1989), Slovak (Rubach 1998; Harris & Kaisse 1999), and American English (Davis & Hammond 1995).

Kaye & Lowenstamm (1984) propose that glides in French occupy true onset positions in some words, but are nuclear onglides in other words. Their evidence comes mainly from the observation that glides in native words act like vowels, whereas those in loanwords act like consonants, but they offer additional support for their claim from facts about syllable structure and co-occurrence restrictions.

There are several well-known phonological processes that occur at the boundary between two words in French and are conditioned by the vowel/consonant status of the initial segment of the second word. Vowel (schwa) elision takes place before a V-initial word, but not before a C-initial word (43a); liaison[19] takes place before a V-initial word, whereas a final consonant is (under certain conditions) deleted before a C-initial word (43b); and suppletive forms of certain determiners are conditioned by V-initial versus C-initial words (43c).

(43) Phonological processes sensitive to word-initial V/C distinction in French
(Kaye & Lowenstamm 1984:135)

	pre-V		*pre-C*	
(a) V elision	✓	[lØ etydjã] 'the student'	NA	[lə̲ bato] 'the boat'

[19]For the purposes of the present discussion, liaison may be regarded as the resyllabification of a word-final consonant, but see, e.g., Schane (1968), Selkirk (1974), and Clements & Keyser (1983) for more detailed discussion of this complex process.

	pre-V		*pre-C*	
(b) Liaison	✓	[pətit̲ etydjɑ̃] 'small student'	NA	[pətiØ bato] 'small boat'
(c) Suppletion	_*V*	[s̲ɛ̲t̲ etydjɑ̃] 'this student'	_*C*	[s̲ə̲ bato] 'this boat'

Words with initial glides fall into two groups with respect to the V/C-sensitive processes exemplified in (43), as shown in (44). Glide-initial native words pattern with V-initial words, and glide-initial (recent) loanwords pattern with C-initial words.

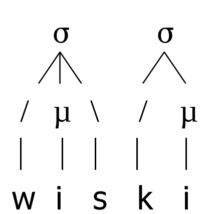
(44) Glide-initial words in French
(Clements & Keyser 1983; Kaye & Lowenstamm 1984)

	Native		*Loanword*	
(a) V elision	✓	[lØ jatys] 'the hiatus' [lØ wazo] 'the bird'	NA	[lə̲ jogi] 'the yogi' [lə̲ wiski] 'the whisky'
(b) Liaison	✓	[lɛz̲ jø] 'the eyes' [pətit̲ wazo] 'small bird'	NA	[lɛØ jogi] 'the yogis' [pətiØ wiski] 'small whisky'
(c) Suppletion	_*V*	[sɛt̲ jatys] 'this hiatus' [sɛt̲ wazo] 'this bird'	_*C*	[sə̲ jogi] 'this yogi' [sə̲ wiski] 'this whisky'

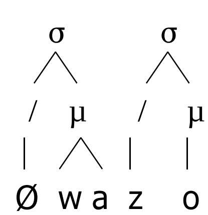
It has been proposed (Milner 1973, Clements & Keyser 1983, Kaye & Lowenstamm 1984) that the difference between the initial glides in native words like *oiseau* [wazo] 'bird' and those in loanwords like *whisky* [wiski] 'whisky' is that the glides are "vocalic" in the former case but "consonantal" in the latter. Kaye & Lowenstamm (1984) further propose that this distinction is actually the result of two different structural representations for the two classes of glides: the glide in *whisky* is a true onset, while that in *oiseau* is part of a complex nucleus, forming a rising diphthong — what has been termed here a nuclear onglide.

(45) Structural representations for glides in French
(after Kaye & Lowenstamm 1984:135)

(a) Glide as onset



(b) Glide as nuclear onglide



That is, the word *whisky* has an element in the onset position, so it behaves like other consonant-initial words. However, *oiseau* has no true onset consonant, so it participates in processes such as vowel elision and liaison just as unambiguously vowel-initial words do.

Kaye & Lowenstamm (1984:135-9) present additional support for the distinction that they draw between the two types of initial glides. They note that words of the *oiseau* type, which trigger pre-V phonological processes, show more stringent co-occurrence restrictions between the glide and the following vowel than do words of the *whisky* type; they interpret these facts to mean that restrictions hold between elements of a complex nucleus that do not hold between an onset glide and a nuclear vowel. Furthermore, the same restricted set of glide+vowel pairs that trigger pre-V phonological processes are also involved in various (synchronic or diachronic) alternations with single vowels, as in *verra* [vɛra] 'see-3SG.FUT' versus *voit* [vwa] 'see-3SG.PRES'; these alternations are at least suggestive that the glide+vowel sequences in question are complex nuclei (in the alternating words) rather than onset+nucleus sequences. Finally, Kaye & Lowenstamm (1984) show that possible word-initial stop+liquid+glide+V sequences correlate with the possible glide+V sequences in *oiseau*-type words. For example, *trois* [trwa] 'three' is permitted, but *trouer* /tru+e/ 'to bore a hole in' is [tru.we], not *[trwe] (cf. *louer* /lu+e/ 'to rent', which is [lwe]). Crucially, the [wa] in *trois* is one of the small number of permitted glide+vowel sequences seen in the *oiseau*-type words, that is, one of the set of possible complex nuclei. However, [we] is not a possible complex nucleus, so in this case the [w] must be syllabified into the onset. A stop+liquid sequence may precede a complex nucleus ([tr·wa]), but it may not form a triply complex onset with a glide (*[trw·e]).

Thus, Kaye & Lowenstamm (1984) have proposed that two distinct syllabic positions for glides must be recognized in French, on the basis of diagnostics for onset versus nuclear status as well as co-occurrence restrictions on complex onsets and complex nuclei. Crucially, the difference between monosyllabic [trwa], with nuclear onglide [w], and disyllabic [tru.we], with onset [w] (*[trwe]), shows that the difference between the two kinds of glides is not simply a loanword/native word difference, but is relevant within the phonology of native words as well.[20]

Arguments in favor of a distinction between onset and rimal syllabification of pre-peak glides have also been made for Spanish (Harris & Kaisse 1999; see also Harris 1983, Hualde 1989) and Slovak (Rubach 1998; Harris & Kaisse 1999). In these languages, facts about syllable weight and (for Spanish) possible syllable shapes and glide fortition patterns show that a pre-

[20]Systematic differences between the phonotactics of native morphemes and etymological loanwords have been given several different treatments in OT, including lexical stratum-specific rankings (Itô & Mester 1995), stratum-specific constraints (Fukazawa, Kitahara, & Ota 1998), and the use of underlyingly specified versus unspecified properties (Inkelas, Orgun, & Zoll 1997). A detailed analysis of how the constraint ranking differs between French native morphemes and loanwords, resulting in their respective syllabifications for glides, will not be pursued here. What is important for the current discussion is simply that there is evidence for a difference between onset glides and nuclear onglides in the phonology of French.

peak glide is parsed as part of the rime unless there is nothing else to be parsed as a true onset, in which case the glide fills that slot.

Harris & Kaisse (1999) present several pieces of evidence concerning the syllabification of glides in Spanish. First, they show that a CGV syllable is heavy, but a GV syllable is light. Antepenultimate stress is possible, as a lexically marked option, in Spanish nouns and adjectives, but this is blocked in words that have a heavy penult or a heavy ultima. Crucially, in all dialects of Spanish, antepenultimate stress is also impossible if the penult or ultima contains a CGV syllable (Harris & Kaisse 1999:149). Therefore, CGV syllables behave like heavy syllables.

(46) CGV syllables are heavy (Harris & Kaisse 1999:149)

(a) Final .CGV.

cal.ví.c[j]e	'baldness'	*but* * 'CVX.CV.CGV#
au.dá.c[j]a	'audacity'	
ne.gó.c[j]o	'business'	

(b) Penultimate .CGV.

tra.v[j]é.so	'mischievous'	*but* * 'CVX.CGV.CV#
me.d[j]ó.cre	'mediocre'	
a.c[j]á.go	'ominous'	

In contrast, GV syllables do not pattern as heavy syllables; a GV penult still allows antepenultimate stress.

(47) GV syllables are light (Harris & Kaisse 1999:148)[21]

o.no.ma.to.pé.[j]i.co	'onomatopoeic'
Plé.[j]a.des	'Pleiades'
Sá.[j]a.go	(surname)

Harris & Kaisse conclude from these facts that a glide contributes to weight if and only if it is not the initial segment in the syllable.

Another piece of evidence that syllable-initial glides in Spanish are syllabified differently from glides preceded by other consonants comes from the inventory of possible syllable shapes. According to Harris & Kaisse, *CGVG*s* and *CGVC*s* syllables are impossible, even though substrings of those sequences are possible syllables (48a). Furthermore, similar syllables with a liquid R in place of the pre-peak glide are possible (48b), and another five-segment syllable

[21]Syllable-initial glides, as in these examples, are subject to glide hardening in many dialects of Spanish. See below.

shape CRGVC is possible (48c), so (unsurprisingly) the relevant restriction has nothing to do with segment count.

(48) Possible syllable shapes (Harris & Kaisse 1999:126)

	(a)	CGVG	[bwej]	'ox'	but not *CGVG*s*
		CGVC	[bjen]	'well'	but not the union of these
		GVC*s*	[juks.]taponer	'to juxtapose'	structures, *CGVC*s*
cf.	(b)	CRVG*s*	[klaws.]tro	'cloister'	
		CRVC*s*	[trans.]formar	'to transform'	
	(c)	CRGVC	pu[.drjen.]do	'rotting'	but not *CRGVG*s*, *CRGVC*s*

The reason for the impossibility of C(R)GVX*s* syllable*s*, according to Harris & Kaisse, is that the glide in these syllables is part of the rime, unlike the liquid in a CR(G)VX(*s*) syllable, which is part of a complex onset. As shown by the stress facts discussed above, glides are weight-bearing when preceded by another consonant, but non-weight-bearing when in absolute syllable-initial position. If Spanish syllables are maximally bimoraic (with an optional weightless final element), this would rule out C(R)GVX*s* — all the underlined elements would be weight-bearing, and so this syllable would be too large.[22]

Thus, there are two pieces of evidence that glides in Spanish are weight-bearing when they are preceded by an onset consonant. First, CGV syllables, but not GV syllables, pattern as heavy syllables for the purposes of stress assignment. Second, a glide is counted toward the maximum syllable size limit when it is preceded by an onset consonant, but not when it is initial in the syllable. Under the standard assumption that a weight-bearing element must be part of the rime, this shows that a pre-peak glide preceded by another consonant is part of the rime. The fact that a syllable-initial glide is not weight-bearing moreover suggests that a glide in this environment is *not* part of the rime, but this fact alone is not necessarily conclusive, since not all rimal segments contribute to syllable weight.

Stronger evidence that a syllable-initial glide (with no preceding onset consonant) is not part of the rime comes from facts about glide hardening. In many dialects of Spanish, syllable-initial [j] in this position may become something like [ʒ] or [ɟ̞], and [w] may become something like [g^w].[23] This kind of sonority-reduction effect would be unexpected in a segment belonging

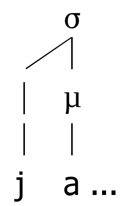
[22]Harris & Kaisse (1999:129) are not working within moraic theory, so they do not describe this limit in terms of moras; they state it as a limit of three segments in the rime, or a restriction that the rime may branch at most twice.

[23]Harris & Kaisse (1999) use the failure of glides to harden when another onset consonant is present as an additional argument that such glides are not true onsets. However, this particular

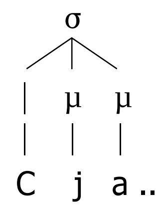
to the rime, but the preference for low-sonority onsets is quite well established (formally, glide hardening would thus be seen as a response to (general) *ONSET/GLIDE).

Therefore, translating Harris & Kaisse (1999)'s proposal into moraic-theory representations, pre-peak glides in Spanish have one of the following two structural positions, depending on whether or not an onset consonant precedes.

(49) (a) True onset



(b) Nuclear onglide



Crucially, in Spanish, a rimal pre-peak glide as in (49b) is associated with its own mora; this is why it contributes to weight. This need not be true for all languages, however. Even offglides, as in [aj̯], are not weight-bearing in all cases, so there should be quantity-sensitive languages in which nuclear onglides do not contribute to syllable weight, indicating that they are adjoined to the mora associated with the syllable peak as shown for French in (45) above. (Note, however, that since French is not quantity-sensitive, a structure with a shared mora cannot be definitively proven in the case of French specifically.) Incidentally, the term "nuclear onglide" is still appropriate in the case of Spanish, even though the vocoid in question heads its own mora, because the syllable *peak* is the following non-high vocoid.

Finally, Davis & Hammond (1995) argue that both of these structural possibilities for pre-peak glides are found in American English. They account for the fact that V is nearly unrestricted in *j*V, *w*V, and C*w*V syllables, but restricted to [u] in C*j*V syllables, by proposing that [j] is a nuclear onglide when a preceding tautosyllabic consonant is present (like glides in Spanish and Slovak), but syllable-initial [j], and [w] in all cases, are true onsets.

In summary, it has been shown that more than one syllabic position is available for glides: they may be true consonantal onsets, or they may be part of the rime as nuclear onglides to the syllable peak. The choice of how to syllabify glides is made on a language-specific basis or even,

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argument does not hold up in the context of the analysis under development here. Recall from the discussion of *#*r* onsets versus #C*r* clusters in Campidanian Sardinian above that [*ONSET/GLI]/σ_1 would never be violated by a glide in a #CGV syllable — even if it were syllabified as a true consonantal onset — because the glide is not the leftmost segment in the syllable. Thus, failure to harden in the context of a preceding onset consonant does not necessarily prove that the glide in question is not also syllabified as an onset. (However, the evidence for rime status based on syllable weight that has just been described seems quite convincing.)

as in French, Spanish, Slovak, and English, in a way that is dependent on the lexical or phonological context of the glides.

Since neither option for the syllabification of glides is universally avoided, there must be separate markedness constraints that prefer each of the structures over the other. Whether a language chooses to syllabify glides as onsets or as nuclear onglides will then depend on the relative ranking of these constraints.

First, there must be a constraint that penalizes true onset glides but not nuclear onglides. For this, we can make use of the familiar constraint *ONSET/GLI (in its general version as shown here, or in position-specific versions where applicable).

(50) *ONSET/GLI For all syllables x, $|a| <$ GLI

where a is the leftmost pre-moraic segment dominated by x
$|y|$ is the sonority of segment y

Now the consequences of the phrasing 'leftmost *pre-moraic* segment' in the formulation of this constraint become clear — a nuclear onglide, which is dominated by a mora, does not violate this constraint as it is given in (50). *ONSET/GLI refers to the onset proper, not just to any non-peak element at the left edge of the syllable.

In addition, there must be a constraint that penalizes nuclear onglides but not true onset glides. One possibility, following Rosenthall (1994), is *BRANCH-μ, which prohibits two vowels from sharing a single mora.[24]

(51) Constraint against nuclear onglides (after Rosenthall 1994:21)

*BRANCH-μ *μ

V_i V_j

[24]As seen above, Harris & Kaisse (1999) demonstrate that, in Spanish (and Slovak), nuclear onglides are themselves weight-bearing vocoids. For languages of this type, the glide is apparently associated with its own mora (see (49b)), so it will not violate *BRANCH-μ. Another constraint is therefore needed to rule out the structure in (49b), to account for languages (or environments within a language) that avoid moraic nuclear onglides in addition to those that share a mora with the syllable peak. One plausible option would be an alignment constraint that penalizes any mora intervening between the syllable peak (the head mora) and the left edge of the syllable. For simplicity of exposition, the rest of the discussion will refer only to *BRANCH-μ, but this should be understood where necessary to represent all the constraints that rule out nuclear onglides, whether weight-bearing or not.

A language that ranks *BRANCH-μ lower than *ONSET/GLI will syllabify glides as nuclear onglides (as long as *BRANCH-μ is also ranked below other relevant constraints, such as IDENT[*f*] constraints to prevent a glide from being changed into some other kind of segment, or MAX-SEG and DEP-SEG to prevent the deletion of the glide or the epenthesis of another segment respectively).

(52) Languages with nuclear onglides

/wa/	*ONS/GLI	IDENT[*f*]	*BRANCH-μ
σ μ a. w a	*!		
σ μ ☞ b. w a			*
c. ba		*!	

A language in which *ONSET/GLI is lowest ranked will syllabify glides as true onsets.

(53) Languages with true onset glides

/wa/	*BRANCH-μ	IDENT[*f*]	*ONS/GLI
☞ a. w a (σ; w attached to σ, a under μ)			*
b. w a (σ – μ; w and a both under μ)	*!		
c. ba		*!	

In this way, the structure that a language chooses for the syllabification of pre-peak glides depends on the relative ranking of *ONSET/GLI, *BRANCH-μ, and other relevant constraints such as IDENT[*f*].[25]

Now, given that pre-peak glides can be syllabified as part of the rime rather than as part of the onset proper, there is an explanation for why glides in some languages are able to "escape" sonority restrictions that hold for onsets otherwise. In languages such as Mongolian, Kuman, Guugu Yimidhirr, and Pitta-Pitta, where an avoidance of initial liquid onsets does not entail an avoidance of word-initial glides, *BRANCH-μ is apparently ranked low enough to allow pre-peak glides to be syllabified into the rime, avoiding violations of [*ONSET/GLI]/σ_1 while still maintaining segmental and featural faithfulness to word-initial glides (54).

[25]Of course, natural languages are likely to have rankings more complicated than the illustrative rankings shown here. In Spanish, for example, a glide+V sequence is syllabified as onset+nucleus when no other onset consonant is present, but as a complex nucleus when there is a preceding onset consonant. This suggests that *BRANCH-μ (and the head-mora alignment constraint; see footnote 24) dominates *ONSET/GLI, such that onset syllabification of glides is preferred to rimal, but *COMPLEXONSET dominates the anti-onglide constraints, forcing glides into the rime when other onset consonants are present. (ONSET is satisfied by either true onset glides or nuclear onglides, so it can have no effect on glide syllabification; see below.)

(54) Languages that ban word-initial liquids but not word-initial glides[26]

(a) [*ONS/GLI]/σ_1 >> [*ONS/RHO]/σ_1 >> [*ONS/LAT]/σ_1 >> **F**
(initial true-onset glides avoided; initial liquid onsets avoided)

(b) [*ONS/GLI]/σ_1 >> **F** >> *BRANCH-μ
(initial true-onset glides avoided by syllabification as nuclear onglides, rather than by segmental or featural unfaithfulness)

At this time, no independent evidence is available to confirm the proposal that the Mongolian-type languages syllabify word-initial glides as nuclear onglides. However, the above discussion of glides in French and Spanish has shown that the nuclear onglide position must be potentially available for pre-peak glides — even for absolute word-initial glides, as seen in French. If word-initial glides in the Mongolian-type languages are analyzed as nuclear onglides, then the fact that surface word-initial glides appear does not invalidate the use of [*ONSET/RHO]/σ_1 and/or [*ONSET/LAT]/σ_1 to account for the absence of word-initial liquids. As a result, the ban on word-initial liquids can in all cases be seen as the work of positional versions of independently motivated onset-sonority markedness constraints.

On the other hand, languages that have anti-onglide constraints like *BRANCH-μ ranked above some relevant faithfulness constraint are predicted to disallow nuclear onglides. Glides cannot escape into the nucleus to avoid onset sonority restrictions in these languages, so if initial onset liquids are banned, then initial glide onsets are banned as well (55).

(55) Languages that ban word-initial liquids and word-initial glides

(a) [*ONS/GLI]/σ_1 >> [*ONS/RHO]/σ_1 >> [*ONS/LAT]/σ_1 >> **F**
(initial true-onset glides avoided; initial liquid onsets avoided)

(b) [*ONS/GLI]/σ_1, *BRANCH-μ >> **F**
(initial true-onset glides avoided by segmental or featural unfaithfulness, not by syllabification as nuclear onglides)

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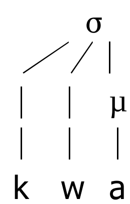
[26]When positional versions like [*ONSET/GLI]/σ_1 are included, a slightly more complex prediction is made: languages with the ranking [*ONSET/GLI]/*str* >> *BRANCH-μ >> *ONSET/GLI, **F** will have true onset glides in most cases (*BRANCH-μ >> *ONSET/GLI, **F**), but nuclear onglides in the relevant strong position ([*ONSET/GLI]/*str* >> *BRANCH-μ, **F**) where true structural onsets must meet stricter sonority requirements. In practice, it may be empirically difficult to confirm that such a language exists, but it does not seem implausible.

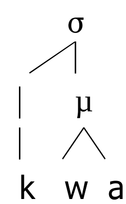
An example of a language that bans word-initial glides as well as liquids (specifically rhotics, in this case) is Sestu Campidanian. Some additional support for a relatively high rank for *BRANCH-μ in Sestu can be seen in a property of this dialect reported in §4.2.1.2.1 above: Sestu, unlike other dialects of Campidanian Sardinian, lacks CGV sequences altogether. Since pre-peak glides can potentially be syllabified either as true onsets or as nuclear onglides, the absence of CGV structures means that both of the following structures are banned in Sestu.

(56) Possible syllabification of CGV syllables

(a) True onset glide



(b) Nuclear onglide



Since true onset glides and nuclear onglides are structurally distinct, the two syllabifications in (56) must be independently excluded. The ranking needed to ban (56a) is tangential to this discussion and will not be further investigated here;[27] what is crucial is that, if CGV syllables are never attested, then in addition to whatever ranking excludes (56a), *BRANCH-μ must also be ranked high enough to exclude (56b). It is instructive to compare Sestu with the nearby Iglesias dialect of Campidanian Sardinian. Iglesias excludes word-initial liquids but not word-initial glides, which indicates that the word-initial glide in a form like [jaja] 'grandmother' (Bolognesi 1998:44) is a nuclear onglide. Iglesias is therefore predicted to permit the structure in (56b). In fact, Iglesias does allow CGV syllables, as in [kwaɖːu] 'horse' (Bolognesi 1998:24).

In summary, a language that bans (initial) onset liquids, but not (initial) onset glides, does not serve as a counterexample to the universally ranked *ONSET/X(/σ_1) subhierarchy, because glides need not be syllabified as true onsets. Given the appropriate constraint ranking, a language can choose to syllabify glides as nuclear onglides instead.

4.2.1.3 Summary: Initial-syllable augmentation

Arapaho and Guhang Ifugao, discussed in §4.2.1.1, provide evidence for the existence of a version of ONSET that is relativized to the strong position initial syllable — these languages allow onsetless syllables generally, but specifically require onsets in initial syllables.

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[27]This is actually quite an interesting problem. It is not *COMPLEXONSET that rules out (56a) in Sestu, because complex onsets involving non-glides, as in *tronu* 'thunder', do occur. One approach might be to make use of a constraint requiring glides (and other vocalic elements) to be moraic — perhaps as part of yet another sonority-related constraint subhierarchy — but the broader consequences of positing such a constraint family, and its interaction with other constraints in the system, require further investigation.

The languages examined in §4.2.1.2 all provide evidence for an initial-syllable-specific version of the *ONSET/X subhierarchy, because they are languages in which high-sonority onsets are banned in initial syllables, but permitted in other syllables. In Mongolian, Kuman, Guugu Yimidhirr, and Pitta-Pitta, the first three constraints in the subhierarchy, [*ONSET/GLI]/σ_1 >> [*ONSET/RHO]/σ_1 >> [*ONSET/LAT]/σ_1, outrank the conflicting faithfulness constraints; as a result, glides and all liquids are banned from the true onset position in initial syllables (although glides do appear word-initially in these four languages, since they have an alternative possible syllabification as nuclear onglides). Mbabaram and Sestu Campidanian have only the first two of these constraints ranked above the conflicting faithfulness constraints, so they ban initial true-onset glides and initial onset rhotics while permitting initial onset laterals. Mbabaram does allow word-initial glides, showing that this language also permits glides to be syllabified as nuclear onglides rather than as true onsets. However, Sestu completely bans word-initial glides as well as rhotics, which correlates with the fact that this dialect also bans rising diphthongs; thus, nuclear onglides are in general disallowed in this language.

The theory of positional augmentation constraints predicts that there should be languages in which even more of the [*ONSET/X]/σ_1 hierarchy is ranked above faithfulness constraints, meaning that even more classes of segments (e.g., glides, liquids, *and nasals*) should be banned from word-initial position in some language. Recall that this prediction is borne out for the stressed-syllable version of this constraint subhierarchy (§3.2.2.4), since Pirahã has even the comparatively low-ranking [*ONSET/D]/$\acute{\sigma}$ ranked high enough to be active. Languages that show a tendency to avoid even medium-sonority onsets such as nasals or voiced segments, whether in stressed syllables, in initial syllables, or in all positions, are admittedly rare, but this may be simply because a language that restricts possible onsets in output forms to such a degree is less effective as a tool for communication and would therefore be subject to strong diachronic pressure to change its constraint ranking.[28] Notably, there are languages that enforce many of the constraints of the *ONSET/X subhierarchy in reduplication, by violating faithfulness constraints on the B(ase)-R(eduplicant) correspondence relation (rather than on the I(nput)-O(utput) relation). Examples include Sanskrit, where it is the least sonorous member of a base onset cluster that is copied in the reduplicant (Steriade 1982, 1988), and Halq'eméylem', where sonorant onsets are avoided in reduplicants (Urbanczyk 1999a).

Further discussion of predicted and attested initial-syllable augmentation constraints is given in §4.2.3 below.

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[28]One language that appears to have the ranking [*ONSET/D]/σ_1 >> IDENT[voice] is Bakairi (Wetzels & Mascaró 2001). This language has several complicated restrictions on the voicing of obstruents, but the relevant fact for present purposes is that voiced and voiceless obstruents are contrastive, but obstruents in word-initial position can only be voiceless. Thanks to Rachel Walker for bringing this example to my attention.

4.2.2 Positional augmentation in roots

This section presents examples of positional augmentation effects in the other psycholinguistically strong position, the root. The root qualifies as a psycholinguistically strong position because roots are important in the organization of the lexicon and thus in how lexical entries are accessed (see §4.3.3 below). As a strong position, the root is predicted to resist positional neutralization, and such cases are indeed attested (see, e.g., McCarthy & Prince 1995; Casali 1996; Beckman 1998; Alderete 1999b, 2001). Likewise, roots are predicted to undergo positional augmentation effects. Augmentation constraints that are seen to affect roots include HAVESTRESS/Root (§4.2.2.1); it may also be the case that the familiar root-minimality effects are the result of root-specific augmentation constraints (§4.2.2.2).

4.2.2.1 Obligatory root stress: HAVESTRESS/Root

One well-attested positional augmentation constraint for roots is HAVESTRESS/Root, formulated as follows (see §2.3.2.6 on general HAVESTRESS).

(57) HAVESTRESS/Root — For all syllables *x*, if the head of *x* is affiliated with a root, then *x* bears stress

If this constraint is ranked high enough to be active, then a language will show a requirement for root stress. In some cases, as in Diegueño (Yuman; Langdon 1975, 1977), root stress is mandatory, indicating that HAVESTRESS/Root is undominated. There are also languages, such as Tuyuca (Tucanoan; Barnes 1996; Smith 1998), in which the requirement for root stress is subordinated, e.g., to the faithful preservation of input affix stress, but when all else is equal, root stress is enforced — an instance of "the emergence of the unmarked" (McCarthy & Prince 1994). Additional languages that have been claimed to have a requirement for root stress include Tahltan (Athapaskan; Cook 1972, Nater 1989, Alderete 1999b, 2001), Chukchee (Paleo-Siberian; Krause 1979), Nancowry (Nicobarese; Radhakrishnan 1981), and Mbabaram (Australian; Dixon 1991).

It is important to note that not all languages that prefer to place stress on roots can serve as evidence for the **M/Root** constraint HAVESTRESS/Root. For example, Alderete (1999b, 2001) argues that the preference for root stress in Cupeño (Uto-Aztecan; Hill & Hill 1968) has its basis in root-specific faithfulness (**F/Root**) constraints; an underlying root stress is preferentially realized over an underlying affix stress, but an underlying affix stress will be realized when the root is unstressed, just as in Tuyuca (see below). Crucially, however, when no morphemes in a word have an underlying stress, the surface form has stress on the word-initial syllable, whether or not it is part of the root. The default, markedness-driven pattern is thus left-edge stress, not root stress. This motivates the following ranking for Cupeño, in which HAVESTRESS/Root plays no role.

(58) FAITH(Stress)/Root >> FAITH(Stress) >> ALIGN-L(σ́, PrWd)

Thus, crucial evidence for HAVESTRESS/Root comes not from Cupeño, but from languages like Diegueño and Tuyuca, in which roots are *compelled* to have stress, rather than merely being given priority to realize an underlying stress when they have one.

Diegueño (Yuman; Langdon 1975, 1977) is a language in which roots always bear stress in output forms. (Here and in the following discussion, roots are underlined.)

(59) Root stress in Diegueño (Langdon 1977:239-240)

(a)	mát	'land'
(b)	tə-xə-mə-kʷán-p	'is tangled up'
(c)	m-aːkuːxáp[29]-c-mə-yu *you-catch.up-SAME.SUBJ-you-be*	'Are you catching up with him?'

In a Diegueño-type language, with mandatory root stress, HAVESTRESS/Root must be ranked above all relevant faithfulness constraints, as well as above any markedness constraints (such as stress-alignment constraints or **M/σ́** constraints) whose satisfaction would cause stress to fall outside the root. A representative set of constraints that must be crucially dominated by HAVESTRESS/Root in a Diegueño-type language is shown in (60).

(60) A language with mandatory root stress (hypothetical form)

/ma+du+tá/	HAVESTR/Rt	ALIGN-L(σ́)	[*PK/HIV]/σ́	FAITH(Stress)
☞ a. madúta		*	*	*
b. máduta	*!			*
c. madutá	*!	**		

In Diegueño-type languages, the positional augmentation constraint HAVESTRESS/Root is undominated, so stress always appears on a root vowel. Unlike the ranking for Cupeño, the high-ranking constraint that compels root stress here cannot possibly be a positional faithfulness constraint such as MAX-PROM/Root (which penalizes the deletion of a root stress; Alderete 1999b, 2001), because the satisfaction of a faithfulness constraint, by definition, cannot *force* roots to have stress. The relevant constraint must be one that specifically requires the root to bear stress, that is, the **M/Root** constraint HAVESTRESS/Root.

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[29]Langdon (1977:239) notes that the stem *aːkuːxáp* contains three prefixes, but she does not segment them. According to Langdon's (1975, 1977) descriptions, roots in Diegueño are always monosyllabic, so the root here must be *áp* or *xáp*.

Another language for which the existence of HAVESTRESS/Root is crucial is Tuyuca (Tucanoan; Barnes 1996; Smith 1998). Here, HAVESTRESS/Root is not undominated as it is in Diegueño-type languages. Tuyuca has a lexical contrast between stressed and unstressed roots, and between stressed and unstressed affixes. When a word is formed from a stressless root and a stressed affix, the surface form will have stress on the affix, violating HAVESTRESS/Root in order to satisfy faithfulness constraints. However, in situations where faithfulness to underlying stress is not at stake, the effects of HAVESTRESS/Root emerge. Namely, when a word in Tuyuca contains only stressless morphemes, the obligatory default stress is inserted into the root rather than into an affix, so that HAVESTRESS/Root is satisfied. Once again, a system that has no markedness constraint specifically requiring root stress is unable to account for this pattern.

According to Barnes (1996), stress in Tuyuca is assigned at the level of the PrWd, which consists of a root optionally followed by one or more suffixes.[30] Both roots and suffixes can be underlyingly specified for stress, and the location of stress within roots is also lexically contrastive[31] (suffix stress location is generally predictable; see Barnes 1996 for discussion).

(61) Lexical contrasts for stress in Tuyuca (data from Barnes 1996)

	Roots		**Suffixes**	
Stressed	hóa	'to write'	-mẽ́nã	'with'
	póa	'hair'	-mãkẽ́	'stuff'
	waí	'fish'	-díkɨ	'only'
	kapéa	'eye'	-sotoá	'on top of'
	keeró	'lightning bug'	-jú	'beforehand'
	hóo	'to plant manioc'	-wí	(an evidential)
	hoó	'to cut slashes'	-gó	(fem. sg. vb. sfx.)
Unstressed	hoo	'to submerge oneself'	-a	(an evidential)
	nõã	'who'	-i	(an evidential)
	waka	'splinter'	-je	(change of focus)
	waso	'to change'	-sa	(thematic importance)

A stressed root is one that bears stress regardless of what suffix is attached to it (62a), while an unstressed root is one that bears stress when concatenated with certain suffixes but not with

[30]There is a two-morpheme window for stress assignment in Tuyuca — all morphemes after the first two in a PrWd (or the first three, in certain circumstances involving classifiers) are ignored in determining the placement of stress. See Barnes (1996:46 ff.) for discussion. Since Tuyuca has no prefixes, the root will always be included in the stress-assignment window.

[31]The verb roots analyzed by Barnes (1996) as having a lexically specified floating stress are reanalyzed in Smith (1998) with lexical stress on the root-final mora.

others (62b). A stressed suffix is one that bears stress when attached to an unstressed root[32] (62c); an unstressed suffix is one that never bears stress (62d).

(62) Stressed and unstressed morphemes in combination (Barnes 1996:41)

		Roots	
		stressed	*unstressed*
Suffixes		(a) /hóa/ 'to write'	(b) /waso/ 'to change'
stressed	(c) /-jú/ (ASP.)	hóaju	wasojú
unstressed	(d) /-i/ (EV.)	hóai	wasói

Thus, surface stress appears on an affix when a lexically stressed affix is combined with a lexically unstressed root. This fact indicates that MAX-PROM (63), which bans the deletion of input stress specifications, must dominate HAVESTRESS/Root, as shown in (64).

(63) MAX-PROM A metrical prominence (=stress) in the input must have an output correspondent. (Alderete 1999b, 2001)

(64) Stressed affix and unstressed root: affix bears stress

/hoo + wí/ *submerge.oneself*-EV 'he submerges himself'

/hoo+wí/	MAX-PROM	HAVESTRESS/Rt
a. hoówi	*!	
☞ b. hoowí		*

Because the faithfulness constraint MAX-PROM outranks HAVESTRESS/Root, the latter can never force stress to fall on a lexically unstressed root rather than on a lexically stressed affix. However, the effects of HAVESTRESS/Root emerge whenever MAX-PROM is inactive. One such situation arises when a PrWd is composed entirely of unstressed morphemes, as in (65). Since there are no input stresses to be deleted, no candidate violates MAX-PROM. The

[32]Affix stress also surfaces when a verb with final stress is combined with a monosyllabic nominalizer. In this case, the verb stress is deleted, and the affix stress is realized. The analysis presented in Smith (1998) accounts for this pattern by means of a noun-specific positional faithfulness constraint that prevents deletion of stress in morphemes that are [+N(oun)], including nominalizers.

undominated constraint CULMINATIVITY requiring every PrWd to have exactly one stress (see §2.3.2.6) forces stress insertion, but the choice between root stress (65b) and affix stress (65c) falls to HAVESTRESS/Root, which selects the candidate with root stress.[33]

(65) No underlying stress: default stress falls on root

/hoo + a/ *submerge.oneself*-EV 'I submerge myself'

/hoo+a/	CULMINATIVITY	MAX-PROM	HAVESTRESS/Rt
a. hooa	*!		*
☞ b. hoóa			
c. hooá			*!

Since there are both general and root-specific faithfulness constraints (McCarthy & Prince 1995; Beckman 1998; Alderete 1999b, 2001), insertion of a default stress into a root is a greater faithfulness violation than insertion of the stress into the affix (66).

(66) Faithfulness violations for stress insertion

/hoo+a/	DEP-PROM/Root	DEP-PROM
a. hoóa	*!	*
b. hooá		*

No matter how DEP-PROM and DEP-PROM/Root are ranked with respect to one another, insertion of default stress into a root rather than into an affix could never be optimal if these were the only relevant constraints in the system. Default stress on roots can be compelled only if HAVESTRESS/Root is part of the system and outranks DEP-PROM/Root (67). (The ranking of general DEP-PROM with respect to HAVESTRESS/Root is irrelevant, since undominated CULMINATIVITY will force one violation of general DEP-PROM whenever there is no input stress.)

[33]Barnes (1996) states that default stress is always inserted on the *rightmost* vowel (mora) of the root, which indicates that the ranking HAVESTRESS/Root >> ALIGN-R(σ́, PrWd) determines default stress placement. Crucially, it is not simply *left*-edge alignment of stress that is responsible for placing stress on the root rather than on a suffix.

(67) HAVESTRESS/Root compels root-stress insertion

/hoo+a/	HAVESTRESS/Rt	DEP-PROM/Rt	DEP-PROM
☞ a. hoóa		*	*
b. hooá	*!		*

The other configuration in which HAVESTRESS/Root shows emergent effects is a word in which there is a lexically specified stress both on the root and on an affix, as in (68). In this case, undominated CULMINATIVITY rules out any candidate with more than one stress. All candidates that satisfy CULMINATIVITY violate MAX-PROM equally, so MAX-PROM is not active in determining the winner. Again, the decision falls to HAVESTRESS/Root, which chooses root stress (68b) over affix stress (68c).

(68) Multiple underlying stresses: root stress survives

/hóo + wí/ *plant.manioc*-EV 'he plants manioc'

/hóo+wí/	CULMINATIVITY	MAX-PROM	HAVESTR/Rt
a. hóowí	*!		
☞ b. hóowi		*	
c. hoowí		*	*!

A candidate that deletes an underlying affix stress would also be chosen over one that deletes an underlying root stress, as in (68), by faithfulness constraints, just as in Cupeño (Alderete 1999b, 2001) — deleting an affix stress violates only MAX-PROM, but deleting a root stress violates both MAX-PROM and MAX-PROM/Root. However, there is no faithfulness alternative for the obligatory *insertion* of stress into roots (as in (67)). For the insertion case, HAVESTRESS/Root is crucial. Thus, Tuyuca provides additional evidence for the inclusion of HAVESTRESS/Root in the universal constraint inventory.

The relevant constraint ranking for Tuyuca is summarized in (69).

(69) CULMINATIVITY >> MAX-PROM >> HAVESTRESS/Root >> DEP-PROM/Root

└──→ DEP-PROM

Undominated CULMINATIVITY ensures that every PrWd has one and only one stress. MAX-PROM >> HAVESTRESS/Root means that default root stress will never be assigned if there is an underlyingly stressed affix available. But even though HAVESTRESS/Root is dominated, its effects emerge in cases where MAX-PROM is inactive; the crucial case is a word in which no morpheme has an underlying stress, so that a default stress must be inserted.

In summary, HAVESTRESS/Root is an augmentation constraint that acts to enhance the strong position root with the prominent property stress. When this constraint outranks stress-location constraints and faithfulness constraints that preserve underlying affix stress, then stress always falls on roots. Even when this constraint is dominated by faithfulness constraints so that some words bear stress on their affixes, its effects may emerge as a requirement that inserted default stresses fall on roots.

4.2.2.2 Root minimality effects

In addition to the root-stress requirement considered in §4.2.2.1, there is another property that is often enforced specifically of roots: in many languages, roots are subject to minimal-word (i.e., bimoraic or disyllabic) size requirements. Such requirements result from demands that roots be coextensive with prosodic words (Prince 1980; Broselow 1982; Crowhurst 1992; McCarthy & Prince 1986, 1990). Minimality requirements on PrWds are themselves obtained from the prosodic hierarchy: a PrWd must contain a foot, and (non-degenerate) feet are minimally binary.

The question that must be addressed, then, is how to ensure that a root contains a whole PrWd. Minimality effects have most often been analyzed within OT, following McCarthy & Prince (1993ab), as the combined effect of separate alignment constraints demanding that the left and right edges of the morphological category in question to be aligned with the analogous edges of PrWds. Aligning the left edge of a root with the left edge of a PrWd, and the right edge of a root with the right edge of a PrWd, entails that the root contains (at least) one PrWd.

This approach to root minimality requirements, which can be called the "double-edge alignment" approach, is quite attractive; it forces roots to match up with PrWds using nothing but alignment constraints, the existence of which is independently motivated. However, the requirement that roots fill out a prosodic constituent of a particular size is reminiscent of an augmentation process — ensuring that roots are fairly large does have the effect of ensuring that they are perceptually prominent. But formally, there is no way to view the double-edge alignment approach to root minimality as a kind of root augmentation, since roots are mapped onto PrWds only when two independent alignment constraints (for the two edges, L and R) happen both to be high ranking. Under this approach, there is no single constraint that requires roots to contain PrWds or otherwise forces them to be large.

Several previous approaches to root minimality effects did have more of the flavor of root augmentation constraints, however. For example, Prince & Smolensky's (1993:43) constraint LX≈PR(*MCat*) 'A member of the morphological category *MCat* correspond[s] to a PrWd' was designed to be relativized to different morphological categories, so that, e.g., roots, stems, and MWds could each be compelled to equal a PrWd in size. Similarly, earlier work by McCarthy &

Prince (1991 [cited in McCarthy & Prince 1993a]) makes use of morphology/prosody output constraints of the form 'MCat=PCat', a schema which would allow for the instantiation 'Root=PrWd'.

Furthermore, it has been argued in Smith (1998, 1999, 2001) that the lexical category noun behaves as a strong position with respect to avoidance of positional neutralization. As yet, no unambiguous instances of noun augmentation have come to light, but there is at least one language with noun-specific minimality effects: in Chuukese [Trukese] (Muller 1999), nouns must be bimoraic, but verbs need not be; furthermore, monomoraic verbs, without affixation, are well-formed utterances.

Thus, roots and nouns, both of which are strong positions, are both seen to have minimality requirements. This is at least suggestive that the existence of prosodic minimality requirements for a lexical/morphological constituent is related to its status as a strong position. However, additional investigation is needed to determine whether it is appropriate to treat minimal-size requirements as a type of augmentation effect (with a single size-enforcing constraint that can be relativized to strong positions like roots and nouns, perhaps formalized as a word-level counterpart to Truckenbrodt's (1999) phrasal WRAP constraints), or whether the formally simpler double-edge alignment approach is preferable, despite its lack of any fundamental connection to the status of an element as a strong position.

4.2.2.3 Summary: Root augmentation

Roots, as strong positions, are predicted to be eligible for positional augmentation (**M/Root**) constraints. This prediction is borne out: the constraint HAVESTRESS/Root is active in a number of languages, overriding faithfulness (and root faithfulness) constraints and requiring output forms to place stress within the root. Root minimality effects are another possible case of positional augmentation in roots, but further research is required before specific claims can be made about the constraints responsible for minimality effects.

4.2.3 Conclusion: Predicted and attested M/Ψstr constraints

This section has presented examples of languages in which positional augmentation constraints for psycholinguistically strong positions are active: ONSET/σ_1, [*ONSET/X]/σ_1, and HAVESTRESS/Root. As discussed in §2.4, fewer positional augmentation constraints are predicted to exist for psycholinguistically strong positions than for phonetically strong positions; the former are important in early-stage word recognition, so there are substantive reasons to avoid neutralizing crucial contrasts — that is, contrasts in features that are relevant in the early stages of speech perception — in these positions.

The constraint filter that formally represents this substantive pressure is the Segmental Contrast Condition (introduced in §2.4.1, with further discussion and justification in §4.3 below). This filter screens out **M/Ψstr** constraints whose satisfaction would require the neutralization of contrasts that are relevant in early-stage word recognition. Since contrasts involving stress are not important at that stage of processing (see §4.3.4.1 for discussion), HAVESTRESS/Root is a legitimate **M/Ψstr** constraint according to the Segmental Contrast Condition. Furthermore, the Segmental Contrast Condition has a disjunctive formulation, such that an **M/Ψstr** constraint is also acceptable if the strong position is the initial syllable and the constraint is one that enforces low sonority at the left edge. ONSET/σ_1 and the members of the [*ONSET/X]/σ_1 subhierarchy are therefore able to pass the Segmental Contrast Condition as well.

However, a number of other formally possible **M/Ψstr** constraints (which, moreover, pass the Prominence Condition) are predicted not to pass the Segmental Contrast Condition. These are indicated in (70) with the notation 'SCC'.

(70) Predicted positional augmentation constraints for psycholinguistically strong positions

	σ_1	root
ONSET/*str*	Arapaho Guhang Ifugao	***SCC***
[*ONSET/X]/*str*	Campidanian Sardinian Mongolian, Kuman, etc. Mbabaram	***SCC***
[*PEAK/X]/*str*	***SCC***	***SCC***
HAVECPLACE/*str*	***domain mismatch***	***SCC***
HEAVYσ/*str*	***SCC***	***SCC***
HAVESTRESS/*str*	***??***	Diegueño Tuyuca
HTONE/*str*	***?? (SCC?)***	***?? (SCC?)***

For initial syllables, any constraint that refers to segmental contrasts, but whose satisfaction does not aid in left-edge demarcation, will fail to pass the Segmental Contrast Condition. Such constraints include [*PEAK/X]/σ_1 and HEAVYσ/σ_1. A further constraint that is predicted not to exist is HAVECPLACE/σ_1; relativizing HAVECPLACE to the position initial syllable leads to a domain mismatch (§2.2, §2.3.3), since the focus of this constraint makes reference to consonants, not syllables.

As discussed in §2.3.3, any of the markedness constraints in (70) can be relativized to the root with no domain mismatch, since the root is defined with reference only to morphological affiliation, not to segments or to prosodic categories. Nevertheless, most of these constraints are prohibited from having **M/Root** counterparts because of the Segmental Contrast Condition. For roots, there is no left-edge escape clause, so any constraint whatsoever that refers to a segmental contrast will be ruled out by the Segmental Contrast Condition; these include ONSET/Root, [*ONSET/X]/Root, [*PEAK/X]/Root, HAVECPLACE/Root, and HEAVYσ/Root.

The three cells remaining in the chart in (70), representing positional augmentation constraints for which no examples have been presented here, but which are not (unambiguously) predicted to be ruled out by the Segmental Contrast Condition or ill-formed because of a domain mismatch, are indicated with '??'. The constraints in question are HAVESTRESS/σ_1, HTONE/σ_1, and HTONE/Root. The remainder of this section considers each of these three potential **M/Ψstr** constraints.

The positional augmentation constraint HAVESTRESS/σ_1 is very clearly predicted to exist. The simple fact that HAVESTRESS/Root exists confirms that HAVESTRESS/**Ψstr** constraints pass the Segmental Contrast Condition; furthermore, experimental results show that stress does not play the same role as segmental contrasts in early-stage word recognition (see §4.3.4).

While there is at this time no conclusive evidence in support of the existence of HAVESTRESS/σ_1, there is also no evidence that it does not exist. It is uncontroversial that some languages have stress on initial syllables; in fact, as demonstrated by the cross-linguistic survey of stress patterns in Hyman (1977), initial-stress languages are common. Languages with mandatory initial stress include, for example, a large number of the Australian languages, Czech, Cahuilla, and many of the Finno-Ugric languages. If there is a positional augmentation constraint HAVESTRESS/σ_1, then it can account for languages with mandatory initial stress.

(71) Initial stress by HAVESTRESS/σ_1

/tatáta/	HAVESTRESS/σ_1	FAITH(Stress)
☞ a. tátata		*
b. tatáta	*!	
c. tatatá	*!	*

However, languages with mandatory initial stress can also be accounted for with a high-ranking ALIGN-L(σ́, Wd)[34] constraint, as demonstrated for example in Walker (1996).

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[34]The ALIGN-L constraint that most closely overlaps with HAVESTRESS/σ_1 is ALIGN-L(σ́, MWd), because (as argued in §4.4 below) the strong position "initial syllable" is best characterized as the MWd-initial syllable. However, in many stress systems, it will be difficult to distinguish empirically between ALIGN-L(σ́, MWd) and ALIGN-L(σ́, PrWd). In other words, ALIGN-L(σ́, MWd) and ALIGN-L(σ́, PrWd) are both alignment constraints that are potentially

(72) Initial stress by ALIGN-L(σ́, Wd)

/tatáta/	ALIGN-L(σ́, Wd)	ALIGN-R(σ́, Wd)	FAITH(Stress)
☞ a. tátata		**	*
b. tatáta	*!	*	
c. tatatá	*!*		*

Where initial stress is mandatory, such that no form in the language ever violates the constraint calling for it, then there is no way to determine whether initial stress is caused by HAVESTRESS/σ_1 or by ALIGN-L(σ́, Wd). However, as seen in (71) and (72), the two constraints have different patterns of violability. ALIGN-L(σ́, Wd), being an alignment constraint (McCarthy & Prince 1993a), is gradiently violable, but HAVESTRESS/σ_1 is categorically evaluated (either the initial syllable has stress, or it does not).

Because ALIGN-L(σ́, Wd) is gradient, it may still have partial effects in languages where it is crucially dominated — if stress cannot be leftmost, because that would violate some higher-ranked constraint, stress will at least be as far to the left as possible. This is the pattern seen in Western Arrernte stress (§3.2.2.2): stress is initial except in vowel-initial words, where it appears on the second syllable to satisfy ONSET/σ́ (subject to NONFINALITY).

(73) Western Arrernte main stress (Downing 1998; data from Strehlow 1942)

(a) rá:tama 'to emerge'
kútungula 'ceremonial assistant'

(b) arálkama 'to yawn'
ulúrba 'cold; cold wind'

As seen in §3.2, this kind of nearly-edge-bound stress pattern comes about when a higher-ranking constraint (in this case, ONSET/σ́) dominates ALIGN-L(σ́, Wd). Crucially, the alignment constraint is only minimally violated; stress still falls as far to the left as possible, while appearing on a syllable with an onset.

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responsible for enforcing left-edge stress.

(74) Gradient violation of ALIGN-L(σ́, Wd) in Arrernte

/aralkama/	ONSET/σ́	ALIGN-L(σ́, Wd)
a. áralkama	*!	
☞ b. arálkama		*
c. aralkamá		***!

The question now arises as to whether there are any stress systems with a tendency toward left-edge stress, but where violation of the left-stress constraint is categorical rather than gradient. If there are languages where stress, if prevented from falling on the initial syllable, shows no left-edge tropism but falls somewhere else entirely, then this would provide stronger evidence for the existence of HAVESTRESS/σ_1 in addition to ALIGN-L(σ́, Wd).

The status of HTONE/σ_1 and HTONE/Root is less clear. Whether or not these are predicted to be legitimate **M/Ψstr** constraints depends on the degree to which tonal contrasts are utilized in early-stage word recognition, a question that is far from settled (see §4.3.4.2 below). If these constraints do exist, there should be languages in which initial syllables and roots obligatorily bear a H tone, so that (for example) H tones underlyingly associated with other syllables in the word either move or spread to the initial syllable or root respectively.

In summary, §4.2 has presented evidence for the existence of certain **M/Ψstr** constraints, namely, ONSET/σ_1, [*ONSET/X]/σ_1, and HAVESTRESS/Root, and has discussed certain theoretical implications of the existence of these constraints (especially the implications of [*ONSET/X]/σ_1 for the syllabification of pre-peak glides). The discussion here has also shown that the comparatively restricted inventory of **M/Ψstr** constraints is predicted by the constraint filter known as the Segmental Contrast Condition (§2.4). The next section, §4.3, examines in more detail the psycholinguistic basis of the Segmental Contrast Condition.

4.3 Psycholinguistic evidence behind the Segmental Contrast Condition

This section presents psycholinguistic evidence in support of the substantive factors that are formalized in the Segmental Contrast Condition, the filter on **M/Ψstr** constraints introduced in §2.4.1, which is repeated here in (75).

(75) *Segmental Contrast Condition*

If a constraint is of the form **M/Ψstr**, then it must meet one of the following two conditions:

I. Satisfaction of the **M** constraint from which the **M/Ψstr** constraint is built does not alter features that are distinguished in early-stage word recognition.

or

II. **Ψstr** is σ_1, and satisfaction of the **M/Ψstr** constraint serves to demarcate the left edge of σ_1.

First, §4.3.1 presents an overview of the process of word recognition, which serves as background for the discussion of relevant psycholinguistic findings in the remainder of §4.3. §4.3.2 then shows that word-initial material is of particular importance in determining the set of lexical entries to be considered in early-stage word recognition, and §4.3.3 shows that roots have a special role in how the lexicon is organized and hence in how words are accessed. These two conclusions support, first, the identification of initial syllable and root as psycholinguistically strong positions; second, the definition of psycholinguistically strong positions as those positions that are of special importance in *early-stage* word recognition (as distinct from the stressed syllable, which is discussed in §4.3.4); and third, the idea that there are substantive reasons to avoid neutralizing phonological contrasts in these positions (a point further discussed in §4.3.5).

§4.3.4 then presents evidence that segmental and prosodic properties have fundamentally different roles in word recognition, motivating the narrow domain of relevance of the Segmental Contrast Condition: namely, its inapplicability to the strong position stressed syllable and its attention to segmental contrasts specifically. First, results are reviewed showing that stressed syllables are not used directly to access lexical items (although they are used in speech perception in other ways, such as in the related but distinct task of word segmentation). This is why the strong position stressed syllable is not subject to the Segmental Contrast Condition, a proposal that is empirically supported by the wide variety of **M/σ́** constraints discussed in Chapter 3 — while not irrelevant for speech perception, the stressed syllable is not a psycholinguistically strong position in the strict sense. This subsection also examines psycholinguistic evidence bearing on the question of whether tonal contrasts play the same kind of role in early-stage word recognition that segmental contrasts do. In short, the discussion shows that there is no substantive reason to avoid **M/Ψstr** constraints such as HAVESTRESS/Root and HAVESTRESS/σ_1 (and, perhaps, HTONE/Root and HTONE/σ_1); neutralizations affecting the prosodic properties relevant for such constraints have much less of an impact on the efficiency of word recognition. And as seen in §4.2 above, **M/Ψstr** constraints involving prosodic properties like stress are indeed attested.

Finally, §4.3.5 concludes the discussion of the psycholinguistic evidence by showing how that evidence supports the particular formulation that has been proposed for the Segmental Contrast Condition. Namely, decreasing the number of segmental contrasts available in the crucial positions initial syllable and root would have an adverse effect on word recognition (clause I). However, the ability to demarcate word boundaries clearly (as through satisfaction of ONSET/σ_1 and members of the [*ONSET/X]/σ_1 subhierarchy) is useful enough in speech perception to override the general avoidance of segmental-contrast neutralization in psycholinguistically strong positions (clause II).

4.3.1 Word recognition

Before the substantive pressures on psycholinguistically strong positions that are modeled in the Segmental Contrast Condition — and, more generally, the relevance of psycholinguistically strong positions for word recognition — can be considered in detail, some background discussion of the process of word recognition is necessary. (See also, e.g., Altmann 1990a, Forster 1990, Garrett 1990, and Handke 1995 for overviews of various aspects of word recognition and lexical access.)

Spoken-language understanding happens extremely quickly and at a level that is essentially inaccessible to conscious introspection. In the course of this process, a hearer receives acoustic input, matches that input to entries in his or her mental lexicon, and uses the syntactic and semantic information provided by the selected lexical entries (as well as non-linguistic factors such as the discourse context) to arrive at an interpretation of the utterance. *Word recognition*, one component of this procedure, is the process by which an incoming acoustic signal is matched with lexical entries so that the words in the utterance can be identified.[35]

The results of a body of psycholinguistic research indicate that there are two stages in word recognition. When an acoustic signal is first perceived, a set of lexical entries that resemble the incoming acoustic signal is activated, with no influence from syntactic or semantic context. Then, this initially activated set of lexical entries is quickly pared down until the single entry that is the best fit, phonologically and also syntactically and semantically, is identified.

Evidence for a distinction between early and later stages of word recognition comes, for example, from cross-modal priming experiments. Cross-modal priming is an experimental paradigm based on the finding that semantic priming (exposure to a semantically related word) causes a faster lexical-decision response ("word or nonword?") to a target word presented shortly after the prime. In a *cross-modal* priming experiment, participants listen to an auditory stimulus and are asked to make a lexical decision about a visually presented target. If some element in the auditory input causes the activation of a particular lexical entry, then the response time to a lexical decision for a visually presented target that is semantically related to the activated lexical entry should be faster than in control cases (where the visual target is unrelated to any lexical entry that would be activated by the auditory stimulus).

Cross-modal priming studies have shown that when a lexically ambiguous word such as *bug* or *rose* is first perceived, both of the corresponding lexical entries are initially activated, but

[35]Some sources use the term *lexical access* for this process. Both *word recognition* and *lexical access* are used fairly inconsistently in the literature (see Handke 1995:§1.3 for discussion); here, the term *word recognition* is used in the sense defined above, and *lexical access* is used more broadly to refer to aspects of speech processing that involve searching the lexicon or making use of lexically stored information.

within about two hundred milliseconds (equivalent to two or three syllables), only the appropriate entry remains activated (Swinney 1979; Seidenberg, Tanenhaus, Leiman, & Bienkowski 1982). For example, Seidenberg et al. found that, for the auditory stimulus *They all rose*, priming effects for the visual target FLOWER are observed when presented at the offset of *rose*, indicating that the homophonous lexical entries $rose_V$ and $rose_N$ are both activated at this point (even though only the verb is a syntactically appropriate choice). However, if the visual target FLOWER is presented after a 200 msec delay, no priming effects are observed, indicating that the inappropriate $rose_N$ entry is no longer activated.

It is not only homophonous lexical entries that are activated when an auditory stimulus is encountered. A number of studies (including some of those reviewed in §4.3.2-4 below) show that, more generally, a set of phonologically similar lexical entries is initially activated when input is processed. For example, Zwitserlood (1989) found that Dutch listeners showed priming effects for both *geld* 'money' and *boot* 'boat' on the offset of the auditory stimulus [kapiː], which is the initial portion of both *kapitaal* 'capital' and *kapitein* 'captain'. Similarly, Marslen-Wilson & Zwitserlood (1989) found a certain degree of priming for *bij* 'bee' on the offset of *woning* 'dwelling', a word that has a large amount of phonological overlap with *honing* 'honey'; this shows that listeners who hear *woning* activate *honing* (and therefore semantically prime *bij*). (However, Marslen-Wilson and Zwitserlood argue that a lexical entry is most strongly activated when it shares initial material with the auditory input; see §4.3.2.2).

Thus, initial contact with an auditory stimulus results in a certain subset of the lexicon being activated, and the initially activated subset of the lexicon is chosen only on the basis of phonetic/phonological information. Subsequent lexical processing examines the activated entries for goodness of phonological fit as well as for syntactic and semantic compatibility.[36] It is the stage of initial activation that is referred to in the discussion that follows as *early-stage word recognition*; §§4.2-4 present more detailed evidence supporting the claim that the initial syllable

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[36]Many of the auditory-processing models that have been proposed directly incorporate a two-stage model of word recognition. Examples include the Search model (Forster 1976, 1990), the Cohort model (Marslen-Wilson & Welsh 1978; Marslen-Wilson 1984, 1987), the Shortlist model (Norris 1994; Norris, McQueen, & Cutler 1995), and the Neighborhood Activation Model (Luce 1986; Luce & Pisoni 1998). These models differ in the factors and mechanisms that they consider to be involved in selection and competition among lexical entries (see §4.3.5 for additional discussion). However, they all propose that word recognition has two stages: a first stage, in which phonetic/phonological information is used to identify a set of candidate lexical entries for further examination, and a later stage, in which the selected set is narrowed down (often on the basis of more than just phonetic or phonological information) until the best-matching lexical entry is identified.

One influential model of speech perception that does not incorporate two distinct stages of word recognition is TRACE (McClelland & Elman 1986). However, see Norris (1994) on the advantages of a two-stage model such as Shortlist over a model that, like TRACE, attempts to search the entire lexicon at once without first identifying a subset of relevant entries to consider.

and the root are particularly important in early-stage word recognition, that the stressed syllable is not directly involved in this stage of processing, and that segmental features are involved in choosing the subset of lexical entries for initial activation but prosodic properties such as stress are less relevant at this stage.

4.3.2 The importance of word-initial material in early-stage word recognition

There is a considerable amount of psycholinguistic evidence that word-initial material plays a particularly important role in early-stage word recognition. In general, listeners have been shown to pay more attention to initial material than to later material, and to be more adversely affected by the disruption or mispronunciation of initial material than of material later in the word (§4.3.2.1). Word-initial material has also been more directly shown to have a strong influence on early-stage word recognition (§4.3.2.2). It is considerations of the kind addressed in this subsection that justify the identification of the word-initial position as a psycholinguistically strong position with special phonological status.

4.3.2.1 Word-initial material as a focus of perceptual attention

Brown & McNeill (1966) and Browman (1978) investigate the "tip-of-the-tongue" (TOT) phenomenon, in which experimental participants have partially, but not completely, recalled a particular word. Brown & McNeill (1966), using a written questionnaire study, found that the characteristic of the word most likely to be recalled by participants in a TOT state was the initial segment, although final material was more likely to be recalled than medial material.[37] Browman (1978) reports that providing a participant with the initial segment, or confirming the participant's recollection of the initial segment, was the most successful way to bring the participant out of a TOT state and promote actual recall of the target word.

Cole (1973) and Cole & Jakimik (1976, 1980) report the results of experiments in which participants were asked to detect deliberate mispronunciations in the auditory presentation of a short story. Cole (1973) found that listeners were more likely to detect a change in multiple features than a change in only one (i.e., voicing or place), but that a one-feature change was more likely to be detected in initial position than in the second or third syllable. Cole & Jakimik (1976, 1980) found that, in disyllabic words, stress facilitates the detection of mispronunciations equivalently in initial and second syllables (see also §4.3.4.1.1), but they confirm Cole's (1973) findings when unstressed syllables are considered: a mispronunciation in an initial unstressed syllable is more likely to be detected than a mispronunciation in a non-initial unstressed syllable.

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[37]Interestingly, Brown & McNeill (1966) show that words recalled by participants in a TOT state that are related by *meaning*, rather than by sound, to the as-yet unrecalled target word are more likely to be similar to the target word at the right edge than initially, suggesting that this may reflect a general tendency for English words to resemble each other more finally than initially. They conclude that "the *relative* superiority of the SS [similar-sound] curve is greater in the first three positions [than in the final three]" (emphasis in original).

Marslen-Wilson (1975) and Marslen-Wilson & Welsh (1978) present evidence from speech-shadowing tasks that mispronunciations are more likely to be perceived in initial, rather than later, portions of words. In speech shadowing, participants listen to auditory input and repeat it aloud. These studies found that listeners were much less likely to "restore" a mispronunciation (i.e., repeat it back as the correctly pronounced word, indicating that they have not noticed the mispronunciation) when it occurred in an initial syllable. Even when the mispronounced words were embedded in syntactic and semantic contexts that gave strong cues for what the correctly pronounced word should be, leading to a high rate of restoration in non-initial syllables, there were few instances of initial-syllable restorations. Marslen-Wilson (1984), reviewing these results, concludes that the effects of an initial mispronunciation on auditory processing are much greater than those of a mispronunciation in a later position.

Finally, Mattys & Samuel (2000) found that response times for phoneme monitoring (a task in which participants are asked to respond when they hear a particular phoneme) were faster when the target phonemes were onsets to initial syllables than when they were in other positions.

Thus, the studies reviewed here all indicate that listeners are more aware of, or pay greater attention to, material in the initial portion of the word.

4.3.2.2 A special role for initial material in early-stage word recognition

Given that word-initial material is, chronologically, the first portion of a word that a hearer encounters, and that hearers apparently pay special attention to initial material, it has the potential to play an important role in word recognition (Nooteboom 1981; Marslen-Wilson 1984). Several studies provide evidence that this is in fact the case.

Nooteboom (1981) shows that initial fragments are more useful than final fragments in identifying words. He identified a set of (Dutch) words that can be divided in two parts such that both the initial part and the final part are unique. For example, the word *surrogaat* 'substitute' is the only word that begins [sœroː], and the only word that ends [oː'χaːt]. When these fragments were played for listeners to identify, accuracy was higher and response times were faster for the initial fragments than for the final fragments.

Cole (1973) and Cole & Jakimik (1980) report that response times for the detection of mispronunciations, measured from the onset of the mispronounced phoneme, were longer when the mispronunciation occurred in the onset of the initial syllable than when it occurred in later material. Cole and Jakimik point out that this finding is compatible with a model in which word-initial material plays a special role in lexical access.

> According to this view, reaction times are faster to mispronounced second syllables because the intended word has been accessed as one of a set of word candidates from information in its (correct) first syllable.... By the same reasoning, a mispronounced first syllable provides misleading information, since the listener will access word

candidates beginning with the mispronounced syllable.... We assume that the subject initiates a [mispronunciation-]detection response when the second syllable fails to confirm any of the word candidates suggested by the first syllable. Thus, ... a mispronunciation in the first syllable of a word cannot be detected until information from a *subsequent* syllable is available. (Cole & Jakimik 1980:968; original emphasis)

Finally, there is evidence from semantic priming studies indicating that a match in word-initial material is more likely to activate a lexical entry than a match in later material. As noted above, semantic priming is a phenomenon in which prior exposure to one word, such as *captain*, facilitates the recognition of a semantically related target word, such as *boat*. That is, the response time to a lexical decision task ("word or nonword?") for a semantically primed target is faster than that to a control target that was preceded by a unrelated, non-priming word.

Marslen-Wilson, Brown, & Zwitserlood (1989) and Zwitserlood (1989) show that presentation of a phonetic string activates multiple lexical entries whose initial portions are compatible with it. For example, when (Dutch-speaking) listeners were presented with the stimulus [kapiː], which corresponds to the initial portion of two words, *kapitein* 'captain' and *kapitaal* 'capital', they showed semantic priming effects for both *boot* 'boat' and *geld* 'money'; this indicates that both *kapitein* and *kapitaal* were lexically activated by the string [kapiː].

Marslen-Wilson and Zwitserlood (1989) then examine the effect of semantic priming for what they call rhyme primes — words (and nonwords) that are identical to an intended prime word except in the initial segment. Their results show that semantic priming by a rhyme prime, such as *woning* 'dwelling' (tested for its priming effect on the target word *bij* 'bee', which would be primed by the intended rhyming word *honing* 'honey'), was less effective than priming by the intended lexical form (such as *honing* itself) or by an initial partial prime (as in the case of [kapiː] discussed above). Crucially, this was true even in the case of three-syllable rhyme primes, in which the degree of segmental overlap was even greater than that between [kapiː] and *kapitein* or *kapitaal*. Marslen-Wilson and Zwitserlood (1989) conclude that a match in initial material is more important in activating a lexical entry than simply the amount of total match across the whole of the form.

The results reported by Zwitserlood and colleagues are further supported by the findings of Pitt & Samuel (1995) that "beheading" words, i.e., removing their initial onsets, slows recognition. Pitt & Samuel (1995) first demonstrate that response time for a phoneme-monitoring task is faster for words than for nonwords in a condition where the uniqueness point (the point at which the word can be uniquely identified, or the nonword diverges from all possible words) comes early in the word or nonword. That is, successful word recognition at an early point gives the listener access to the lexical entry for that word, which facilitates phoneme monitoring. Listeners know that the target phoneme is part of the word perhaps even before they hear it, so they can respond quickly when they do hear it; but nonwords have no lexical entry, so there is no analogous effect.

However, the response-time advantage for words over nonwords disappeared when the words and nonwords had their initial onsets removed. The removal of the initial onset of a word therefore seems to inhibit word recognition, even when (as in the rhyme-prime study of Marslen-Wilson & Zwitserlood 1989) there is otherwise a good match between the stimulus and the non-initial portion of the target lexical entry.

In conclusion, these results show that word-initial material is paid particular attention in speech perception (§4.3.2.1), and more specifically that word-initial material has a particularly strong influence on how well a given lexical entry is deemed to match the acoustic input during early-stage word recognition, as seen in the results of experiments that test whether or how easily certain lexical entries are activated by a given acoustic input (§4.3.2.2).[38] Thus, the initial syllable is legitimately included in the set of psycholinguistically strong positions.[39]

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[38]The importance of initial material in early-stage word recognition has been given different implementations in different models of speech processing. For example, in the Search model (Forster 1976, 1990), the first few phonemes from the acoustic input function as an access code that activates all lexical entries with a matching initial portion. In the Cohort model (Marslen-Wilson & Welsh 1978; Marslen-Wilson 1984, 1987), the first few segments of the word are used to retrieve a 'cohort' of possible word-candidates from the lexicon with matching initial segments; the cohort is then narrowed down to one word through the use of syntactic, semantic, and further phonetic or phonological information. In interactive activation models such as TRACE (McClelland & Elman 1986), there is no initial retrieval of a set of word-candidates based on the first few segments; instead, all lexical entries that are sufficiently similar to the auditory input become partially activated and compete with each other. In models such as these, the special importance of word-initial material may be incorporated by allowing a word-initial match to enhance activation levels more than a match in later positions in the word, as has been suggested for a TRACE-type model by Marslen-Wilson (1987) and Marslen-Wilson & Zwitserlood (1989).

[39]Most of the psycholinguistic results discussed in this section indicate that the first few segments of a word are important in recognition, but they do not necessarily point to the initial *syllable* as a unit. Nevertheless, the positional-neutralization patterns examined by Beckman (1995, 1997, 1998) show privileged behavior in the initial syllable as opposed to other syllables, indicating that it is indeed a syllable-sized unit that is a phonologically strong position. In fact, there is evidence that syllables are used in processing as a basic perceptual unit, at least in some languages (see, e.g., Mehler, Dommergues, Frauenfelder, & Segui 1981; Segui, Dupoux, & Mehler 1990), although Cutler, Mehler, Norris, & Segui (1986) argue that syllables are not used as basic units for processing by native listeners of English.

If the syllable is available as a basic perceptual unit in the processing of spoken language, then it is not surprising that the initial syllable would be treated as a strong position on the basis of the importance of initial material. (Segui, Dupoux, and Mehler (1990), for example, explicitly propose that early-stage word recognition in French is based on the initial syllable). And even if the syllable is not a universally basic unit of perception, it may well be that the grammar gives

4.3.3 The importance of roots in early-stage word recognition

The morphological root has been identified as a strong position on the basis of its ability to resist phonological processes and to maintain greater numbers of phonological contrasts than affixes can have (see, e.g., McCarthy & Prince 1995; Alderete 1999b, 2001; Urbanczyk 1996ab, 1999b; Pater 1996, 1999; Beckman 1998; Struijke 1998, 2000).

This section reviews evidence that roots qualify for inclusion in the set of psycholinguistically strong positions because they are important in early-stage word recognition.[40] Roots are shown to affect word recognition in inflectionally complex forms (§4.3.3.1), and, crucially, even in derivationally complex forms (§4.3.3.2). The latter result is somewhat surprising, given a widely held view of the structure of the lexicon in which derivationally complex forms have their own lexical entries (Chomsky 1970; Halle 1973; Aronoff 1976; Scalise 1986). This view of the lexicon is supported in that derivationally complex forms often have idiosyncratic, non-compositional meanings; derivational affixes are often less than fully productive; and native speakers are able to distinguish between "actual complex words" and "possible but non-occurring complex words." Nevertheless, the psycholinguistic evidence reviewed in §4.3.3.2 indicates that roots play an important role in early-stage word recognition even for derivationally complex forms.

These results support the proposal that roots play a fundamental role in determining how lexical entries are structured and thus in how morphologically complex lexical entries are accessed during early-stage word recognition.

4.3.3.1 Processing of words with inflectional affixes

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the special status of a strong position to the entire initial syllable because it is the single grammatical constituent that best matches the psycholinguistically relevant "first few segments".

Casali (1996, 1997) actually does propose positional faithfulness constraints for initial segments, but since he is looking at positional faithfulness effects specifically in word-initial vowels, his findings are consistent with initial-syllable faithfulness.

[40]The extent to which information about the complete morphological structure of a word is relevant at prelexical stages of processing — and therefore the extent to which it is relevant for word recognition — is somewhat controversial (see, e.g., Henderson (1985) and Hawkins & Cutler (1988) for reviews of the literature). Furthermore, several of the experiments discussed below are visual rather than auditory experiments, and not all results from visual experiments may be directly applicable to theories of auditory processing. (It is clearly indicated for each experiment below whether or not it was auditory.) Despite these complications, there is a reasonable amount of evidence that roots are important in the recognition of morphologically complex words.

Roots have been shown to be much more involved than inflectional affixes in early-stage word recognition. For one thing, it is known that various aspects of language processing are sensitive to word frequency, but several studies have indicated that, for an inflected form of a particular root, it is the frequency of the root itself or of the whole set of inflected forms that is relevant, rather than the frequency of the individual inflected form. Rosenberg, Coyle, & Porter (1966) ran an experiment in which they presented visual lists including English *-ly* adverbs and then asked participants to recall the presented items. Rosenberg et al. found that adverbs formed from high-frequency adjective roots were more likely to be recalled than adverbs formed from low-frequency adjective roots, even though the adverbs themselves were all low-frequency words. Compatible results for nouns have been found by Baayen and Schreuder and their colleagues: Baayen, Dijkstra, & Schreuder (1997) and Baayen, Burani, & Schreuder (1996) show, for Dutch and Italian respectively, that visual lexical decision times for basic, uninflected nouns are affected by the frequency with which all inflected forms of those nouns occur, not by the frequency of the bare or basic form alone. The results of these three studies show that, for aspects of processing that are sensitive to frequency of occurrence, all inflected forms of a given root are considered tokens of the same item.

Other studies further support the claim that in early-stage word recognition, inflectional affixes are not considered an integral part of the word to be recognized (or at least play a subordinate role to that of roots). A study by van der Molen & Morton (1979) showed that nouns and their plural morphemes were sometimes recalled separately in a visual memory task. Participants were presented with lists of six words each, and were asked to recall the contents of each list. Every list included singular nouns; some lists included plural nouns as well. In 17% of the cases in which nouns were recalled that had been plural in the lists, they were incorrectly recalled in the singular. By contrast, there were extremely few instances of singular nouns being incorrectly recalled as plural forms, with one interesting exception: spurious plurals did occur in cases where a plural noun from the same list had been incorrectly recalled (forgotten entirely or recalled as a singular noun), as though such errors had given rise to a "loose" plural morpheme in memory. van der Molen & Morton (1979) thus conclude that the nouns and the plural morphemes were given somewhat independent representations in memory during the recall task.

Jarvella & Meijers (1983), in an auditory experiment, found a similar separation between verb roots and inflectional morphology in Dutch, a result which is particularly interesting in that some of the inflectional affixes in their study were prefixes rather than suffixes (past-participial *ge-* on two of the three classes of verbs). Listeners were presented with a verb in either a past or past-participle form, and had to identify whether the verb that came at the end of a subsequent string of words was the same or different with respect to either the root or the inflectional form. Jarvella & Meijers found that both "same" and "different" responses were faster for the dimension "root" than for the dimension "form," even when the two verbs given were different forms of the same root. Interestingly, the advantage for "root" over "form" responses was found even in cases where decisions about form involved prefixes and so were in principle possible to make even before the roots themselves could have been recognized. These results suggest that the recognition of a verb root is faster or easier than the recognition of an inflectional affix, and are compatible with a theory in which inflected forms are accessible only if the root is accessed first.[41]

Results from auditory and visual experiments on inflected forms in Serbo-Croatian have been used to argue for a "satellite model" of lexical organization (Lukatela, Gligorijevic, Kostić, and Turvey 1980), in which the oblique-case forms of nouns are accessed through the nominative form. Lukatela et al. (1980) present results from a visual lexical-decision task showing that response times to all oblique case forms of a particular noun are the same, even when the individual frequencies among oblique cases differ (i.e., the genitive is typically much more frequent than the instrumental). Furthermore, the response times to the oblique forms are slower than to the nominative form, again, even when certain oblique forms are no less frequent than the nominative form. These original results have been replicated, again in Serbo-Croatian, by Katz, Boyce, Goldstein, & Lukatela (1987) in an auditory study and by Lukatela, Carello, & Turvey (1987) in a visual study that included nouns whose root shape changes in some but not all oblique forms. While in Serbo-Croatian the form with special status in early-stage word recognition is the nominative form, which does not always correspond exactly to the morphological root (as in [frula] 'flute-NOM' from the bound root /frul-/), the evidence that supports the satellite model does at least show that all the inflectional forms of a given root are stored together and cannot be accessed independently.

Finally, there are studies showing that inflected forms of a root are able to prime the bare or basic form of the root, in many cases to the same extent as "identity priming" of the root by a prior occurrence of the root itself. Stanners, Neiser, Hernon, & Hall (1979), in a visual lexical-decision task using English verb roots, found that regularly inflected verb forms (such as *pours* or *poured*) are as effective at priming the bare root *pour* as is a prior presentation of *pour* itself. They found that irregularly inflected verbs (i.e., *hung* as a prime for *hang*) also showed significant priming effects, although not as much as the regularly inflected forms. But even the partial priming effect observed by Stanners et al. for irregular inflections was, they state, "larger and more robust" than the effect of ordinary semantic priming between morphologically unrelated words (such as *captain* and *boat* or *bee* and *honey*).

Fowler, Napps, & Feldman (1985) argue that the difference found by Stanners, Neiser, Hernon, & Hall (1979) between regular and irregular inflected forms was an artifact of their experimental design. Fowler et al. (1985) used Stanners et al.'s (1979) design and replicated their results, but then, using a modified design that allowed more words to intervene between the prime and the target to reduce the effects of episodic priming (i.e., the participant's actually remembering a prior stimulus-response pair), they found *equivalent* priming of roots by regular and irregular inflected forms. (Similarly, Jarvella & Meijers (1983) found no difference in the response times for "stem" judgments between strong ("irregular") and weak ("regular") verbs in

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[41]However, it will be seen in §4.3.4 that non-initial stressed syllables have been shown to cause spurious lexical-access attempts in Dutch. Since the inflectional prefix *ge-* is unstressed, there may be a stress-related confound in these results.

Dutch.) Fowler et al. (1985) also replicated their results in an auditory version of their study, again finding statistically full priming of roots — and in this study, of complex forms as well — by regular and irregular inflected forms.

Feldman & Moskovljević (1987) found similar results for Serbo-Croatian, namely, that a dative/locative form is primed by the nominative (basic) form just as much as by itself. They found significant priming of the dative/locative by the instrumental form as well, but in this case the priming was significantly less than by the nominative or in the identity-priming case. (This discrepancy is reminiscent of Lukatela et al.'s "satellite model" of the Serbo-Croatian lexicon outlined above, in that the oblique forms of a root may only be able to interact with each other through the mediation of the nominative form.) Feldman and Moskovljević were able to show that words with orthographic and phonological overlap but no morphological relationship had no priming effect, so even if the priming of one oblique form by another is only partial, it is still noteworthy.

Additionally, Reid & Marslen-Wilson (2000) demonstrate with data from Polish that different members of a noun or verb inflectional paradigm prime each other, even when the root portion of a complex form differs from the basic form of the root as a result of phonological or morphophonemic alternations.

In summary, there is evidence from a number of different languages that, in a word containing a root and inflectional affixes, the root is processed separately from the affixes. Furthermore, forms with different inflectional affixes often behave like tokens of the same form with respect to frequency-sensitive phenomena and priming effects. Finally, inflected words appear to be processed as though they are organized around their roots. Thus, compared to inflectional affixes, roots have a privileged status in the structural organization of the lexicon and thus in early-stage word recognition — which seems appropriate, given that the major semantic content of an inflected word is contributed by the root morpheme.

4.3.3.2 Processing of words with derivational affixes

Many studies involving derivational affixes, like those involving inflectional affixes, show a special role for roots in early-stage word recognition. In some cases, the derivational affixes themselves give rise to priming effects; as might be expected, they also seem to add complexity to the processing of words. Nevertheless, in most studies, roots are still seen to have an importance equal to or greater than that of derivational affixes.

There is evidence that roots inside derivationally complex words have priming effects, just as they do in forms with inflectional morphemes. Stanners, Neiser, Hernon, & Hall (1979), in the visual study discussed in §4.3.3.1, found that adjectival and nominal derivatives of English verbs significantly prime their verb roots, but not as much as the roots themselves or regular inflectional forms do. However, as noted above, Fowler, Napps, & Feldman (1985) take issue with the experimental design used in the Stanners et al. study; once again, with their modified design, Fowler et al. found that morphological derivatives were able to prime their roots to an extent that was not significantly different from identity priming by the roots themselves, in both visual and auditory experiments.

Stanners, Neiser, & Painton (1979) did a series of experiments involving derivational prefixes. They found only partial priming of target words with bound roots (such as *revive* or *progress*) when the roots and prefixes were presented separately (i.e., combined with other prefixes or roots respectively) ahead of time. However, there seem to be some problems with these experiments. First, Stanners, Neiser, & Painton (1979) did not attempt to factor out the separate effects of priming contributed by the root and the prefix, since both were presented in each case. Also, the distance between targets and primes in these experiments was only 8-12 items, so presumably the criticisms raised by Fowler et al. (1985) about the confounding effects of episodic priming in Stanners, Neiser, Hernon, & Hall's (1979) experiments are valid here as well.

The fourth experiment in Stanners, Neiser, & Painton (1979) was different in several respects. First, the prefixed forms involved free roots with productive prefixes like *un-* and *re-*. Second, the distance between prime and target was increased to an average of 31 intervening items, which is more like the experimental design used by Fowler et al. (1985). Finally, Stanners et al. used the prefixed form as a prime and looked for priming effects on the bare root, rather than looking for priming effects on a complex form by a pair of other complex forms. In this experiment, they actually did find full priming of bare roots by prefixed forms: the degree of priming by prefixed forms did not differ significantly from identity priming by the roots themselves.

Evidence that roots are primed by derivationally complex forms has been found in other languages as well. Feldman & Moskovljević (1987) found priming of roots by derived forms in Serbo-Croatian. Boudelaa & Marslen-Wilson (2000) report priming effects in Arabic between words that share the same morphological root even when they are not closely semantically related, such as *mudaaxalatun* 'conference' and *duxuulun* 'entering', which share the root /dxl/.

There is a certain amount of evidence suggesting that derivational prefixes are removed or ignored to allow processing of roots first, an operation dubbed "prefix-stripping" by M. Taft & Forster (1975). For example, M. Taft, Hambly, & Kinoshita (1986), in both auditory and visual experiments, compared lexical-decision response times to four kinds of nonwords: real (bound) stems with real, but inappropriate, prefixes (*dejoice*), real stems with non-prefixes (*tejoice*), non-stems with real prefixes (*dejouse*), and non-stems with non-prefixes (*tejouse*). They found that the prefixed forms were more difficult than the non-prefix forms overall (having both slower response times and higher error rates). But crucially, the prefixed forms were more difficult to reject for stems than for non-stems, while the non-prefix forms were rejected just as quickly and accurately whether they contained real stems or not. In other words, there is no evidence that the nonwords that started with non-prefix strings were decomposed, so the fact that some of them contained real stems was apparently irrelevant to the processor. However, a difference between stem and non-stem forms appeared in the nonwords that started with real prefixes. In this case, it appears that the processor may have used the presence of the prefix as a cue to look inside the word for evidence of a stem.[42]

In earlier work, M. Taft (1979) also found root-frequency effects for prefixed words containing bound roots. For example, he found that participants were able to recognize *deploy* more quickly than *deflate*, even though the two words have the same frequency of occurrence, because *-ploy* has an overall frequency that is higher than that of *-flate* (compare *employ* and *inflate*). Bradley (1980) found root-frequency effects for suffixed forms if the suffixes were productive and semantically transparent, like *-ness*, *-ment*, and *-er* (agentive).

Thus, while the available evidence is not absolutely conclusive, because of possible confounding effects in certain experiments stemming from the use of visual rather than auditory stimuli, the lack of a detailed comparison of inflectional with derivational prefixes, and the separate effects of stress pattern on lexical access in some languages, there is evidence that roots have a special role even in the processing of words with derivational morphology. Root-priming effects and root-frequency effects are found with derived forms just as for inflected forms, and experimental participants appear to search for roots inside prefixed forms.

However, there is evidence that derivational morphology is somewhat more important in early-stage word recognition or word-level processing than inflectional morphology; again, this seems intuitively reasonable, given the greater semantic contribution of derivational morphology and the fact that derived forms are probably lexically listed. For example, some results indicate that extra complexity is introduced by derivational structure. Manelis & Tharp (1977) had experimental participants view pairs of stimuli and give a positive response only if both were words. The stimuli all ended in letter sequences that could be suffixes, and included real words, either monomorphemic (*somber*) or bimorphemic (*dark+er*), and three classes of nonwords: C[ontrol] (*locter*), W[ord] (*<u>desk</u>er*), and F[ragment] (*<u>garm</u>er*, cf. *garment*). They found that when both stimuli were words, response times were shorter when both words were either simple or complex, but longer if the pair was mixed. They also found that both the W and F nonwords were rejected more slowly than the controls. Jarvella & Meijers (1983), in the Dutch verb experiment described above, found that response times for the class of verbs that start with a derivational (inseparable) prefix were slower than for the other classes of verbs. These results — as well as those from M. Taft et al. (1986) reported above, where responses to prefixed nonwords were slower than those with non-prefixes — all indicate that derivational morphological structure may add complexity to word recognition.

There are also psycholinguistic results suggesting that at least some derivationally related words have separate lexical entries rather than being grouped together as part of the entry of the

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[42]However, there is a possibility of interference from the effects of stress, since the stress would fall on the stem, and stressed syllables have been shown to initiate lexical access attempts in English (see §4.3.4.1).

root. Schreuder & Baayen (1997), in a visual experiment measuring lexical-decision times to Dutch nouns, found an effect of the combined frequency of inflected forms of a noun (see also §3.4.3.1), but the total frequency of the "morphological family," including derived forms and compounds containing the noun in question, had no effect. Bradley (1980) found a difference between semantically transparent and opaque derivational affixes in English; while root frequency affected forms with transparent suffixes like *-ment* or *-ness* (as noted above), there was no effect of root frequency on forms with opaque, nonproductive affixes like *-(t)ion*, suggesting that the latter words have their own lexical entries.

Finally, there is evidence that derivational affixes can have priming effects. Boudelaa & Marslen-Wilson (2000) show that, in Arabic, forms with two different roots but the same "word-form" (i.e., *binyan* or morphological template) prime each other as long as the word-form makes a semantic contribution in each case. For example, *xud*ˤ*uuʕ-un* 'submission' primes *ħuduuθ-un* 'happening', whereas *suʒuun-un* 'prisons', which contains the same vowel pattern but is semantically unrelated, does not. (However, Boudelaa & Marslen-Wilson (2000) also cite studies by Frost and Deutsch and colleagues reporting that word-form has no priming effect in closely related Hebrew.)

Nevertheless, taken together, these results do not indicate that derivational affixes play a more significant part *in word recognition* than roots, although some of them suggest that derivational affixes may contribute links among lexical entries or otherwise affect the way that the lexicon is structured.[43]

Thus, the psycholinguistic findings reviewed in this section support the proposals made above about psycholinguistically strong positions. Namely, they show that roots and initial syllables are important in early-stage word recognition in a way that other positions, particularly stressed syllables (see §4.3.4) and derivational affixes, are not. Therefore, these two positions can be grouped together as the set of psycholinguistically strong positions, crucially defined in terms of their special role in early-stage word recognition.

4.3.4 Absence of a role for prosodic properties in early-stage word recognition

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[43]Revithiadou (1999ab) has proposed, based on accentual phenomena, that if a derivational affix is the head of a word, it can have the status of a strong position. However, there is an alternative account of these accentual phenomena, with in fact broader empirical coverage (Alderete 1999b), and derivational heads have not been convincingly shown to behave as strong positions with respect to contrasts outside the domain of stress and accent. There also seem to be no examples of augmentation in derivational heads. Therefore, derivational heads have not been included in the set of strong positions here — a decision that is further supported by the psycholinguistic evidence reviewed in this section, which does not indicate that derivational affixes play a primary role in early-stage word recognition.

The Segmental Contrast Condition has been proposed as a constraint filter that restricts **M/Ψstr** constraints to those whose satisfaction does not entail the neutralization of segmental contrasts in psycholinguistically strong positions (aside from the special case of σ_1 left-edge demarcation effects; see §4.3.5). This filter correctly predicts the relatively small inventory of augmentation constraints that can be relativized to the psycholinguistically strong positions initial syllable and root, especially compared with the large number of attested augmentation constraints for the strong position stressed syllable, which is comparable in size.

This subsection reviews psycholinguistic evidence bearing on the role of the prosodic properties stress and tone in speech perception. The findings presented here motivate two of the characteristics of the Segmental Contrast Condition as formulated above. First, the fact that this filter applies to augmentation constraints relativized to roots and initial syllables but not to those for stressed syllables — more generally, the proposal that the stressed syllable is not included in the set of psycholinguistically strong positions — is supported by the findings in §4.3.4.1: while the stressed syllable is involved in certain aspects of speech perception (§4.3.4.1.1), its major role is in the segmentation of the speech stream rather than in accessing lexical entries directly (§4.3.4.1.2); furthermore, this use of the stressed syllable in speech segmentation is language-specific rather than universal, since it depends on the system of stress placement in a given language (§4.3.4.1.3). Thus, the stressed syllable is not as fundamentally relevant for early-stage word recognition as are the initial syllable and the root.

Another correct prediction made by the Segmental Contrast Condition as formulated above is that **M/Ψstr** constraints referring to prosodic properties, such as HAVESTRESS/Root, are attested. The second goal of this subsection is to provide psycholinguistic evidence motivating the Segmental Contrast Condition's distinction between segmental and prosodic properties with respect to augmentation constraints for psycholinguistically strong positions. The evidence reviewed here shows that this distinction is justified because prosodic properties such as stress (§4.3.4.1) do not play the same role in early-stage word recognition that is played by segmental properties. That is, stress is used in later stages of word recognition, to confirm which lexical entry should be selected out of those that are initially activated by the auditory input. However, mismatches in stress do not prevent the early-stage activation of a lexical entry for comparison with the auditory input, even in languages where stress is lexically contrastive. The case of tonal contrast is considered in §4.3.4.2. Here, the psycholinguistic results are few and somewhat tentative, but there is at least some evidence that tonal contrasts behave differently from segmental contrasts in speech perception, and thus that HTONE/**Ψstr** constraints may pass the SCC.

4.3.4.1 The role of stressed syllables in speech perception

To support the claim stated above, that the stressed syllable is not fundamentally relevant in early-stage word recognition in the way that the initial syllable and the root are relevant, requires some discussion. There is a fair amount of evidence that stressed syllables actually are important in certain aspects of speech perception and processing, particularly in stress-timed languages such as English and Dutch (§4.3.4.1.1). However, there is also evidence that stress location and stress-related contrasts are not fully utilized in early-stage word recognition (§4.3.4.1.2). Following explicit or implicit proposals by L. Taft (1984), Norris, McQueen, & Cutler (1995), and Mattys & Samuel (2000), an argument is presented (§4.3.4.1.3) that the role of the stressed syllable in early-stage word recognition is only an indirect and language-particular one. Stressed syllables are indeed utilized in certain languages during speech processing, but they are used mainly to help locate initial syllables, not to access the lexicon itself. Thus, the stressed syllable is not a psycholinguistically strong position, so **M/σ́** constraints are not subject to filtering by the Segmental Contrast Condition.

4.3.4.1.1 How stressed syllables are involved in processing

A number of researchers have observed that stressed syllables appear to have some kind of special status in speech processing. This section reviews these results.

Cole & Jakimik (1976, 1980) show that listeners are better able to detect mispronunciations (in running speech) when they occur in stressed syllables. However, this result might simply reflect the fact that stressed syllables tend to be uttered more distinctly than unstressed syllables, and need not be related to word recognition per se.

Brown & McNeill (1966), in their study of the "tip-of-the-tongue" state, found some provisional evidence that it is possible to recall the stress pattern of the target word while in a TOT state. They examined the words offered by the experimental participants as "sounding similar" to the word they were trying to recall, and found that these words had a tendency to share stress with the target words. However, for various statistical reasons, they were only able to investigate the disyllabic words in their materials, which were only 31 out of 233 words. Brown & McNeill (1966:330) can conclude only that "we are left suspecting that [the participant] in a TOT state has knowledge of the stress pattern of the target, but we are not sure of it."

Nakatani & Schaffer (1978), in an experiment using "reiterant speech" (i.e., speech in which a single syllable, in this case [ma], is repeated over and over to replace the original segmental content of a phrase), found evidence that listeners used prosodic information to locate word boundaries. Reiterant speech was used to mimic adjective+noun phrases of the shape [mama#ma] or [ma#mama], with various stress patterns. Certain of their listeners were able to use their knowledge of possible versus impossible stress patterns to locate word-boundaries; in particular, when two primary-stress syllables were adjacent, these participants placed the word boundary between them.

There is evidence that stressed syllables (primary or secondary), when they occur in non-initial position, give rise to spurious lexical-access attempts. Cutler & Norris (1988) report the results of experiments in which (English-speaking) listeners were asked to detect real words embedded inside longer nonwords. They found that listeners were able to detect the real word *thin* in both *thintef* ['θɪntəf] and *thintayf* ['θɪnˌtejf], but that *mint* was detected much more easily in *mintef* ['mɪntəf] than in *mintayf* ['mɪnˌtejf]. They conclude that the presence of the secondary stress in ['mɪnˌtejf] causes segmentation of the speech stream, and a new attempt at lexical access, at the phone [t], and this impedes recognition of the word *mint*. (The word *thin*, on the other hand, is complete before the beginning of the second stressed syllable in ['θɪnˌtejf], so recognition of this word is not impaired.)[44] These findings have been replicated by Norris, McQueen, & Cutler (1995) for English and by Vroomen & de Gelder (1995) for Dutch.

Luce & Cluff (1998) report additional evidence, from a semantic priming study, that non-initial stressed syllables cause spurious lexical-access attempts in English. They used words like *hemlock*, that had two heavy syllables, where the second syllable was homophonous to an unrelated monosyllabic word (i.e., *lock*), and where gating studies showed that the original disyllabic word would be recognized before its offset. They found that, e.g., *hemlock* would semantically prime a word related to *lock* but unrelated to *hemlock*, such as *key*. This result indicates that a new access attempt was initiated at the second stressed syllable in these words.

Another source of evidence that speakers of English and Dutch make use of stressed syllables in processing comes from misperceptions involving word boundaries. L. Taft (1984) found that both an iambic sequence (i.e., W(eak-)S(trong)) that is ambiguous between a one-word and a two-word interpretation (*in* # '*vests* versus *in*'*vests*), and an iambic nonsense word, are more likely to be given a two-word interpretation than a trochaic sequence (SW) would be. Cutler & Butterfield (1992) investigated a corpus of natural misperceptions and also produced misperceptions in the laboratory by having participants listen to faint speech and report what they thought they heard. Their results from the two investigations show that the insertion of a word boundary is more common than boundary deletion before a stressed syllable, and that boundary deletion errors are more common than boundary insertion errors before an unstressed syllable. The faint-speech results were replicated by Vroomen & de Gelder (1995) for Dutch; Bond (1999) reports analogous findings from a different corpus of naturally occurring English misperceptions.

Finally, there is evidence that words that start with unstressed syllables, or perhaps non-main-stress syllables, are more difficult to process in English. Cutler & Clifton (1984) found that

[44]One might argue that the results reported by Cutler & Norris (1988) could have another explanation: the [t] in *mintef* is more likely to be syllabified with the preceding syllable than is the [t] in *mintayf*, because of the different stress patterns of the two nonwords, and it might be this difference rather than the initiation of a lexical-access attempt that makes it harder to perceive *mint* in *mintayf* than in *mintef*. However, results from experiments by Cutler, Mehler, Norris, & Segui (1986) show that the difference in syllabification between *ba.lance* and *bal.cony* does not affect English-speaking listeners' ability to recognize the substrings *ba* or *bal* in these words (whereas for French-speaking listeners, the difference between *ba.lance* and *bal.con* has an effect). While the Cutler et al. (1986) task involved the spotting of syllable-sized nonword sequences, not the spotting of entire words as in the Cutler & Norris (1988) experiment, Cutler et al.'s results suggest that dividing a target between two syllables does not necessarily make that target more difficult for English speakers to find.

lexical decision response times for SW words were faster than those for WS words. Gow & Gordon (1993) report that both initial and final syllables were detected faster in trochaic forms than in iambic forms. Similarly, Mattys & Samuel (2000) found that words that do not begin with a primary stress result in a processing delay and create more of a memory load (i.e., cause poorer performance on another task being carried out simultaneously) than words with initial primary stress. A somewhat related finding is reported, also for English, by L. Taft (1984) and Cutler & Clifton (1984): when SW words are mispronounced as WS, response time is slowed. However, when WS words are mispronounced as SW, this either has no effect on response time (Cutler & Clifton 1984) or even reduces response time (Taft 1984).

4.3.4.1.2 How stressed syllables are *not* involved in processing

The evidence presented above shows that stressed syllables are somehow relevant for speech processing, at least in English and Dutch. However, there is evidence that the stress pattern, or the location of main stress in a word, is not relevant in early-stage word recognition. Most strikingly, knowledge of the stress pattern of a word seems not to prevent the activation of a lexical entry that has a different stress pattern but the same segmental content.

First of all, it is important to factor out the effects of *sentence*-level stress when investigating the role of word stress in processing. Shields, McHugh, & Martin (1974) found that the presence of sentential stress (i.e., a pitch accent) decreased response time for phoneme monitoring (in nonwords), but that when the experimental nonwords were cut from their sentential contexts and spliced into lists of nonwords, mere word-level stress had no effect on response time. This result also raises the question of whether Cole & Jakimik's (1976, 1980) findings, that mispronunciations *in running speech* were better detected in stressed syllables, were caused by sentential stress rather than word stress. It has been known since work by Cutler (1976) that sentential focus (as signaled by preceding intonational contour) facilitates the processing of a word, but it may be only that sentence stress draws the hearer's attention to a word for semantic or pragmatic reasons, and this increased attention is responsible for the faster phoneme-monitoring and mispronunciation-detection times reported by Shields, McHugh, & Martin (1974) and Cole & Jakimik (1976, 1980).

Cole & Jakimik (1980) provide a further reason to discard the hypothesis that early-stage word recognition proceeds directly by means of stressed syllables. They note:

> The hypothesis that word candidates are accessed from stressed syllables did not fare well in the present experiment. According to this hypothesis, we should observe faster reaction times to words with intact stressed syllables than to words with mispronounced stressed syllables, since only words with intact stressed syllables will produce word candidates which include the intended (but mispronounced) word. (Cole & Jakimik 1980:968)

Cutler & Clifton (1984) and Cutler (1986) report findings that rather strongly discredit the possibility of a direct relationship between stressed syllables and early-stage word recognition. Cutler & Clifton's (1984) results show that knowing the stress pattern of a word in advance does not make response time any faster in a lexical decision task. Cutler (1986) found that each member of a pair like ˌ*for*ˈ*bear*/ˈ*fore*ˌ*bear*, homophones that differ only in stress (crucially, not in vowel quality), lexically activates the other; presentation of *forbear* shows semantic priming effects for words that are semantically related to *forebear*, and vice-versa. This indicates that a mismatch in stress pattern is not enough to keep a word from being lexically activated when its segmental content matches that of the auditory input being processed, or, in Cutler's (1986) terms, that lexical prosody does not constrain lexical access.[45]

4.3.4.1.3 Stress-based segmentation as a language-particular processing strategy

The results presented thus far indicate two rather different patterns. On the one hand, in Dutch and English, stressed syllables have been shown to affect processing, because (a) they trigger lexical-access attempts even when they appear word-medially (as in *hemlock*) and (b) words that do not start with stressed syllables are more difficult to process. On the other hand, stress patterns are not utilized in early-stage word recognition, because (a) prior knowledge of the stress pattern does not facilitate word recognition and (b) a mismatch in stress pattern is not important if segmental material matches.

But these two sets of facts do not appear contradictory once it is understood that recognizing words in continuous speech actually involves two distinct operations. One operation, of course, is word recognition itself: the acoustic/phonetic signal must be matched to entries in the lexicon so that syntactic and semantic information becomes available for sentence processing. But another operation that must be performed is that of (word) segmentation — before words can be recognized, the continuous speech signal must be divided into words.

As noted by many researchers, including L. Taft (1984), Cutler & Norris (1988), and Norris, McQueen, & Cutler (1995), identifying the beginnings of words in the speech stream is not a trivial task. It is not even possible to assume that every word starts where a previous word ends, because some words are contained inside longer words (such as *fan* in *fantastic*), and

[45]A recently published paper by Cutler & van Donselaar (2001) shows that in Dutch, a stress mismatch does reduce the activation of candidates for word-recognition to some degree — words differing only in stress contour do not show exactly the same patterns of lexical activation, so they are not functionally homophones in early-stage word recognition in the way that English ˈ*fore*ˌ*bear* ~ ˌ*for*ˈ*bear* are. However, Cutler and van Donselaar still found that a segmental mismatch had a much larger effect than a stress mismatch in removing word candidates from consideration. Thus, the distinction made by the Segmental Contrast Condition may not be between contrasts that are *relevant* and *not relevant* in word recognition, but between contrasts that are *relevant to a certain degree* and *less relevant than that degree*. Crucially, segmental properties and stress still differ in their importance.

furthermore hearers continue to understand speech even after encountering a word that they do not know or that is unintelligible, such they might not know where that word would end.

Taft (1984), Cutler & Carter (1987), and Vroomen & de Gelder (1995) note that in English and Dutch, words are likely to have initial stress. Cutler & Carter (1987) compiled statistics from a 33,000-word computer-readable English dictionary and found that words with initial primary or secondary stress (including monosyllables) made up 73% of the words listed. They next examined a 190,000-word natural-speech British English corpus, and found that over 70% of the lexical words had initial primary or secondary stress. Moreover, they found that over three-fourths of the strong syllables in the corpus were the initial (or only) syllables of lexical words, whereas two-thirds of the weak syllables were the initial (or only) syllables of function words. Vroomen & de Gelder (1995), using the CELEX database, found that only 18.6% of English lexical words start with weak syllables. For Dutch, they found that only 12.3% of lexical words had (invariant) initial weak syllables, and of those, 96% began with the prefixes *be-*, *ge-*, or *ver-*.

Thus, in both English and Dutch, a relatively efficient processing strategy for finding the onset of a lexical word is to go to where the stressed syllables are. This insight is the basis for the Salience to Onset segmentation strategy of Taft (1984) and the Metrical Segmentation Strategy (MSS) of Cutler & Norris (1988) and Norris, McQueen, & Cutler (1995), for English, as well as the Syllable-Based Segmentation Strategy of Vroomen & de Gelder (1995) for Dutch (a modification of the MSS). While these proposals differ in certain details, they all essentially claim that segmentation of the speech stream, in these languages, takes place when a stressed syllable is encountered. Since segmentation is a precursor to word recognition, these processing strategies are in effect assuming that stressed syllables *are* initial syllables.[46] But the role of stressed syllables in early-stage word recognition is not a direct one; it is indirect, through the use of stressed syllables for segmentation.

Further reason to believe that stressed syllables do not have a universal, basic role in early-stage word recognition comes from considerations of stress placement cross-linguistically. Hyman's (1977) survey of stress patterns, containing about 400 languages, includes the following statistics:

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[46]Interestingly, a common strategy employed by children who are learning English or Dutch is to truncate initial unstressed syllables, so that all words do start with stressed syllables. Children learning these languages are also sometimes observed to shift stress onto initial weak syllables; see Fikkert (1994), Pater (1997), and references therein. Jusczyk, Houston, & Newsome (1999) have also shown that infants in an English-language environment are able to segment strong-weak words from running speech at an earlier age than weak-strong words.

(76) Cross-linguistic stress patterns (Hyman 1977)

Dominant initial stress	114
Dominant penultimate stress	77
Dominant final stress	97
No dominant stress placement	113

The first three figures include languages with predictable stress on the position indicated as well as languages that simply show a majority of words with stress on that position. That is, both Polish and Spanish are placed in the category of "dominant penultimate stress;" while Polish does have obligatory penultimate stress with few exceptions (mostly loanwords), Spanish has a number of words with final and antepenultimate stress (including certain verb tenses with obligatory final stress). Nevertheless, it is reasonable to consider these figures in the context of the current discussion, since both English and Dutch are themselves languages that show a preference rather than a requirement for initial stress.

In any case, Hyman's (1977) survey indicates that languages that favor stress at or near word-final position — penultimate or final stress — are about as common as languages that favor initial stress. Furthermore, approximately as many languages have phonemic stress as have initial stress. Thus, while it is reasonable to suggest that languages like English and Dutch can facilitate word-segmentation by equating stressed syllables with initial syllables, such a strategy is much less likely to be useful for a language with predominantly penultimate stress, like Polish; predominantly final stress, like Turkish; or lexically contrastive stress, like Russian.

Of course, languages with a tendency to have stress in penultimate or final position may well use the location of the stressed syllable to compute the most likely location for the following word-boundary, in a modified metrical segmentation strategy tailored to the metrical pattern of the language in question. But the crucial point for the present discussion is that actually *equating* the stressed syllable with the initial syllable is a segmentation strategy that will only be useful for a subset of the world's languages.

This point is made explicitly by proponents of the MSS and similar strategies. Taft (1984) states,

> The language-specific version of the strategy specifies which portions of the signal are salient for that language, as well as the relationship between these salient portions and the onsets of words. (Taft 1984:90)

Norris, McQueen, & Cutler (1995) make a similar statement:

> [T]he stress-based metrical segmentation procedure...is appropriate for stress-timed languages such as English. Of course, this procedure could not operate for languages

> in which there is no alternation of strong and weak syllables. Nonetheless, a separate procedure of segmentation based on metrical structure can operate in any language; it is only different across languages insofar as the metrical structures of the languages themselves differ. (Norris, McQueen, & Cutler 1995:1210)

In conclusion, stressed syllables are used, at least in some languages, to locate word boundaries for the purposes of word recognition. However, unlike initial syllables, stressed syllables are not directly used in early-stage word recognition. Therefore, by the definition introduced above, stressed syllables are legitimately excluded from the set of psycholinguistically strong positions.

Furthermore, since the presence or absence of stress on a given syllable is not relevant in early-stage word recognition (as seen, for example, in Cutler's (1986) findings that one word will prime another that differs from it only in stress contour), **M/Ψstr** constraints that involve stress, such as HAVESTRESS/Root (§4.2.2.1), are able to pass the Segmental Contrast Condition.

4.3.4.2 On tonal contrasts in early-stage word recognition

In addition to stress, tone is another prosodic property that is used by languages to distinguish lexical items. Because tone can be lexically contrastive, it is logically possible that languages with tonal contrasts might treat tone on a par with segmental features, and disallow **M/Ψstr** constraints that make reference to tone. However, it has been shown above that information about stress, although it can be used to form lexical contrasts, is apparently not used in early-stage word recognition. Therefore, it is also possible that tone and stress, both being prosodic properties, might pattern together in this respect. Unfortunately, there have not been as many studies on the extent to which tone is utilized in early-stage word recognition as there have been for stress, and the results that have been found are somewhat mixed.

On the one hand, there is evidence that tonal and segmental contrasts are treated differently by the processor, and in particular that it takes more time for tonal information to become available to listeners than segmental information. If tonal information is indeed slow to become available, it would presumably not be used in early-stage word recognition.

Cutler & Chen (1997) report that tone takes longer to process than segmental information in Cantonese, a language with several lexical tones. In a "same-different" task (which requires deciding whether or not two auditory stimuli represent the same word), participants had slower response times and made more errors when the words in a stimulus pair differed only in tone than when they contained different segments, even in cases where the differing tones were perceptually quite distinct.

Walsh Dickey (in prep.) also found a difference in timing between segmental and tonal information in a same-different task in Igbo, a tone language in which any syllable may bear either a H or a L tone. The words used in the experiment were of the shape VCV. In each "different" pair, the words differed in only one feature: a segmental feature in the consonant (C), the first vowel (V1), or the second vowel (V2), or the tone in the first (T1) or second (T2) syllable. Walsh Dickey found that words differing in T1 had significantly longer response times than words differing in V1, even though the tonal and segmental mismatches occurred at the same chronological point in the two cases; this finding suggests that segmental information was more readily available than tonal information during the first syllable. On the other hand, words differing in T2 had response times that were just as fast as the V2 cases, suggesting that by the time the second syllable had been reached, tonal and segmental information were both available.

Finally, Cutler & Chen (1997) found that in a Cantonese lexical decision task, nonwords were more likely to be erroneously labeled as words when they differed from actual words in tone than when they differed in segmental features. These results also seem to indicate that tone is not as salient or useful in word recognition as segmental features are, whether because of a difference in the time at which the information becomes available or for some other reason.

Thus, the results from Cantonese and Igbo seem to show that tonal and segmental features are handled differently in speech perception, and in fact that tonal information becomes available to the processor more slowly than segmental information does. In further support of this finding, acoustic analyses of tone-to-syllable alignment patterns in several languages have shown that tonal targets are often realized somewhat later than the peak of the syllable with which they are phonologically affiliated (see, e.g., Silverman & Pierrehumbert (1990) on English; Arvaniti, Ladd, & Mennen (1998) on Modern Greek; and Xu (1999) on Mandarin). If there is a delay in the accessibility of tonal information during speech processing, it may be the case that at the point of early-stage word recognition, differences in lexical tone do not exclude lexical entries from initial activation.

Another language for which the role of tonal features in processing has been investigated is Japanese. Lexical contrasts between syllables bearing H and L tone are found in many Japanese dialects, including standard or Tokyo-area Japanese. However, these systems are traditionally classified as pitch-accent systems rather than as tone systems proper, because what must be lexically stored is not a separate tone specification for each syllable, but the location in the word (if any) where the pitch falls from H to L.

Psycholinguistic evidence for the role of lexical pitch accents in the perception of (Tokyo) Japanese is somewhat mixed. On the one hand, there is evidence, similar to that discussed above for lexical tone in Cantonese and Igbo, that pitch information becomes available to the listener at a later point in time than segmental information. Walsh Dickey (1996) had Japanese-speaking listeners perform a same-different task in which some of the "different" pairs contained different segments, but others differed only in accent. Listeners' responses to "different" pairs were much slower when the words differed only in accent than when segmental differences were involved.

However, there is also evidence that pitch accent does have some effect on processing in Japanese. For example, Minematsu & Hirose (1995) showed that presenting Japanese words with incorrect accent patterns made them harder for experimental participants to identify.

Perhaps the strongest evidence that Japanese pitch accent is relevant in early-stage word recognition is the finding by Cutler & Otake (1999) that accent apparently does help to constrain the initial selection of a set of lexical entries to be further compared with the auditory input being processed (unlike stress in English (Cutler 1986); see §4.3.4.2). Words with different tonal shapes, such as *ame* HL 'rain' and *ame* LH 'candy', were found not to behave as homophones in lexical-priming tasks. This indicates that even in early stages of word recognition, *ame* HL is not considered a good match for *ame* LH — a decision that would seem to require reference to tonal information.

So it may be that tonal properties, unlike stress, are used in early-stage word recognition, at least for Japanese. The question nevertheless remains as to whether there is a fundamental difference between pitch-accent systems and true tonal systems in this respect, given the results reported above for the tonal languages Cantonese and Igbo where tonal information did not appear to be available in early stages of speech perception. Interestingly, there is some evidence that the relevant difference is not between pitch-accent and true tone systems in general, but rather between Japanese and the other languages investigated specifically.

Walsh Dickey (in prep.) suggests that one reason why tonal information may not be utilized in perception as early as segmental information is that it may be difficult to correctly identify the tone in the first syllable of a word, at least when spoken in isolation. Since tone is relative (i.e., the specific pitches used for "high" and "low" tones will depend on the pitch range of an individual speaker), perhaps the identity of the first tone of an utterance cannot be established without comparing it to subsequent tones. Thus, Walsh Dickey proposes, the tones in the first syllables of the Igbo words cannot be identified until they are compared with the second-syllable tones. This hypothesis is consistent with the reported reaction times: the time needed for listeners to respond to a difference in first-syllable tone was equivalent to the time needed to respond to a difference in *second*-syllable tone or vowel quality.

Crucially, however, for Cutler & Otake's (1999) Japanese listeners, identifying H versus L tone probably did not require information from an external context. Cutler and Otake's listeners could tell, with an accuracy significantly above chance, whether a single syllable excised from a word bore H or L tone in the word from which it was taken. When they measured the acoustic properties of their experimental materials, Cutler and Otake found that there was a strong correlation between H tones and level pitch on the one hand, and between L tones and changing pitch on the other. Furthermore, they found that the tones of the individual excised syllables were most reliably identified by the listeners when they conformed the most strongly to this pattern. Thus, listeners were making use of this kind of syllable-internal difference to distinguish H from L tones even without a surrounding context to help them identify the speaker's pitch range.

In summary, it can be tentatively concluded that tone is used in early-stage word recognition in some languages but not in others, and that this difference may be related to whether tones can be identified within the syllable to which they are associated, or whether external context is needed. However, there are still open questions: if pitch accent is used in early-stage word recognition in Japanese, why were the same-different results reported by Walsh Dickey (1996) so much slower for accentual differences than for segmental ones? And if being able to identify tones within the context of their own syllable is a crucial factor, why did Cutler & Chen (1997) find that Cantonese tonal differences required long response times in a same-different task even when the tones were quite different from one another?

At this point, no more will be said about the status of tone in word recognition, especially since the investigation of tone-related positional augmentation constraints is itself a topic for further research (§4.2.3). It may even turn out to be the case that the decision about whether tone is relevant for early-stage word recognition is determined, not on a universal basis, but with reference to facts about the individual grammar of a language. Nevertheless, there is still a prediction that can be made. Namely, a particular feature is something that can be legitimately referred to by an **M/Ψstr** constraint only when that feature is *not crucial in early-stage word recognition*, and this — not the distinction between "segmental" and "prosodic" — is what is actually encoded in the formulation of the Segmental Contrast Condition (see §2.4.1). The mnemonic label "segmental" used in the name of this filter might need be changed once the relationship between tone and processing is better understood, but the substantive motivation behind the filter remains the same.

4.3.5 Conclusions: Psycholinguistic evidence and M/Ψstr constraints

The three preceding sections, §§4.3.2-4, have presented a number of psycholinguistic findings that are relevant for **M/Ψstr** constraints. To be sure, a great many of these results come from experiments on Western European languages, especially English and Dutch. It will be interesting to see how future psycholinguistic experimentation on additional, less closely related languages contributes to our understanding of the structures and processes involved in word recognition.

This section now relates the psycholinguistic findings reviewed above to particular aspects of the theory of **M/str** constraints laid out in Chapter 2. §4.3.5.1 addresses the exclusion of the stressed syllable from the set of psycholinguistically strong positions and the resulting predictions about possible positional augmentation constraints for stressed syllables. §4.3.5.2 shows how the psycholinguistic evidence presented above is reflected in the formulation of the Segmental Contrast Condition.

4.3.5.1 Classifying the stressed syllable

The psycholinguistic findings discussed above justify the distinction made here between the initial syllable and the root, which are classified as psycholinguistically strong positions, and the stressed syllable, which is not. The initial syllable and the root are especially important in early-stage word recognition — the initial syllable is important because the first few segments of a word have a particularly strong influence over which lexical entries are activated by a given auditory input, and the root is important because roots help determine how morphologically complex words are stored in the lexicon and therefore how they are activated. In contrast, while the stressed syllable may in some languages be used during speech processing to help identify the beginnings of words, it is not directly involved in early-stage word recognition.

The exclusion of the stressed syllable from the set of psycholinguistically strong positions has implications for a general theory of positional augmentation constraints: it predicts that **M/σ́** constraints should not be subject to any constraint filter that is specifically relevant for **M/Ψstr** constraints. Indeed, the Segmental Contrast Condition, an **M/Ψstr** constraint filter, does not apply to **M/σ́** constraints. As seen in chart (47) in §2.3.3, there are a number of **M/σ́** constraints that refer to segmental contrasts (and whose potential **M/**$\boldsymbol{\sigma_1}$ and/or **M/Root** counterparts *are* blocked by the Segmental Contrast Condition).

4.3.5.2 On the formulation of the Segmental Contrast Condition

The experimental results reviewed in §§4.3.2-4 identify certain substantive pressures on psycholinguistically strong positions that stem from their special role in early-stage word recognition. The substantive pressures in question are those that have been formalized in the Segmental Contrast Condition (§2.4.1), repeated here in (77). This section addresses each clause of the constraint filter in turn, showing how it is related to the psycholinguistic evidence.

(77) *Segmental Contrast Condition*

If a constraint is of the form **M/Ψstr**, then it must meet one of the following two conditions:

I. Satisfaction of the **M** constraint from which the **M/Ψstr** constraint is built does not alter features that are distinguished in early-stage word recognition.

or

II. **Ψstr** is σ_1, and satisfaction of the **M/Ψstr** constraint serves to demarcate the left edge of σ_1.

Clause I of the Segmental Contrast Condition reflects two aspects of early-stage word recognition that have been identified in §§4.3.2-4: in this phase of word recognition, (a) psycholinguistically strong positions are influential in determining which lexical entries are to be activated, and (b) segmental properties are more important than prosodic properties such as stress in determining how well a given lexical entry matches the incoming auditory signal. Clause I follows proposals by, e.g., Nooteboom (1981) and L. Taft (1984) that speech processing is more efficient if psycholinguistically strong positions are given a large number of phonological contrasts to draw from, since these positions have a particularly strong influence on determining which lexical entries are activated in early-stage word recognition. Behind this claim is the assumption that using a larger number of contrastive categories divides the lexicon more finely, so that there will be fewer lexical entries matching any given initial sequence (this assumption is examined more closely below). However, clause I differs from its antecedents in the literature by specifically excluding prosodic properties such as stress (§4.3.4.1) and perhaps tone (§4.3.4.2) from its scope. Because prosodic properties are effectively disregarded at this stage of word recognition, whether or not contrasts involving these properties are available in psycholinguistically strong positions would have no particular influence on word recognition.

The idea that contrast preservation in psycholinguistically strong positions is important for the efficiency of word recognition has been discussed by, among others, Nooteboom (1981), L. Taft (1984), Beckman (1997, 1998), and Casali (1996, 1997). Nooteboom (1981) speculates about the implications that a special role for initial material in processing might have for the distribution of phonological information within words. Nooteboom points out that the beginning of the word is particularly informative, both because it is the least predictable (i.e., in most cases, no previous phonological information about the content of the word in question is available to the hearer), and also because, as discussed above, it has been demonstrated to carry more weight in early-stage word recognition. Nooteboom suggests that languages are likely to have made use of the asymmetry in informational content between initial and later material.

> In phonological terms one would predict that (1) in the initial position there will be a greater variety of different phonemes and phoneme combinations than in word final position, and (2) word initial phonemes will suffer less than word final phonemes from assimilation and coarticulation rules. (Nooteboom 1981:422)

Taft (1984:229) makes a similar observation, stating that crosslinguistically, "processes which cause phonological contrasts to be lost should be permitted word-finally but not word-initially." Taft notes that if word-initial material is important in early-stage word recognition, then a reduction in the number of word-initial contrasts by some phonological process would result in more lexical entries matching every possible initial syllable, and this might lead to a greater computational load.

These considerations predict that positional augmentation constraints for psycholinguistically strong positions are to be dispreferred.[47] Positional augmentation constraints require the presence of properties that bolster the perceptual prominence of strong positions. In general, such constraints are compatible with the intrinsic prominence that strong positions have;

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[47]Another linguistic consequence of the pressure to maintain a larger number of contrasts in psycholinguistically strong positions is the very inclusion of these positions in the set of strong positions, which gives them positional faithfulness constraints — **F/σ_1** constraints and **F/Root** constraints — and the corresponding potential for resisting positional neutralization (see Beckman 1995, 1997, 1998 and Casali 1996, 1997; positional faithfulness and other analytical approaches to positional neutralization are further considered in §5.2).

in other words, positional augmentation constraints make strong positions stronger by giving them an additional perceptually salient characteristic (§2.3.1). However, if a positional augmentation constraint is satisfied, this does mean that a phonological contrast in a strong position is neutralized. Thus, the substantive pressure for psycholinguistically strong positions to preserve contrasts relevant for early-stage word recognition means that (segmental property) neutralization is to be avoided — even when that neutralization would enhance perceptual prominence, as in the case of positional augmentation.

As noted above, the claim that contrast neutralization in psycholinguistically strong positions is something to be avoided depends on a particular assumption: that having more contrasts in positions important for early-stage word recognition facilitates word recognition. This assumption is clearly supported by models of word recognition that were influential when Nooteboom and Taft wrote the statements just quoted. For example, in the Search model (Forster 1976, 1990), the first few segments in the auditory signal are used to select an access code, which is linked to all lexical entries that begin with those segments. The early version of the Cohort model (Marslen-Wilson & Welsh 1978; Marslen-Wilson 1984) does not directly incorporate access codes, but analogously, the first few segments perceived are used to select a "cohort" of all lexical entries that begin with those segments. These models make a straightforward prediction that a language with more segmental contrasts available in the psycholinguistically strong positions will be more efficient at finding the lexical entry that matches an incoming signal. Having more segments to start words with means that fewer words need begin with the same sequence of segments. As a consequence, the set of lexical entries activated in early-stage word recognition by any given initial segment sequence will be on average smaller, which makes the task of narrowing the set down to one item computationally simpler.

However, more recent models of word recognition do not determine the initially activated set of lexical entries in the same way as the Search and early Cohort models. The assumption that word recognition is facilitated by having more contrasts in psycholinguistically strong positions therefore needs to be reexamined.

A major problem with the Search and early Cohort models is that their implementation of the special role of initial material in word recognition is too inflexible. In particular, the set of lexical entries activated in early-stage word recognition cannot be constrained by categorical decisions about the identity of the initial few segments, because if one of those segments happened to be misperceived, it would be impossible for the processor to recover — even if the misperception involved only one feature of one of the initial few segments, the target word would not be present in the set of lexical entries activated under the selected access code or in the selected cohort. In fact, changing early segments in a word does hamper recognition more than changing later segments, but it does not necessarily prevent recognition, or initial activation, altogether (see §4.3.2).

Subsequent two-stage models of word recognition, such as the later version of Cohort (Marslen-Wilson 1987), Shortlist (Norris 1994; Norris, McQueen, & Cutler 1995), and the Neighborhood Activation Model (Luce 1986; Goldinger, Luce, & Pisoni 1989; Luce & Pisoni 1998), have addressed this problem by having the auditory input activate a set of lexical entries that are *sufficiently similar* to, though not necessarily a complete match for, the incoming auditory signal. Thus, the target word will no longer be incorrectly excluded from the initially activated set if one of its first few segments is misperceived, because words with segments that are sufficiently similar to the perceived segments will all receive some activation. (The special role of word-initial material can still be implemented in such a model by giving extra activation to lexical entries whose initial portions are a good match to the incoming signal, as suggested by Marslen-Wilson (1987).)

In these later two-stage models of word recognition, where *sufficient similarity* determines which lexical entries are to be activated, it is of course necessary to specify how similarity is to be measured. The model that is most explicit about how to characterize similarity among lexical items is the Neighborhood Activation Model, henceforth NAM (Luce 1986; Goldinger, Luce, & Pisoni 1989; Luce & Pisoni 1998). In the NAM, as in other two-stage models, the acoustic/phonetic input activates a set of lexical entries that will subsequently be narrowed down to the best match. What determines the members of the activated set is a distance measure involving their degree of acoustic/phonetic similarity to the incoming signal.

In the NAM, the *neighborhood* of a target word is the acoustic/phonetic space centered on that word such that other words in the neighborhood — that is, neighbors — will receive (a significant degree of) lexical activation when the target word is presented. (So far, however, only a rough characterization of this acoustic/phonetic space has been given; see below for further discussion.) Because neighbors are activated together and must compete with each other, the model predicts that words in dense neighborhoods, with many neighbors, are more difficult to recognize than words in sparse neighborhoods, with few neighbors.

Experimental findings by Luce, Pisoni, and their colleagues support the NAM as a model of activation and competition in word recognition: words in sparse neighborhoods are indeed easier to recognize than words in dense neighborhoods. This result suggests that *sufficiently similar* in lexical activation must be defined in terms of acoustic/phonetic distance, not by some relative measure like "the *n* most similar lexical entries to the incoming signal". Otherwise, the density of words within a neighborhood as defined by acoustic/phonetic distance would not be relevant.

The crucial question that must be addressed for clause I of the Segmental Contrast Condition is this. Does having a larger number of contrastive segments in psycholinguistically strong positions still facilitate word recognition under a model of processing like the NAM, as it does under an older model like Search or early Cohort? Or is having a larger number of contrastive segments now predicted to inhibit word recognition because the inventory would contain more phonemes that are phonetically similar, potentially leading to denser neighborhoods?

The answer to this question is not yet completely clear, because it depends on exactly how the similarity neighborhood for a given word is to be defined. Goldinger, Luce, & Pisoni (1989) and Luce & Pisoni (1998) discuss experiments that were carried out on three-phoneme words, mostly of the shape CVC. Given the constrained nature of their experimental corpus, they were able to use a simple definition of neighbor: any word that can be converted to the stimulus word by the addition, deletion, or substitution of a single phoneme. Under this working definition of similarity neighborhood, one would in fact be forced to conclude that a language with a larger inventory of contrastive elements will have denser neighborhoods than a language with a smaller inventory. That is, more distinct CVC combinations are possible where there are more Cs and Vs in the inventory, so a given CVC word would be expected to have more neighbors when the language has more phonemes.

However, it is highly doubtful that this simple algorithm reflects the way that neighborhoods are actually determined. As Luce and Pisoni observe,

> Clearly, this method of computing neighborhood membership makes certain strong assumptions regarding phonetic similarity. In particular, it assumes that all phonemes are equally similar and that the similarities of phonemes at a given position are equivalent (Luce & Pisoni 1998:16).

Furthermore, and perhaps more importantly, the above method of identifying neighbors will exclude any word that contains the stimulus word but is longer than the stimulus word by more than one phoneme. This situation is not considered by Goldinger, Luce, & Pisoni (1989) or Luce & Pisoni (1998) because their experiments are restricted to three-phoneme words. However, many researchers, including Shillcock (1990) and Norris, McQueen, & Cutler (1995), have found that the presentation of a short word, such as *can*, also activates longer words that contain it, such as *candle* or *cantaloupe*. If these longer words are activated, then the model must be modified to treat them as neighbors.

When the problem of words embedded inside longer words is considered, the picture changes drastically. Given that speech processing happens across time, it is highly likely that words whose first few segments are identical — even if one word is much longer than the other — are much stronger competitors, which is to say treated during early-stage word recognition as much closer neighbors, than words beginning with phonetically similar but nevertheless distinct phonemes (see the Shillcock (1990) and Norris, McQueen, & Cutler (1995) findings for embedded words just mentioned, and Zwitserlood's (1989) findings for initial partial primes discussed in §4.3.2.2 above). Crucially, a language with a larger phoneme inventory can populate its lexicon with more distinct short words than a language with a smaller inventory can; having more short words means having fewer longer words that contain other words of the language.

Thus, even in more recent models of word recognition that define the initially activated set of lexical entries, not in terms of a categorical match to the initial few segments of the input, but in terms of acoustic/phonetic distance from the perceived input, it still appears that having a larger number of contrasts facilitates word recognition. Thus, there is a genuine substantive pressure behind clause I of the Segmental Contrast Condition.

One further point to note is that the substantive pressure for psycholinguistically strong positions not to neutralize segmental contrasts, as formalized in clause I, does not mean that contrasts are *never* neutralized in those positions; clearly, this is not the case. For example, a general markedness constraint banning some typologically marked segmental property is often ranked above all faithfulness constraints in a given language (including any positional faithfulness constraints), so that the segmental property in question is never contrastive in any position, including psycholinguistically strong positions. After all, large segmental inventories, as helpful as they may be for partitioning the lexicon, are problematic for other substantive reasons; for example, large inventories must include segments that are less perceptually distinct from one another and involve greater articulatory complexity. The point is simply that neutralizing some contrast *specifically* in a psycholinguistically strong position, where it would have been helpful in word recognition, while still putting forth the perceptual and articulatory effort to maintain that contrast in other positions, is not an efficient allocation of resources. It is this particular situation that satisfaction of a segmental-contrast **M/Ψstr** constraint would lead to, and that is why there is a filter that eliminates precisely such constraints.

In summary, clause I of the Segmental Contrast Condition reflects a substantive pressure that is based on two facts about early-stage word recognition: psycholinguistically strong positions are important at that stage, and certain contrasts are much more influential than others in distinguishing lexical entries during that stage. Thus, clause I allows a given **M/Ψstr** constraint to be included in CON only if its satisfaction would not entail the neutralization of contrasts that are used to distinguish lexical entries during early-stage word recognition.

The substantive factors behind clause II of the Segmental Contrast Condition are somewhat less complex. First, segmentation of the speech stream — finding the edges of words — is a nontrivial aspect of auditory processing (§4.3.4.1.3). Furthermore, having an onset and having a lower-sonority onset are both ways of making a syllable more perceptually prominent (§2.3.2.3.1). As noted by Taft (1984),

> [A] word recognition model which makes crucial use of word onsets...would value a phonological system which marks word onsets as clearly as possible. Thus, if a language permits phonological processes word-initially, they should be processes which make the [word] onset more salient. (Taft 1984:229)

Thus, clause II of the Segmental Contrast Condition permits a **M/Ψstr** constraint to be included in CON if *Ψstr* is σ_1 and satisfaction of the constraint affects the leftmost segment (see §2.4.1). Since these two clauses form a disjunction, an **M/Ψstr** constraint is legitimate if it passes at least one of the two. As a consequence, ONSET/σ_1 and [*ONSET/X]/σ_1 are legitimate constraints, because even though they refer to segmental properties in a psycholinguistically strong position, failing clause I, they aid in left-edge demarcation, thereby passing clause II.

In conclusion, the Segmental Contrast Condition, like the Prominence Condition, is a constraint filter that models substantive requirements on positional augmentation constraints. Unlike the Prominence Condition, however, the Segmental Contrast Condition applies specifically to positional augmentation constraints for psycholinguistically strong positions. The substantive requirements involved in the Segmental Contrast Condition are all related to early-stage word recognition, which is to be expected, given that psycholinguistically strong positions are precisely those positions that are important in that particular aspect of speech processing.

4.4 Defining "initial syllable"

This chapter has examined a number of topics related to positional augmentation in psycholinguistically strong positions. The discussion began with examples of languages in which **M/Ψstr** constraints play an active role in phonological patterning. Then, psycholinguistic evidence related to these positions and their role in early-stage word recognition was considered in some detail to justify the particular implementation of the Segmental Contrast Condition that was proposed in §2.4.1.

There is one more question related to positional augmentation in psycholinguistically strong positions that needs to be considered: what kind of "initial syllable" is actually a strong position? This section shows that the patterning of **M/σ_1** constraints within the broader theory of positional augmentation supports the choice of *initial syllable of the morphological word* (MWd) as the designation of the strong position in question (§4.4.1). A comparison of this result with Beckman's (1995, 1997, 1998) choice of *root*-initial syllable as the position that is relevant for **F/σ_1** constraints is then given (§4.4.2).

4.4.1 "Initial syllable" as MWd-initial syllable

The languages discussed in §4.2.1 provide evidence for the existence of **M/σ_1** constraints, specifically, for ONSET/σ_1 and members of the [*ONSET/X]/σ_1 subhierarchy. Arapaho and Guhang Ifugao are languages in which "initial syllables" are required to have onsets; Mongolian, Kuman, Guugu Yimidhirr, Pitta-Pitta, Mbabaram, and the Sestu dialect of Campidanian Sardinian are languages in which high-sonority elements are banned from onset position in "initial syllables." This section shows that for these languages, the onset-related requirements hold of word-sized, not root-sized, domains (§4.4.1.1), and argues that the "word" in question must be the morphological word rather than the prosodic word (PrWd) (§4.4.1.2).

4.4.1.1 Evidence for a word-sized domain

Of the languages from §4.2.1, several — Mongolian, Kuman, Guugu Yimidhirr, Pitta-Pitta, and Mbabaram — have no prefixes, which means that roots are always word-initial. These languages cannot help determine whether the requirements on "initial syllables" are actually enforced on word-initial or root-initial syllables. However, Arapaho and Guhang Ifugao (as well as Sestu Campidanian, discussed in §4.4.1.2 below) provide crucial evidence that it is a word-sized constituent that is relevant.

Arapaho (Salzmann 1956; §4.2.1.1) is a language in which ONSET/σ_1 ensures that all "initial syllables" have onsets. According to Salzmann (1956:55, note 9), Arapaho has prefixes. Nevertheless, Salzmann clearly states,

> There are four vowel phonemes in Arapaho...They are found *only medially and finally*, thus contrasting with consonants which are found also initially. (Salzmann 1956:51; emphasis added)

Since there are words that begin with prefixes — that is, not all words begin with roots — an onset requirement for root-initial syllables cannot account for mandatory *word*-initial onsets in Arapaho. The relevant "initial syllable" must be a word-initial syllable.

Similarly, Guhang Ifugao (Newell 1956; Landman 1999) is a language with mandatory onsets in "initial syllables" enforced by ONSET/σ_1. Like Arapaho, it has prefixes, but all words, including those that do not start with roots, must have an onset in the initial syllable.

> Syllable patterns VC and V may not occur *word-initially*. *All words* begin with consonants. (Newell 1956:523; emphasis added)

Thus, the relevant "initial syllable" for Guhang Ifugao is also a word-initial syllable; enforcing onsets only in the initial syllables of roots would again be inadequate.

However, the question arises whether an onset requirement for *root*-initial syllables might be necessary in Guhang Ifugao in addition to one for word-initial syllables (see also the discussion of root-initial faithfulness effects in §4.4.2 below). Landman (1999) observes that there appear to be constituents smaller than the word that are forced to have onsets. For example, the prefix /mun-/ attaches only to forms with initial onsets (78).

(78) Initial onset requirement *inside* complex words (Landman 1999:15)

mun.ʔu.gút	'sew'	mun.há.pit	'speak'
mun.ʔag.gé.aʔ	'I'm looking for'	mum.bú.uŋ	'wear necklace'
mun.ʔo.lé	'do slowly'	mun.lá.ik	'squash'
mun.ʔút.ʔut	'pain'	mun.na.nóŋ	'remain'

The potential problem is this. Roots are always consonant-initial when they occur word initially (i.e., without /mun-/), because in that context high-ranking ONSET/σ_1 is relevant. By the principle of richness of the base, even a potential input consisting of a vowel-initial root will surface unfaithfully, so that it starts with a consonant (Landman 1999 suggests that [ʔ] has been epenthesized in such cases; see §4.2.1.1). However, ONSET/σ_1 (where σ_1 is *word*-initial syllable) is unable to compel a root to surface consonant-initially when it is preceded by /mun-/. In other words, what prevents a vowel-initial root like the hypothetical /ole/ from surfacing as [ʔole] in isolation, but as *[mu.no.le] when prefixed by /mun-/?

It turns out that even positing an ONSET constraint for *root*-initial syllables is not helpful here. A putative ONSET/$\sigma_{1\text{-}Rt}$ constraint, requiring root-initial syllables to begin with onsets, would not distinguish between [mun.ʔo.le] and a form like *[mu.no.le], in which the prefix-final consonant /n/ is syllabified to provide the root-initial syllable with an onset: both candidates would satisfy the constraint.

Fortunately, there are a number of promising solutions to the problem of *[mu.no.le]-type forms, which do not require positing an ONSET/$\sigma_{1\text{-}Rt}$ constraint in addition to the ONSET/σ_1 already needed for word-initial syllables in this and other languages. For example, output-output faithfulness constraints could be invoked to ensure that roots embedded in complex words have the same form that they take in isolation — namely, with an initial consonant.[48] Alternatively, it could be the case that /mun-/ subcategorizes for a word rather than for a bare root, so that words with /mun-/ have the structure [$_{MWd}$ mun [$_{MWd}$ ʔole]], and ONSET/σ_1 itself is relevant for the initial syllable of the embedded MWd as well as the initial syllable of the complex form.[49]

Thus, for Arapaho and Guhang Ifugao, the requirement for "initial" onsets clearly holds of word-sized domains. Conversely, there is no conclusive evidence that a similar requirement

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[48]For other examples of languages in which requirements that hold of roots in isolation are extended through high-ranking output-output faithfulness constraints to hold of roots inside complex forms as well, see the discussion of "paradigm occultation" in McCarthy (1998).

[49]This second approach has some similarities to Cohn & McCarthy's (1998) analysis of a similar pattern in Indonesian. Cohn & McCarthy invoke an alignment constraint that requires left-edge alignment between a root and a PrWd. This forces a syllabification like məŋ.[$_{PrWd}$ʔi.si] 'fill' from /məN +[isi]$_{Rt}$/, because syllables cannot cross PrWd boundaries. However, one difference between Indonesian (or at least in the dialect of Indonesian described by Cohn (1989, 1993) and Cohn & McCarthy (1998)) and Guhang Ifugao is that words without initial onsets are tolerated in Indonesian. The two approaches to Guhang Ifugao suggested above have the advantage of relating the inability of final consonants in prefixes like /mun-/ to be syllabified into the onset position of a hypothetical V-initial root to the requirement that roots have initial onsets in isolation.

holds specifically of roots. "Initial syllable" is therefore best characterized as "word-initial syllable".

4.4.1.2 Defining the relevant word-sized domain

The previous section has argued that augmentation phenomena affecting the "initial syllable" show that the relevant syllable is one that is initial in a word-sized domain. Two kinds of word-sized constituents are relevant in phonology: the morphological constituent MWd and the prosodic constituent PrWd. However, the theory of positional augmentation constraints developed here is most compatible with *MWd-initial syllable* as the characterization of the strong position in question, because of the status of the initial syllable as a psycholinguistically strong position.

As discussed above and in Chapter 2, there are two main sources of evidence that the initial syllable is a strong position for psycholinguistic reasons. First, experimental results show that initial material is important in early-stage word recognition (§4.3.2). Second, attested initial-syllable augmentation constraints are more limited than those for the phonetically strong position stressed syllable, a position of equivalent size (see (47) in §2.3.3 and (70) in §4.2.3). If the initial syllable were a phonetically strong position like the stressed syllable, the two positions would be expected to have the same set of positional augmentation constraints.

Given that the initial syllable is a psycholinguistically strong position, it must be the MWd, not the PrWd, that is the relevant word-sized domain. Psycholinguistic evidence shows that morphological information is relevant in early-stage word recognition and lexical organization (§4.3.3), but prosodic information bears only an indirect relationship to early-stage word recognition (§4.3.4). Since psycholinguistically strong positions are defined as those positions that are critically important in early-stage word recognition — a definition that is further supported by the different behavior of initial syllables and stressed syllables with respect to their inventories of positional augmentation constraints — a morphologically defined word is the more theoretically appropriate choice.

The remainder of this section considers and rejects potential evidence that the PrWd is the relevant domain for positional augmentation in the "initial syllable" after all. First, an apparently phrasal metathesis pattern in the Sestu dialect of Campidanian Sardinian (see also §4.2.1.2.1), presented by Bolognesi (1998) as evidence that rhotics are banned specifically in PrWd-initial position, is argued not to distinguish between MWd and PrWd; that is, while there is no evidence from Sestu to *prove* that MWd is the domain in question, Sestu is shown at least to be *compatible* with the MWd proposal. Then, the tendency toward initial-consonant fortition in large prosodic domains, which resembles some of the initial-syllable onset effects seen in §4.2.1, is addressed. Prosodic domain-initial fortition is shown to be a phonetic rather than a phonological effect. This means that it cannot be directly related to true initial-syllable augmentation effects, which are phonological. Thus, the existence of initial fortition in large prosodic domains is not of itself evidence that the domain of the phonologically relevant "initial syllable" must be prosodically defined.

In Sestu Campidanian (Bolognesi 1998), as discussed in §4.2.1.2.1, rhotic (and glide) onsets are prohibited in "initial syllables". Contrary to the proposal made here, Bolognesi (1998:Ch 8) argues, based on a rhotic metathesis phenomenon, that it is specifically the PrWd whose initial syllable may not have a rhotic onset. However, the data that Bolognesi presents to support his claim do not, in fact, conclusively distinguish between PrWd and MWd.

Bolognesi shows that, in Sestu and other Campidanian dialects of Sardinian, there are a number of metathesis phenomena — both synchronic and diachronic — involving [r].[50] First, there are a number of Sestu words of the shape C*r*VCːV that correspond to Standard Sardinian words of the shape CV*r*CV, suggesting that there has been (diachronic?) metathesis creating a complex onset in order to improve performance on NoCoda.[51]

[50]In addition to the two [r]-metathesis phenomena discussed here, there are others not directly related to initial-onset sonority effects, such as the migration of an [r] from a complex onset in a final syllable into a complex onset in the preceding syllable. See Bolognesi (1998) for discussion.

[51]The gemination of the medial voiceless stops (phonetically realized not as length but as resistance to certain lenition processes) and the lenition of the medial voiced stops in the metathesized forms in (79) are the usual realizations of "long" consonants in Sestu; that is, the base prosodic position of the [r] seems to be maintained in the metathesized form, triggering compensatory "lengthening". See Bolognesi (1998) for further discussion of "long" segments and their phonetic realizations.

(79) [r] coda-to-complex onset metathesis (Bolognesi 1998:419)

Sestu	*Standard Sardinian*	
prokːu	porku	'pig'
tsrupːu	tsurpu	'blind'
fratʃːi	fartʃi	'sickle'
krupːa	kurpa	'fault'
mratsːu	martsːu	'rotten (of cheese)'
krutsːu	kurtsːu	'short'
sroɣu	sorgu	'father in law'[52]
sre'βi(ɾi)	ser'bi(ɾi)	'to be useful'
spraʒi	spardʒi	'to spread'
mraʒini	mardʒini	'margin'

The coda-[r] metathesis shown in (79) is pervasive. In fact, Bolognesi (1998:419) states, "In Sestu Campidanian and other related dialects, the liquid /r/ is found in coda position only in a limited set of words, all of which exhibit the same prosodic structure." Namely, the words that maintain coda [r] are disyllabic and vowel-initial (80).

(80) [r] codas maintained (Bolognesi 1998:419)

orku	'ogre'	ardʒa	'tarantula'
arku	'bow'	argu	'sour'
ɛrba	'grass'	ordʒu	'barley'

It is clear (as Bolognesi also notes) that the absence of [r] metathesis in these contexts is related to the prohibition of word-initial rhotic onsets in Sestu. If the coda [r] were to move into the onset of its syllable, as in (79), it would become the leftmost onset consonant in the initial syllable: **rokːu*. (Metathesis in the opposite direction, producing forms such as **okru*, would violate a general prohibition against C*r* onset clusters in word-final syllables; see Bolognesi (1998:Ch 8) for discussion.)

Interestingly, these vowel-initial, [r]-coda words productively undergo metathesis when they are preceded by a determiner (81). It is this fact that leads Bolognesi to conclude that the ban on rhotic onsets in Sestu must be sensitive to initial position in the PrWd; once there is prosodically dependent material preceding the morpheme in question, [r] does appear in initial position within the morpheme, because now it can do so without being initial in the PrWd.

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[52]Bolognesi (1998:419) actually lists these two forms in the opposite columns, but they are listed correctly on p 35 (and the Sestu form is given as *sroɣu* several times in the text).

(81) Rhotic metathesis (Bolognesi 1998:419)

(a) *Isolation form*		(b) *With determiner preceding*	
orku	'ogre'	sː rokːu	'the ogre'
arku	'bow'	kust rakːu	'this bow'
ɛrba	'grass'	kusː rɛβa	'that grass'
ardʒa	'tarantula'	sː raʒa	'the tarantula'
argu	'sour'	sː raɣu	'the sour one'
ordʒu	'barley'	sː roʒu	'the barley'

However, there are a number of complications that weaken Bolognesi's claim that it is crucially PrWd-initial position where rhotic onsets are prohibited. First, no supporting evidence is presented to confirm that these determiners are functioning as clitics (that is, morphemes that are prosodically integrated but still morphosyntactically separate). If it turns out that no such evidence is available, it might be the case that these determiners have become prefixes, actually combining with nouns morphosyntactically to form a complex MWd, so that a metathesized [r] as in (81b) is no longer in MWd-initial position (and therefore does not violate *[ONSET/RHO]/σ_1). Note that there is more going on here than metathesis: the determiners appear in their pre-vocalic forms (compare the pre-consonantal forms *sːu/sːa, kustu/kusta, kusːu/kusːa*) even though the nouns, having undergone metathesis, are not actually vowel-initial. This opaque interaction may be an indication of the morphologization of these determiner+noun combinations.[53]

Thus, pending further investigation, it can be concluded that the Sestu metathesis facts as discussed by Bolognesi (1998) do not really favor PrWd over MWd as the appropriate characterization of the domain in which the "initial syllable" is a strong position.

A second phenomenon that might appear to support the choice of PrWd-initial syllable as the proper characterization of this strong position is the occurrence of initial-syllable onset fortition at various levels of the prosodic hierarchy. If it is a general characteristic of every prosodic level that consonants in domain-initial position tend to undergo fortition, then one might propose that ONSET/σ_1 and *[ONSET/X]/σ_1 are simply the instantiation of this phenomenon at the PrWd level. However, there are two reasons why these **M/σ_1** constraints

[53]Moreover, recall from §2.3.3 that, since relationships between morphological and prosodic categories must be mediated by segments, the MWd-initial syllable has been defined as the leftmost syllable whose head is affiliated with a given MWd. Under this definition, even if the determiners and nouns in (81) do not combine morphosyntactically to form a complex MWd, the [r] in the metathesized forms (81b) still does not violate *[ONSET/RHO]/σ_1, because (by virtue of resyllabification of the determiner-final C) the [r] is not the leftmost onset segment in the MWd-initial syllable.

should not be equated with prosodic domain-initial effects: first, initial-onset fortition in phrasal and larger prosodic categories is phonetic (gradient and variable), not phonological (categorical); and second, initial syllables of large prosodic domains are never seen to license a larger array of phonological contrasts than other positions, which is an important diagnostic of strong-position status (Beckman 1997, 1998).[54] Thus, being initial in a prosodic domain — including PrWd — does not give a syllable the status of a phonologically relevant strong position, able to resist positional neutralization and to undergo phonological, categorical positional augmentation. It is therefore the initial syllable of a MWd, not the initial syllable of a PrWd, that is a member of the set of strong positions.

Prosodic domain-initial fortition has been documented for a number of phonetic properties in several languages (e.g., Pierrehumbert & Talkin 1992; Silva 1992; Jun 1993; Dilley, Shattuck-Hufnagel, & Ostendorf 1996; Fougeron & Keating 1997; Fougeron 1998; Keating, Cho, Fougeron, & Hsu 1998; Lavoie 2000; Cho & Keating 2001; Keating, Wright, & Zhang 2001). For example, Keating, Cho, Fougeron, & Hsu (1998) found that speakers of French, Korean, and Taiwanese all made some distinction between smaller and larger prosodic categories in terms of the stop closure duration and/or degree of linguopalatal contact in domain-initial [t] and/or [n], although the specific levels of the prosodic hierarchy that were distinguished varied by language, by speaker, and by consonant. The VOT of voiceless aspirated stops is longer in phrase-initial than in word-initial position in English (Pierrehumbert & Talkin 1992) and Korean (Jun 1993). Domain-initial [n] has less nasalization (as measured by low-frequency spectral components) in French (Fougeron 1998) and Korean (Cho & Keating 2001) in higher-level prosodic domains.

Thus, there is a fair amount of evidence that consonant articulations are more extreme or prototypically consonantlike (that is, "stronger") in the initial position of a given prosodic domain than in medial positions within the domain; e.g., a word-initial consonant that is also in phrase-initial position is often stronger than a word-initial consonant in phrase-medial position, and a phrase-initial consonant that is also in utterance-initial position is often stronger than a phrase-initial consonant that is internal to an utterance. Furthermore, in many cases, the effect is cumulative, so that progressively stronger articulations are seen at the edges of progressively larger prosodic constituents. One striking example is VOT in Korean [t], for which three different speakers all had increasingly longer VOT in the initial position of prosodic words, accentual phrases, intonational phrases, and utterances (Keating et al. 1998; Cho & Keating 2001).

However, these domain-initial fortition effects are typically gradient and variable; the Korean VOT results just described notwithstanding, it is more common to find that different speakers distinguish different levels of the prosodic hierarchy to different degrees for different consonants. Cho & Keating (2001) state, "[W]e do not assume that the effects of prosody on articulation are strictly categorical... Indeed, in our previous work we have never found

[54]On the other hand, there is evidence that *heads* of the various prosodic constituents do have special status with respect to faithfulness. See §1.3.1, footnote 7.

uniformity across speakers of a language as to how many or which prosodic constituents show initial strengthening." In this important respect, prosodic domain-initial fortition differs from initial-syllable onset epenthesis and onset sonority[55] effects, which are phonological phenomena resulting from the satisfaction of ONSET/σ_1 and *[ONSET/X]/σ_1 constraints.

All this is not to say that prosodic domain-initial fortition is completely unrelated to **M/σ_1** constraints. For example, the general tendency toward domain-initial fortition may bolster the substantive pressure formalized as clause II of the Segmental Contrast Condition (which allows segmental-contrast **M/Ψstr** constraints if they are related to left-edge demarcation; §2.4.1, §4.3.5), on the grounds that MWd-initial and PrWd-initial positions often overlap. However, it is not PrWd status alone that has the ability to make a syllable a phonologically relevant strong position.

In conclusion, evidence from the locus of "initial-syllable" augmentation phenomena in morphologically complex words, and considerations stemming from the psycholinguistic basis of the strong-position status of the "initial syllable", indicate that it is the MWd-initial syllable that is a member of the class of strong positions recognized by the phonology and available for constructing positional faithfulness and augmentation constraints.

4.4.2.   "Initial syllable" and resistance to positional neutralization

In the Schema/Filter model of CON (§2.2.1), constraints are constructed from a set of general constraint schemas that freely apply to elements from a set of phonological primitives and thereby generate individual, contentful constraints. As discussed in §2.2.1.1, the set of strong positions *str* is included in the set of phonological primitives, and elements from the set *str* are selected by the **C**/*str* schema, which relativizes constraints, including both markedness and faithfulness constraints, to strong positions. Thus, the positions in the set *str* are the only formally possible positions to which otherwise context-free constraints can be relativized.[56] Crucially, both positional faithfulness and positional augmentation constraints make reference to the same set of strong positions. Therefore, it is important to consider whether the conclusions concerning the designation of "initial syllable" as MWd-initial syllable, which have been reached on the basis of facts about positional augmentation, are compatible with evidence from positional neutralization concerning the special status of the "initial syllable".

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[55]In fact, according to Cho & Keating (2001), Fougeron (1998) argues that the decrease in nasalization in French [n] in the initial position of larger prosodic domains is best analyzed as the result of muscular tension in the levator palatini, rather than as the result of some general trend toward lower sonority in domain-initial positions.

[56]That is, positional faithfulness and positional augmentation constraints, in which an otherwise independent constraint is relativized to a particular, extra-phonologically salient position, are distinguished here from context-dependent markedness constraints such as *$NV_{[oral]}$, which in a sense makes reference to the "position" N__ (cf. Kager 1999).

Beckman (1995, 1997, 1998) surveys a number of positional neutralization phenomena that indicate that material in initial syllables is especially resistant to featural neutralization.[57] Phonological structures that are contrastive only in initial syllables include: mid vowels in Shona, nasal and long vowels in Dhangar-Kurux, round vowels in Turkic, clicks in !Xóõ, consonants with secondary articulations in Shilluk, and coda consonants with independent (non-shared) place features in Tamil (Beckman 1998:56).

As Beckman (1997:footnote 4) observes, many of the languages that she examines do not have prefixes, so that it is not possible to distinguish between root-initial and MWd-initial syllables in many cases. However, some of the languages with special feature licensing abilities in "initial syllables", including Shona and other Bantu languages, do have prefixes — and in these languages, it is crucially the *root*-initial syllables that behave as strong positions. But as shown in §4.4.1.1 above, restricting initial-syllable augmentation effects to root-initial syllables is incompatible with the crucially word-initial onset requirements found in languages such as Arapaho and Guhang Ifugao. How can this apparent discrepancy between positional augmentation and positional neutralization in "initial syllables" be resolved?

It seems that it may be necessary to recognize both MWd-initial and root-initial position as members of the set of psycholinguistically strong positions (roots being important in the internal structure of the lexicon, as discussed in §4.3.3). If this is the case, there should be examples of both positional augmentation in root-initial syllables and resistance to positional neutralization in MWd-initial syllables. There may in fact be an attested case of the latter, in the Bantu language Esimbi (Hyman 1988; Walker 1999, to appear). In this language, non-high vowels are banned everywhere except in the word-initial syllable, even when this syllable is a prefix.[58] Further investigation is needed to determine whether there are positional augmentation effects specifically in root-initial syllables.

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[57]Casali (1996, 1997) proposes that the relevant "initial" unit with privileged status is a segment, not a syllable. However, since the effect he is trying to account for is the resistance of initial vowels to deletion (at the expense of final vowels, in [...V]+[V...] contexts), his findings are compatible with the recognition of the initial syllable as a strong position. (One apparent counterexample is Nawuri (Casali 1996:25), in which front vowels surrounded by consonants become centralized, even in initial syllables, but a word-initial front vowel never becomes centralized, even when a C-final word precedes. However, granting strong-position status to word-initial segments or vowels is not truly necessary even for this case, because Nawuri could simply have a high-ranking output-output faithfulness constraint that protects initial front vowels from centralizing in derived or phrasal contexts.)

[58]Esimbi is a complicated case, however, because the vowel height features that are realized in word-initial position are actually contributed by the root. Thus, root height features are the ones that are preserved (root faithfulness), but the feature contrast is permitted to appear only in word-initial position (MWd-initial syllable faithfulness — ?). See also footnote 9 in Chapter 5.

4.5 Summary and conclusions

This chapter has examined positional augmentation in psycholinguistically strong positions. Examples of **M/Ψstr** constraints responsible for root and initial-syllable augmentation phenomena in various languages have been presented, and various implications of these phenomena for the formal distinction between ONSET and *ONSET/X constraints, and for distinct syllable positions for onset glides and nuclear onglides, have also been discussed.

The case studies examined here support a prediction made by the model of **M/str** constraints developed in Chapter 2: **M/Ψstr** constraints are restricted, not only by the Prominence Condition, but also by the Segmental Contrast Condition. Psycholinguistic evidence has therefore been reviewed in support of the formulation that has been given to the Segmental Contrast Condition: since the initial syllable and the root are important in early-stage word recognition, there are substantive pressures against segmental contrast neutralization in these positions. Initial-syllable augmentation constraints that manipulate onset sonority are tolerated, however, because this facilitates segmentation of the speech stream. Importantly, contrasts involving prosodic features such as stress are not blocked by the Segmental Contrast Condition, because such contrasts are not as influential in early-stage word recognition as contrasts involving segmental features are.

Finally, the proper characterization of the "initial syllable" has been considered. Examples of augmentation in, crucially, *word*-initial syllables have been presented, and *MWd* has been chosen over PrWd as the relevant word-sized domain. Implications for these results with respect to cases of resistance to positional neutralization in "initial syllables" have also been explored.

While several questions concerning augmentation in psycholinguistically strong positions may remain for future investigation, a number of findings have emerged: it is important to recognize a distinction between phonetically and psycholinguistically strong positions; psycholinguistically strong positions are intimately involved in early-stage word recognition; and this involvement leads to restrictions on the nature of possible **M/Ψstr** constraints that are not relevant for **M/Φstr** constraints.