The formal definition of the ONSET constraint and implications for Korean syllable structure

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1   Introduction

The crosslinguistic preference for syllables to have onsets has been modeled by various rules, principles, and constraints in a number of phonological frameworks. Early generative discussions include Kahn (1976), Selkirk (1982, 1984), Steriade (1982), Clements & Keyser (1983), and Itô (1986, 1989). In Optimality Theory (Prince & Smolensky 2004 [1993]), this preference is formalized as the ONS(ET) constraint. ONSET finds widespread acceptance among OT practitioners, but not much attention has been paid to developing and defending a precise formal definition for this constraint.

This paper provides additional support for the formal definition of ONSET proposed in Smith (2002, 2003, 2008), a definition that makes reference to no details of syllable-internal structure other than the fundamental head/nonhead distinction. This *head-based* definition of ONSET has crosslinguistic empirical support and contributes to a view of the phonology-phonetics interface according to which constraints are only indirectly related to phonetic factors, even when functionally motivated. In the discussion that follows, the head-based definition of ONSET is shown to allow for a consistent, noncontradictory phonological analysis of the syllable position of glides in Korean. Moreover, the account of glides now available under this view of ONSET is shown to prepare the ground for a nonstipulative account of a ban on word-initial liquids in South Korean dialects, an otherwise independent phenomenon.

Prince & Smolensky's (2004 [1993]) original definition of ONSET is given in (1). According to this definition, a syllable will satisfy ONSET only if it begins with a segment syllabified as a true structural onset. A syllable that begins with a nonpeak segment that is syllabified as part of the syllable rime, as with a rising diphthong such as [i̯a], does not satisfy this version of the constraint.

(1)   Prince & Smolensky's (2004) ONSET

    (a) ONS   A syllable must have an onset (Prince & Smolensky 2004: 106)

    (b) 'We will say a syllable "has an onset" if...it has an Ons node...'
       (Prince & Smolensky 2004: 110)

In contrast, the formal definition of the ONSET constraint adopted in this paper is as in (2). According to this definition, ONSET is satisfied as long as the head segment of the syllable is preceded by some other segment in that syllable.

(2)   ONSET   'Syllables have onsets'

> For all syllables σ, $a \neq b$
> > where a is the leftmost segment dominated by σ
> > > b is the head segment of σ

Discussion of this definition of ONSET, and why it is preferable to other proposed or conceivable definitions, is given in §2.

The implications of the head-based definition of ONSET for Korean are discussed in §3 and §4. Previous research has presented apparently contradictory evidence to support both claims that Korean glides are onsets, and claims that they are rimal. However, §3 demonstrates that the evidence in support of Korean glides 'as onsets' reduces to evidence that the glides resolve hiatus, that is, that they satisfy ONSET. Under the definition of ONSET developed here, this is predicted to be the case *even if the glides are syllabified in the syllable rime.* Thus, all the available evidence about glide syllabification in Korean can now be seen to be compatible with the claim that Korean glides are part of the syllable rime. Once this analysis is adopted for the glides, a sonority-based, and therefore phonetically and phonologically motivated, account becomes possible for the ban on word-initial liquids in South Korean dialects. This account, and crosslinguistic support for such an approach, are presented in §4.

Finally, the head-based definition of ONSET has theoretical implications, because it is relevant for ongoing debates about the nature of the phonetics-phonology interface. As shown in §5, ONSET has the same functional motivation as the *ONSET/X constraint family, which enforces low sonority in onset consonants. However, while ONSET is independent of syllable structure beyond head/nonhead status, the *ONSET/X constraints are crucially *dependent* on syllable structure – they evaluate only segments that are syllabified as true structural onsets. Therefore, ONSET and *ONSET/X, despite their shared functional motivation, are formally distinct constraints. This shows that it is not the case that functionally motivated constraints are projected directly from the phonetics; the relationship between phonetic information and phonological constraints is indirect.

2   ONSET **is sensitive to head/nonhead status only**

There are a number of logically possible ways to give an explicit phonological definition for a constraint whose intent is to penalize onsetless syllables. The definition adopted here is the following (repeated from (2) above), proposed in Smith (2002, 2003, 2008).

(3)   ONSET   'Syllables have onsets'

> For all syllables σ, $a \neq b$
> > where a is the leftmost segment dominated by σ
> > > b is the head segment of σ

This constraint formalization demands only that the head segment of a syllable not be leftmost in its syllable; the exact position in hierarchical syllable structure taken by the desired prehead segment is irrelevant. Formally, the head segment is the syllable peak or 'designated terminal element' (Liberman & Prince 1977); this follows the standard assumption in prosodic theory that

every prosodic constituent has a dependent that is phonologically designated as its head (see, e.g., Selkirk 1986, 1995).
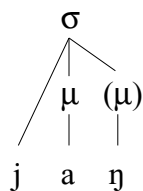
The remainder of this section now considers general implications of the head-based definition of ONSET, and argues against alternative formalizations.

Adopting the head-based definition of ONSET turns out to have important consequences for glides, because two phonologically distinct syllable positions have been identifed for prepeak glides (Kaye & Lowenstamm 1984; Davis & Hammond 1995; Harris & Kaisse 1999; see also Selkirk 1982: 343). For example, in French, some prepeak glides act 'like vowels' while others act 'like consonants,' triggering different sets of allomorphs and distinct co-occurrence restrictions (Kaye & Lowenstamm 1984). In Spanish, prepeak glides preceded by another consonant act rimal, contributing to syllable weight, while syllable-initial prepeak glides act like onsets, undergoing fortition in many dialects (Harris & Kaisse 1999). These different patterns in glide behavior have been used to motivate a representational distinction between what are called here *true onset glides,* glides that are syllabified as structural onsets, and *rimal onglides,* glides that are syllabified as part of the syllable rime, forming a rising diphthong with the syllable peak.

This representational distinction can be made in any theory of subsyllabic structure that recognizes some kind of structural difference between onset and rime, including a model in which the rime is a separate constituent that excludes the onset (e.g., Selkirk 1982, 1984; Blevins 1995); for concreteness, this paper assumes moraic theory as implemented by McCarthy & Prince (1986) and Hayes (1989). On this view of subsyllabic structure, a true structural onset is defined as a prepeak segment that is a direct dependent of the syllable node. Any prepeak segment that is not a direct dependent of the syllable node, being dominated by a mora instead, is by definition part of the rime.

(4)   Two possible syllable positions for prepeak glides

(a) Glide as true onset   (b) Glide as rimal onglide[1]
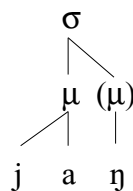
What is crucial here is that, under the head-based definition of ONSET given in (2) above, both (4a) and (4b) satisfy the constraint. Even though only (4a) is a syllable with a true structural onset (daughter of σ), both of these representations satisfy the requirement that the head segment ([a]) not be leftmost in its syllable.

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1 In a language where a rimal onglide contributes independently to syllable weight, as in Spanish (in cases where another onset consonant precedes; Harris & Kaisse 1999), it would be dominated by its own mora rather than sharing the mora of the syllable peak.

In the discussion that follows, curly brackets {} are used to demarcate segments contained in the syllable rime. This notation makes it convenient to distinguish between [j{a}], a true onset glide, and [{ja}], a rimal onglide.

As outlined in §1, this indifference to syllable structure in the definition of ONSET is empirically motivated; justification is presented in §3 and §4 below. First, however, this section defends the proposal that ONSET must be defined on the basis of the head/nonhead distinction, rather than other conceivable distinctions, such as values for the feature [±consonantal] or relative sonority.

2.1 ONSET does not refer to [±consonantal] or the CV tier

Many definitions for ONSET require that syllables start with 'C' (McCarthy & Prince 1993; Karttunen 1998; Eisner 1997), or that they not start with 'V' (Kager 1999; McCarthy 2003). Examples are given in (5).

(5)　　CV-based definitions of ONSET

　　　　(a) McCarthy & Prince (1993: 101)

　　　　　　ONSET　　Align (σ, L, C, L)
　　　　　　　　　　For every σ, there is some C such that the Left edge of σ and the Left edge of C are aligned

　　　　(b) Kager (1999: 93)

　　　　　　ONSET　　*[$_\sigma$ V

The exact conditions under which these constraints would assign violations are not clear, because this depends on how the *C/V* notation is to be interpreted. However, C and V must not simply be equivalent to the feature specifications [+consonantal] and [−consonantal] respectively, for two reasons. First, glides, which are [−consonantal] ('V'?), do satisfy ONSET; glide formation or glide spreading often occurs in order to resolve hiatus (see, e.g., Rosenthall 1994 and Levi 2004; additional evidence that glides satisfy ONSET is discussed in §3 below). Second, many languages allow [+consonantal] segments ('C'?) to serve as syllable peaks, so if ONSET merely demands that each syllable begin with something [+consonantal], then this constraint would inappropriately be satisfied by an onsetless syllable with a [+consonantal] peak. That this is not so is shown by Imdlawn Tashlhiyt Berber (Dell & Elmedlaoui 1985, 1988; Prince & Smolensky 2004; Ridouane 2008), where onsets are obligatory (except word initially, where other constraints come into play) even when the syllable peak is a [+consonantal] segment. For example, the syllabification [tx̣.zn̩t] 'you stored', where all medial syllables have onsets, is chosen over *[tx̣ẓ.n̩t], which does better with respect to nucleus sonority ([z̩] is better than [x̩]), but has an onsetless medial syllable (Prince & Smolensky 2004: 24). If ONSET were satisfied by the presence of a [+consonantal] segment at the left edge of the syllable, [n̩t] would not violate this constraint.

Assuming that the CV notation used in (5) refers to slots on the CV tier does not straightforwardly rescue this definition, either. Proponents of X-slot theory (Levin [Blevins]

1985, Blevins 1995) and moraic theory (Hayes 1989; McCarthy & Prince 1986) have demonstrated that the distinction between C and V slots is secondary, being derivative from the role that a segment plays in syllable structure.

Therefore, the only successful interpretation of ONSET definitions like those in (5) is to let C/V stand for 'not syllabic'/'syllabic,' which reduces to the very proposal being made here: ONSET is a constraint that requires a syllable not to begin with its peak (the 'syllabic' segment in the syllable).

2.2 ONSET does not refer to relative sonority

Another conceivable way to formalize the ONSET constraint is to require every syllable to begin with a rise in sonority. Such a definition would transparently reflect the functional motivation for ONSET, discussed in §5, which is to intersperse low-sonority segments between syllable peaks in order to increase the perceptual salience of the speech stream. However, another example from Imdlawn Tashlhiyt Berber shows that ONSET is satisfied even when the prepeak segment is of a *higher* sonority class than the peak. The syllabification [i.sa.wl̩] 'he talked', with a syllable [wl̩], is chosen over *[i.sa.ul], with [ul]. Again, the unattested form better satisfies constraints demanding high-sonority peaks, because [u] is better than [l̩]. So, if [wl̩] did not satisfy high-ranking ONSET, there would be no reason to choose this syllabification over [ul] (Prince & Smolensky 2004: 24; Ridouane 2008: 325). And yet in this syllable, the leftmost segment, [w], is *not* lower in sonority than the nucleus, [wl̩]. Therefore, a definition of ONSET that is sensitive to differences in sonority is not empirically supported.

The examples discussed in §2 confirm that what the ONSET constraint requires in syllable-initial position is neither a [+consonantal] feature specification nor a sequence of segments with rising sonority. The head-based definition of ONSET succeeds in avoiding these problems. Next, §3 and §4 show that the head-based definition has desirable consequences for the analysis of several otherwise unrelated syllable-structure phenomena in Korean. Thus, the definition of ONSET adopted here is furthermore preferable to one, like that in Prince & Smolensky (2004), that refers to the structural onset position within a syllable.

3   Head-based ONSET and the syllabification of Korean glides

The proposal that ONSET is insensitive to differences in the syllable position of prepeak segments sheds new light on several patterns in the phonology of Seoul Korean. For years, there has been a debate over the phonological representation of glides in Korean syllable structure. Some researchers claim that Korean glides are onsets, or 'consonants' (e.g., B.G. Lee 1982; Y.S. Kim 1984; Ahn 1985; Y. Lee 1994). Others take the position that Korean glides are rimal onglides, or 'vowels' (e.g., Martin 1954, 1992; H.S. Sohn 1987a,b; Han 1990; C.W. Kim & H.Y. Kim 1991; H.M. Sohn 1994; I. Lee & Ramsey 2000).

This question has been difficult to settle for a number of reasons. First, much of the evidence originally presented to support one view or the other, such as evidence from language games or place-based co-occurrence restrictions, was later shown to be inconclusive in choosing between the two structural alternatives (for detailed discussion of this debate, see especially Y.S. Kim

1984, Ahn 1985, Y. Lee 1994, and H.Y. Kim 1998 for the pro-onset position, and H.S. Sohn 1987a,b, C.W. Kim & H.Y. Kim 1991, and Shim 1997 for the pro-rime position). Second, the evidence that does actually withstand scrutiny appears to be contradictory; each side of the debate has evidence that the other side has been unable to explain away.

The argument pursued here is as follows. Essentially all of the evidence in support of the claim that Korean glides are syllabified as onsets reduces to the claim that glides resolve hiatus – that is, that they satisfy the ONSET constraint. However, according to the head-based definition of ONSET, rimal onglides actually satisfy this constraint as well. Therefore, proposing that Korean glides are rimal onglides, in combination with the definition of ONSET adopted here, allows for a consistent account of glide behavior in Korean.

The remainder of this section summarizes the evidence that Korean glides resolve hiatus and presents several arguments from the literature that these glides are rimal onglides and not true structural onsets.

3.1 The distribution of glides in Korean

The syllable template for Korean is (C)(G)V(C) (H.M. Sohn 1994: 445), where C is a [+consonantal] element, G is a glide, and V is a vowel (nucleus). Thus, glides may be syllable initial (6), or they may co-occur with a preceding onset consonant (7), which is the only configuration in which two segments precede the syllable peak.

(6)   Simplex glide onsets (data from H.M. Sohn 1994)

(a) initial	[**w**aŋ]	'king'		[**j**aŋ]	'sheep'	
	[**w**ən.tʃʰik]	'principle'		[**j**ə.ɾɨm]	'summer'	
(b) medial	[o.nju.**w**əl]	'May and June'		[kjoː.**j**uk]	'education'	

(7)   C+glide onsets (data from H.M. Sohn 1994, 1999)

(a) initial	[k**w**aː.il]	'fruit'		[k**j**uːl]	'orange (n.)'	
	[k**w**əl.ljək]	'power'		[p**j**əŋ]	'bottle'	
				[m**j**oː.dʒi]	'graveyard'	
(b) medial	[i.ɾ**w**ən]	'one *won*'		[hak.k'**j**o]	'school'	
	[tʃən.h**w**a]	'telephone'		[ko.h**j**aŋ]	'hometown'	
	[tʃi.g**w**ən]	'staff'		[k**w**əl.ljək]	'power'	
				[o.nj**u**.wəl]	'May and June'	

These are the only contexts in which glides are found; in particular, glides do not systematically occur to the right of the peak within a syllable.[2]

3.2 Evidence for Korean glides as 'onsets'

As noted above, the strongest argument in favor of the claim that Korean glides are 'consonants,' that is, that they are syllabified as onsets, is that glides resolve hiatus. Evidence that glides resolve hiatus is now presented, with data from suffix allomorphy, glide coalescence, and glide deletion in turn.

One piece of evidence showing that glides are able to resolve hiatus comes from suffix allomorphy patterns. Several suffixes in Korean have two allomorphs, one consonant initial and one vowel initial, which are combined with stems ending in the opposite segment class in order to form V+C and C+V sequences at morpheme boundaries. Examples include the suffixes that mark nominative ([-ga]~[-i]), accusative [-ɾɯl]~[-ɯl], topic ([-nɯn]~[-ɯn]), and directional or instrumental ([-ɾo]~[-ɨɾo] (Martin 1992: 195--196). It is not clear for all pairs whether both allomorphs are lexically listed, or whether one is derived from the other in the synchronic phonology (H.M. Sohn 1999: 163), but the relevant point for the current discussion is that the V-initial allomorph is not selected when a stem is V-final. The avoidance of V+V sequences in these morphological forms indicates that Oɴsᴇᴛ is being satisfied through allomorph selection. Crucially, there are suffix allomorph pairs of this type where the allomorph that occurs with V-final stems begins with a glide. This shows that glides behave like other consonants in Korean in satisfying Oɴsᴇᴛ.

The vocative is one such morpheme. This suffix alternates between [-ja] after V-final names and [-a] after C-final names.

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2 One marginal exception may be the offglide in the diphthong [ɨj], which is described by Martin (1992: 26) and H.M. Sohn (1994:440) as a spelling pronunciation for orthographic <ɨj> used by some younger speakers, although K.O. Kim (1978: 76--77) describes it instead as a rising diphthong with a back unrounded onglide, [ɰi]. In any case, orthographic <ɨj> in Seoul Korean is more generally pronounced [ɨ] in absolute word-initial position and [i] in other contexts, except that it is [e] in the case of the genitive marker. The other orthographic diphthongs with 'offglides' are consistently pronounced as monophthongs or *rising* diphthongs in Seoul: <əj> as [e], <aj> as [ɛ] or [æ] (a category that has merged with [e] for some speakers), and <oj> as [ø] or [we] (Martin 1992: 11--12, 24).

(8)   Vocative suffix allomorphy: [ja]~[a]
        (data from Ahn 1985: 49--50; Y. Lee 1994: 138; Yun 2001: 74)

(a) Vowel-final names		(b)	Consonant-final names	
name	*vocative*		*name*	*vocative*
[su.mi]	[su.mi.ja]		[sun]	[su.na]
[tʃin.se]	[tʃin.se.ja]		[tʃin.suk]	[tʃin.su.ga]
[min.su]	[min.su.ja]			

The last example in (8a) confirms that the [j] glide is not simply copied from the stem-final vowel, which would have produced *[min.su.wa].

A second example of suffix allomorphy involving a glide-initial allomorph after a V-final stem is the [-ja] allomorph of the verb infinitive suffix /-a/, as seen in (9).

(9)   Verb infinitive suffix /-a/, with idiosyncratic [-ja] alternant (Y.S. Kim 1984: 12--13)

        /ha + ʌ + la/ *do*-INF-IMPER ⟶   [ha.jə.ɾa] 'do!'   (also [ha.ɾa], [hɛ.ɾa])

The morphophonology of the infinitive suffix is complicated, so only the immediately relevant facts are presented here; see, e.g., H.S. Sohn (1987b) and Martin (1992: 465--466) for additional details. This suffix consists of a harmonizing vowel, represented as /ʌ/, which is realized as [a] or [ə] depending on the vowel in the preceding syllable. After verb stems ending in [e], [ɛ], or [a], the infinitive suffix usually surfaces as zero, which accounts for the [ha.ɾa] form in (9). However, as discussed by Y.S. Kim (1984), certain verbs show optional consonant-initial alternants of the infinitive suffix. The consonant involved is unpredictable and depends on the individual verb; Y.S. Kim (1984: 12) gives the examples /o + a + la/ [o.nə.ɾa] 'come!' and /ka + a + la/ [ka.gə.ɾa] 'go!' in addition to the form shown in (9). What is important here, as Kim emphasizes, is that there would be no advantage to choosing the [j]-initial form of the infinitive suffix over its usual vowel-initial form if glides did not serve to avoid hiatus just as the other idiosyncratic infinitive-initial consonants [n g] do.

Another set of patterns showing that syllable-initial glides satisfy ONSET in Korean are those in which general processes of glide coalescence or glide deletion are blocked in contexts where hiatus would arise if those processes applied. For example, there is a optional pattern of glide coalescence in which [–hi, –rd] back vowels merge with [j] to become front vowels (C.W. Kim 1968; C.W. Kim & H.Y. Kim 1991; H.S. Sohn 1987a,b). Specifically, [j]+[ə] becomes [e], and [j]+[a] becomes [ɛ], as exemplified in (10). However, Y. Lee (1994) notes that this coalescence process is blocked in absolute word-initial position (11a), and Yun (2001) demonstrates that it is blocked in intervocalic position as well (11b) – these are contexts where no other onset consonant is available.

(10)   Optional GV coalescence in CGV syllables

    (a) Word-initial examples
       (data from C.W. Kim 1968: 520--521; H.S. Sohn 1987b: 162; C.W. Kim & H.Y. Kim
       1991: 121; Martin 1992: 39)

[pjə]	~	[pe]	'rice plant'	[pjə.ɾak]	~	[pe.ɾak]	'thunder'
[pjəl]	~	[pel]	'star'	[pjəŋ.wən]	~	[peŋ.wən]	'hospital'
[pʰjə]	~	[pʰe]	'spread'	[pʰjəŋ.jaŋ]	~	[pʰeŋ.jaŋ]	'Pyŏngyang'
[kjə]	~	[ke]	'chaff'	[hjəŋ.nim]	~	[heŋ.nim]	'elder brother'
[mjət]	~	[met]	'how much?'	[mjə.nɨ.ɾi]	~	[me.nɨ.ɾi]	'daughter-in-law'

[p'jam]	~	[p'ɛm]	'cheek'

    (b) Medial examples (data from H.S. Sohn 1987b: 162; Martin 1992: 25, 38)

[pi.njə]	~	[pi.ne]	'stick hairpin'
[səl.mjəŋ]	~	[səl.meŋ]	'explanation'
[ki.ta.ɾjə.jo]	~	[ki.ta.re.jo]	'waits' (/kitali + A + jo/ '*wait*-INF-POLITE')

(11)   GV coalescence blocked in .GV syllables

    (a) Word-initial examples (data from Y. Lee 1994: 141)

[jə.dʒa]	*[e.dʒa]	'woman';	cf. [kjə.dʒa]	~	[ke.dʒa]	'mustard'
[jə.ul]	*[e.ul]	'stream';	cf. [kjə.ul]	~	[ke.ul]	'winter'

    (b) Medial example (data from Yun 2001: 78)

[pu.jə]	*[pu.e]	(place name)

A similar argument in favor of the ability of syllable-initial glides to function as onsets is made by Yun (2001), who focuses on an optional[3] glide deletion phenomenon that, once again, affects glides in CGV syllables, but not .GV syllables. The target of the deletion process is [j] when it is follwed by [e]. (Since [e] is also the output of coalescence in the case of [jə], this process of [j] 'deletion' before [e] may in fact be another case of coalescence, i.e., [je] —> [e] with the value

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3 Martin (1992: 109--110) describes this as a mandatory process: 'The phoneme string /je/
   occurs only after a pause; in other positions it is automatically replaced by /e/...'
   [transcriptions converted to IPA]. However, Yun (2001: 68) states that for his variety of
   Korean, the deletion process is optional.

of [±back] vacuously output as [–back] as it is, nonvacuously, in the case of [ja] —> [ɛ] and
[jə] —> [e].)

(12)   [j] deletion in C[je] sequences (data from Yun 2001: 68)

     (a) Word-initial examples

        [pʰje]   ~ [pʰe]   'bother'
        [nje]   ~ [ne]   'yes'

     (b) Medial example

        [sa.ɾje]   ~ [sa.ɾe]   'reward'

(13)   Resistance to [j]-deletion in #GV (data from Yun 2001: 68)

     (a) [je]   *[e]   'example'
        [kje]   ~ [ke]   'a traditional mutual financial association'

     (b) [je.san]   *[e.san]   'budget'
        [kje.san] ~ [ke.san] 'calculation'

For both the GV coalescence pattern and the glide-deletion pattern, there is a difference between glide-initial and C-initial syllables. Where the glide is the sole prepeak segment, it is resistant to these optional phonological processes that, in other contexts, remove glide segments from surface forms. Crucially, if [je] were *not* a syllable that satisfied ONSET, the [j]-deletion form *[e] should be equally acceptable (given the general optionality of the glide-deletion rule). Thus, for [j]-deletion as for GV coalescence, the special behavior of the syllable-initial case shows that glides are relevant for the ONSET constraint.

In summary, the facts discussed above have been presented in the literature as evidence that Korean glides have the status of 'consonants,' or onsets. (Discussion of the role of glides in resolving hiatus or serving as onsets can also be found in Y. Lee 1997 and Cho 2000). However, what these facts actually show is that glides in Korean satisfy ONSET. Under the revised definition of ONSET presented here, rimal onglides also satisfy this constraint. Therefore, these various arguments that glides are able to resolve hiatus in Korean do not contradict the claim that prepeak glides are actually syllabified as rimal onglides.

Some additional facts about Korean glides, independent of their ability to resolve hiatus, have also been presented in the literature in support of glides as onsets. However, these arguments are less compelling than those about hiatus resolution. One such argument has to do with rhyming conventions in poetry. H.Y. Kim (1998: 120) notes that '[t]he onset and the prenucleus G do not affect the rhyming pattern at all...' That is, there is no evidence from rhyming conventions that a prepeak glide functions as part of a subsyllabic constituent with the syllable peak. However,

rhyme schemes have an aesthetic, conventionalized dimension in addition to their linguistically motivated dimension, and there are other known cases where the units that must match in a rhyming convention are not phonological constituents. One example is English, where rhyme involves the span from the head segment of the prosodic word to the end of the prosodic word (Clements & Keyser 1983: 23--24); this domain includes a subpart of the head syllable plus, potentially, one or more additional syllables, and is clearly not any sort of prosodic constituent. Similarly, it may simply be the case that poetic rhyme in Korean is defined starting at the syllable peak, rather than at the left edge of the syllable rime.

Another argument has been raised by Yun (2001). This argument concerns what are sometimes described as the 'front rounded vowels' of Korean (Martin 1992: 24; H.M. Sohn 1999: 158). These are orthographically represented as <wi> (high) and <we>, <oj> (mid), and are transcribed sometimes as [y] and [ø] (e.g., H.M. Sohn 1999) and sometimes as [wi] and [we] (e.g., Martin 1992). According to Yun's intuitions, these 'vowels' are always diphthongal, consisting of a labial glide plus [i] or [e]. Moreover, Yun claims that this labial glide is realized as a front glide, [ɥ], when another onset consonant is present (C[ɥ]V), but as a back glide, [w], when the glide is syllable-initial (.[w]V).

Yun argues that because there is a difference in the phonetic realization of the glide that depends on the presence or absence of a preceding C, the syllabification of the glide is different in these two contexts. He draws a comparison with Spanish, which has rimal onglides when a consonant precedes (C{GV}), but true onset glides when the glide is syllable-initial (G{V}) (Harris & Kaisse 1999). However, the evidence presented by Harris and Kaisse to motivate different syllable positions for glides in CGV versus .GV includes facts about syllable weight and sonority, phenomena which are known to correlate with syllable structure. It is much less clear that the backness alternation that Yun discusses is something that should depend on a difference in syllable structure. Even if the glide is undergoing some sort of assimilation or dissimilation process involving the following front vowel, it has been shown that place-of-articulation interactions are much less likely to respect syllable constituent boundaries than, for example, co-occurrence restrictions based on sonority class (Steriade 1988b: 121). Finally, the observation that the backness of the labial glide can be determined by the following vowel is found elsewhere (e.g., Martin 1992: 24), but the additional claim in Yun (2001), that the choice between [w] and [ɥ] is influenced by the presence of a preceding consonant, seems to be a novel claim, so it would be desirable to confirm this claim with empirical measurements.

Thus, the truly compelling evidence in favor of Korean glides as 'onsets' is, more precisely, evidence that glides satisfy the constraint ONSET. However, as ONSET is defined here, this is true even of rimal onglides. Consequently, there is in fact *no* compelling evidence that Korean glides are syllabified in true onset position.

3.3 Previous evidence that Korean glides are not syllabified as true onsets

The traditional view of Korean prepeak glides is that they are part of the syllable rime. This view is reflected in, and perhaps reinforced by, orthographic practice. Since its development in the fifteenth century (see H.M. Sohn 1999: Ch 6 for an overview), *hangul* orthography has

indicated a /j/ glide as a diacritic on the nuclear vowel, and a /w/ glide by linking the symbol for either /u/ or /o/ with the symbol for the nuclear vowel. Moreover, if the glide is the only prepeak element in the syllable, it is preceded by the symbol for 'zero onset' just as a syllable-initial nuclear vowel would be.

There is also evidence of a more directly phonological nature to support the view that Korean glides are not syllabified as true onsets. H.Y. Kim (1998: 120), following Duanmu (1990), observes that we expect to see consistent sonority distance effects between members of an onset cluster. In particular, if a cluster C_1C_2 with a certain sonority distance between C_1 and C_2 is allowed, then onset clusters with a greater sonority distance should be legal as well. On the assumption that CG sequences in Korean are onset clusters, the minimum required sonority distance would appear to be quite small, since even nasals or liquids can occur with glides, as seen for example in (7) above. However, the only possible 'clusters' are those that have a glide as the second member, regardless of the sonority distance; even a stop+liquid cluster is impossible, despite the fact that the sonority distance there is much larger than for a nasal+glide or liquid+glide sequence. This indicates that CGV sequences are not complex onsets; G here is not syllabified as part of a true structural onset (see Baertsch 1998 for similar argumentation concerning Spanish).

Admittedly, some caution is necessary here, because showing that G in CGV is not an onset does not automatically prove that G in .GV is not an onset. As mentioned in §2 above, some languages treat glides in CGV and .GV syllables differently in precisely this way (Davis & Hammond 1995; Rubach 1998; Harris & Kaisse 1999). Indeed, Yun (2001) has made this claim for Korean (see also related discussion in Shim 1997 and K.S. Kang 2003). Furthermore, in addition to the rimal onglide structure C{GV}, there is another possible phonological analysis for a phonetic CGV sequence in which G is not an onset: The CG sequence might be a complex consonant, CG (H.Y. Kim 1998).

However, the rimal onglide approach finds additional support from a phenomenon that has not yet (to my knowledge) been applied to the question of glide structure in Korean. Namely, Seoul and other South Korean dialects have a word-initial liquid onset ban, which is analyzed in the following section as a requirement for lower-sonority onsets in initial position. The fact that glides, the highest sonority 'onsets,' appear to be exempt from such restrictions receives a straightforward explanation if glides are syllabified as rimal onglides.

Thus, adopting the head-based definition of ONSET not only resolves the controversy over glide structure in Korean, but also relates two aspects of the language that were not previously seen to be connected: glide syllabification and the avoidance of word-initial liquids.

4   Further implications for liquid-specific sonority effects

In South Korean dialects, liquid onsets are prohibited in two structurally similar contexts: after a (nonliquid) consonant, and in word-initial position (except in recent loanwords). The two prohibitions both affect liquids that are syllable onsets, and moreover in both cases the underlying liquids surface as [n]. Because of these similarities, a number of researchers have tried to derive both patterns from a general ban on liquid onsets (Iverson & K.H. Kim 1987; S.K.

Kang 1991; Han 1993; H.M. Sohn 1994: 474; McDonough 1995; Smith 1997). However, a different approach to the postconsonantal ban on liquids has greater explanatory success. On this view, the postC liquid ban is part of a more general pattern of syllable-contact effects (Murray & Venneman 1983), where no onset may be higher in sonority than a preceding coda (Iverson & H.S. Sohn 1994; Davis & Shin 1999; Um 2003). Since liquids are higher in sonority than all other potential coda consonants in Korean, this syllable-contact requirement happens to resemble a prohibition against post-C liquid onsets.

Although the syllable-contact account of medial liquid-nasal alternations captures an important generalization, proposals taking this perspective on Korean liquids have left the word-initial liquid ban without a phonetically motivated phonological analysis. Several researchers have observed that a ban on word-initial liquids is consistent with the crosslinguistic tendency toward initial 'strengthening' or sonority-lowering effects (Iverson & H.S. Sohn 1994; Um 2003).[4] Nevertheless, formal accounts of the word-initial liquid prohibition have not incorporated this insight into the phonological analysis directly; even recent constraint-based analyses have resorted to stipulative constraints along the lines of '*$_{WORD}$[*l/r*' (Um 2003: 128).

One obstacle to pursuing a sonority-based account of this word-initial liquid ban would be the fact that glides, which are even higher in sonority than liquids, are nevertheless tolerated as word-initial onsets. However, this section demonstrates that the apparently contradictory behavior of initial liquids and glides in Korean (and in other languages with similar patterns) is resolved once we adopt the rimal onglide analysis presented in §3. If Korean prepeak glides are not true structural onsets, but instead are syllabified as part of the syllable rime, there is an explanation for why they are exempt from restrictions on sonority that apply to true stuctural onsets.

§4.1 first demonstrates the behavior of liquids in Korean and reviews the evidence for treating word-initial and post-C cases of liquid-nasal alternation separately. A sonority-based account of the initial liquid ban is then presented in §4.2, along with discussion of how the rimal onglide analysis from §3 makes this approach to the initial liquid-nasal alternations possible.

4.1 The word-initial liquid ban in Seoul Korean

Korean has a single liquid phoneme; its realization is fully predictable. The liquid surfaces as [l] in coda position, including the geminate structure V[l.l](G)V, and as [ɾ] when intervocalic or in a V.[ɾ]GV sequence; examples of these liquid realizations can be seen in (14), (15), and (16) below. Most relevant for the current discussion is the fact that in Seoul and other South Korean dialects, the liquid surfaces as a nasal [n] in word-initial position (except in recent loanwords).

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4 See also Kim-Renaud (1986: 41) and Iverson & K.H. Kim (1987: 379), who analyze the word-initial and post-C liquid bans as a unified onset ban rather than recognizing a role for syllable contact, but nevertheless point out the connection to sonority reduction as a plausible phonetic motivation for avoiding liquids.

(14)   Word-initial liquids surface as [n] (data from Um 2003: 112, 113)

input[5]	output	gloss	related forms		
/lo-pjən/	[no.bjən]	'roadside'	/toː-lo/	[toː.ro]	'road'
/lon-tʃɨŋ/	[non.dʒɨŋ]	'proof'	/sə-lon/	[sə.ron]	'introduction'
/lak-wən/	[na.gwən]	'paradise'	/kʰwɛ-lak/	[kʰwɛ.rak]	'joy'
/lu-kak/	[nu.gak]	'pavilion'	/po-lu/	[po.ru]	'fort'
/lɛ-il/	[nɛ.il]	'tomorrow'	/tʃən-lɛ/	[tʃəl.lɛ]	'tradition'

As outlined above, the word-initial liquid ban in Seoul Korean is taken to be a sonority-based restriction on word-initial onsets. Before turning to the details of this analysis, however, it is necessary to clarify how the word-initial pattern relates to the other case of liquid-nasal alternation in Korean. The liquid phoneme also surfaces as [n] in word-medial onset position when another consonant (a coda) precedes (except that when the preceding consonant is coronal, /t + l/ or /n + l/, it assimilates to the liquid instead, producing a geminate [l.l].)

(15)   Noncoronal nasal + liquid —> nasal + [n] (data from Davis & Shin 1999: 288)

input	output	gloss	related forms		
/kam-li/	[kam.ni]	'supervision'	/to-li/	[to.ri]	'ethics'
/sam-lju/	[sam.nju]	'third rate'	/i-lju/	[i.rju]	'second rate'
/tʃəŋ-li/	[tʃəŋ.ni]	'arrangement'			
/jəŋ-lak/	[jəŋ.nak]	'downfall'	/tʃu-lak/	[tʃu.rak]	'plunge'

If the preceding consonant is an oral stop, then the stop becomes a nasal as well, so that an input stop+liquid sequence becomes a nasal+nasal sequence in the output.

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5   Because this is an allophonic alternation, driven entirely by markedness constraints, the UR cannot be uniquely established as /l/ or /ɾ/ (see Prince & Smolensky 2004: §225 on richness of the base) – although it does contrast with /n/, which shows that the UR for the liquid phoneme must be distinct from /n/. For expository convenience, this discussion will follow conventional practice and represent the liquid phoneme as /l/. However, because this alternation is allophonic, it must be the case that the faithfulness constraints that enforce the [l]~[ɾ] contrast are ranked low enough to be irrelevant. Therefore, even if inputs were to contain /ɾ/ instead of /l/, the correct output candidate would still be chosen.

(16)   Noncoronal stop + liquid —> nasal + [n] (data from Davis & Shin 1999: 288)

input	*output*	*gloss*		*related forms*		
/pəp-li/	[pəm.ni]	'principle of law'		/pəp + ɨl/	[pə.bɨl]	'law-ACC'
/tʃap-lok/	[tʃam.nok]	'a miscellany'		/tʃap-sə/	[tʃap.s'ə]	'sundry writings'
				/ki-lok/	[ki.rok]	'write down'
/kjək-li/	[kjəŋ.ni]	'separation'		/kan-kjək/	[kan.gjək]	'gap'
				/kə-li/	[kə.ɾi]	'street'
/pak-lam/	[paŋ.nam]	'exhibition'		/pak-sik/	[pak.ʃ'ik]	'knowledgeable'
				/ju-lam/	[ju.ram]	'cruise'

Davis & Shin (1999) demonstrate convincingly that the medial, post-C cases of liquid nasalization are syllable-contact effects (see also Iverson & H.S. Sohn 1994; Um 2003). Crucially, other segment classes also undergo alternations in onset and/or coda position that result in flat or falling sonority levels across the syllable boundary. As seen in (16), an input stop+liquid sequence is realized as nasal+nasal, rather than stop+nasal, confirming that more is at stake than a simple ban on onset liquids. The syllable-contact analysis is able to account for the change in both the coda and the onset in this circumstance – the sequence has gone from a highly marked sonority rise across the syllable boundary to a less marked, more desirable sonority plateau.

However, the *word-initial* liquid-nasal alternations in (14) cannot be attributed to a syllable-contact effect, because in initial position, syllable contact requirements are irrelevant. The word-initial pattern therefore requires a separate explanation.[6]

Indeed, there is further evidence that the two cases of liquid alternation should be treated separately. First, the post-C liquid ban is more widespread among dialects of Korean than the word-initial liquid ban; North Korean dialects have the same pattern of post-C liquid alternations as in (15) and (16) above, but allow initial liquids to surface unchanged (Cho 1997: 91; Davis & Shin 1999: 310). Second, Cho (1997) and Um (2003) show that (even in South Korean dialects) loanwords are exempt from the word-initial liquid ban, while still being subject to the syllable-contact requirement. Crucially, when a liquid-initial loanword appears in the post-C environment as the second element in a compound word, the liquid surfaces as [n] (Um 2003: 116). This rules out an alternative approach in which there is just one constraint against all liquid onsets and word-initial *faithfulness* protects the initial liquids in loanwords. Instead, this pattern confirms that initial and post-C liquid alternations are separate processes, driven by distinct *markedness* constraints.

It is also worth noting that the fact that liquids surface in the same way – as nasals – in response to both syllable-contact restrictions and initial onset sonority restrictions does not prevent us

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6 Intervocalic liquids, which are subject neither to syllable-contact effects nor to restrictions on onsets in word-initial position, simply surface as liquids. Thus, the approach adopted here does not require intervocalic liquids to be ambisyllabic – contra the proposals in, for example, S.K. Kang (1991) and Smith (1997).

from treating the two restrictions separately. This is simply a consequence of the fact that the same faithfulness constraint, IDENT[nasal], is ranked low enough to be the constraint that is violated in both cases.

Thus, the initial liquid-nasal alternations require an explanation that is distinct from the syllable-contact requirement that affects post-C liquids. This explanation is the subject of §4.2.

4.2 Liquid-onset prohibitions and *ONSET/X sonority constraints

Korean is not the only language to have a ban on word-initial liquids; similar patterns are found in a number of languages. For example, Mongolian (Poppe 1970; Ramsey 1987), Kuman (Trefry 1969; Lynch 1983; Blevins 1994), and many Australian languages, including Guugu Yimidhirr (Haviland 1979; Dixon 1980), Pitta-Pitta (Blake & Breen 1971; Blake 1979, Dixon 1980), and Panyjima (Dench 1991: 133; Flack 2006) likewise ban all initial liquids. Most of these languages have more than one liquid phoneme – Guugu Yimidhirr and Pitta-Pitta have three and four liquid phonemes respectively that would be expected to occur in word-initial position if not for the initial-liquid ban (see Smith 2008 for more detailed discussion). Related patterns of initial-onset restriction are found as well: rhotic onsets (though not laterals) are banned from initial position in the Iglesias dialect of Campidanian Sardinian (Bolognesi 1998) and in Mbabaram (Australian; Dixon 1991), while the Sestu dialect of Campidanian Sardinian (Bolognesi 1998) bans both glide and rhotic onsets in word-initial position.

A clear generalization to be made is that the segments subject to word-initial onset bans in these languages – liquids (laterals and rhotics) and glides – are the potential onset segments that have the highest sonority. Indeed, a variety of phonological phenomena demonstrate that onsets prefer to have low sonority. For example, in reduplication, an onset cluster in the base is sometimes copied as a simplex onset in the reduplicant; in some languages, the choice of which onset consonant to copy depends on which has lower sonority (Steriade 1982, 1988a; McCarthy & Prince 1986). In child language acquisition, target onset consonants are sometimes replaced by consonants of lower sonority, and when words are truncated or clusters are reduced, it can be the lower sonority consonant that survives as the output onset (Gnanadesikan 2004; Barlow 1997). There are even cases of sonority-driven onset-sensitive stress (Smith 2002; Gordon 2003), in which stress is attracted to syllables with lower-sonority onsets. Thus, the effect observed in languages that avoid word-initial liquids and glides can be attributed to the crosslinguistically attested constraints penalizing high-sonority onsets.[7]

In order to model patterns like these, the following family of constraints can be defined (Smith 2002, 2003).

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7 Flack (2006) argues against an acoustically driven 'licensing-by-cue' approach to an initial (and postconsonantal) lateral ban in three Australian languages, Ngandi, Jingulu, and Warlpiri, concluding that a sonority-based approach is better motivated.

(17)   *Onset/X   'Onsets do not have sonority level X'

For every segment *a* that is the leftmost onset segment of some
syllable σ, |*a*| < X
    where |*y*| is the sonority of segment *y*
        X is a particular step on the sonority scale

*Onset/X is a family of related constraints, one for each level of the sonority scale. The
cosntraints in this family are universally ranked on the basis of the sonority scale such that the
highest-sonority onsets are most strongly dispreferred. *Onset/X is a modification of Prince &
Smolensky's (2004 [1993]) original *Margin/X constraint family; the modification is necessary
because *Margin/X treats onsets and codas uniformly, even though the two positions actually
have different sonority preferences (Zec 1988; Clements 1990; see also Selkirk 1984).

(18)   *Onset/X constraints: sonority scale determines ranking

*Ons/glide >> *Ons/rhotic >> *Ons/lateral >> *Ons/nasal >> ...

The fact that onset sonority restrictions sometimes occur only in word-initial position is also part
of a larger pattern: Prominent positions like the word-initial syllable can be subject to positional
markedness constraints (Smith 2002). In fact, onset sonority restrictions have also been
observed for another prominent position, the stressed syllable; glide onsets are avoided in
stressed syllables in Niuafo'ou (de Lacy 2001), and, as noted above, stress may be preferentially
attracted to syllables whose onsets have the lowest possible sonority (Smith 2002; Gordon 2003).

For the initial-syllable cases under discussion here, the relevant constraint family is a positional
version of *Onset/X that is relativized to the strong position *initial syllable* (σ1) (Smith 2002,
2003).

(19)   *Onset/X–σ1   'Onsets in initial syllables do not have sonority level X'

For every segment *a* that is the leftmost onset segment of some
syllable σ, if σ is a σ1, then |*a*| < X
    where |*y*| is the sonority of segment *y*
        X is a particular step on the sonority scale

The avoidance of high-sonority onsets in initial syllables can now be seen as a case where the
*Onset/X–σ1 constraint for the lowest prohibited sonority level outranks at least one relevant
faithfulness constraint. For example, the Sestu dialect of Campidanian Sardinian (Bolognesi
1998) avoids glide and rhotic onsets in initial syllables. Where a word-initial onset of one of
those sonority classes is expected, on the basis of etymology or dialect comparison, the Sestu
form has a prothetic vowel, which causes the problematic consonant to surface in a position other
than onset of σ1.

(20)   Initial glide and rhotic onsets avoided in Sestu Campidanian

    (a) [arːuβiu] 'red' < Lat. *rubeum*   (b) [ajaju] 'grandfather'

       [arːɔða]   'wheel' < Lat. *rota*   [ajaja] 'grandmother'

       [arːaðiu] 'radio' < Ital. *radio*   vs. related dialects: [jaju], [jaja]

For this language, the problematic high-sonority onsets are avoided by epenthesis, so *Onset/Glide–σ1 and *Onset/rhotic–σ1 must each be ranked above Dep, the constraint against epenthetic segments (McCarthy & Prince 1995).

(21)   Ranking for Sestu Campidanian

    (a) Crucial ranking for glide case: *Onset/Glide–σ1 >> Dep

/jaju/ 'grandfather'	*Ons/gli–σ1	*Ons/rho–σ1	Dep
i. jaju	*!		
☞ ii. ajaju			*

    (b) Crucial ranking for rhotic case: *Onset/rhotic–σ1 >> Dep

/ruβiu/ 'red'	*Ons/gli–σ1	*Ons/rho–σ1	Dep
i. ruβiu		*!	
☞ ii. arːuβiu			*

The case of Sestu is straightforward, because the set of segment classes banned as onsets in word-initial syllables is a contiguous range of the sonority scale from rhotics up through the highest onset sonority class, glides. However, the pattern seen in Korean, as well as in a number of other languages as mentioned above, introduces a complication. In these languages, high-sonority onsets such as rhotics, or all liquids, are banned, but glide onsets are allowed.

This glide exemption from sonority restrictions on onsets is unexpected given the nature of the *Onset/X constraint family.[8] Consider the Iglesias dialect of Campidanian Sardinian (Bolognesi 1998), which differs minimally from Sestu in allowing glide onsets in initial syllables even though rhotic onsets are banned in that position. The appearance of a prothetic vowel in a putatively rhotic-initial word motivates the ranking *Onset/rhotic–σ1 >> Dep, exactly as seen for Sestu in (21b). However, *Onset/rhotic–σ1 >> Dep implies *Onset/glide–σ1 >> Dep, because glides are higher on the sonority scale than rhotics, and the sonority scale fixes the family-internal ranking of the *Onset/X constraints. *Onset/glide–σ1 >> Dep is the ranking exemplified in (21a) for Sestu, but this seems to make the wrong prediction for Iglesias, where the desired winner is [jaju], not *[ajaju] as in Sestu. Moving Dep above *Onset/glide–σ1 does not solve the

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8 An analogous point can be made if stringency constraints (Prince 1997, de Lacy 2004) are used in place of this universally ranked constraint scale; see Smith (2008) for discussion.

problem, since this ranking now incorrectly predicts that rhotic onsets are tolerated just as the higher-sonority glide onsets are.

In Korean as well, the implication is that if *ONSET/RHOTIC–$\sigma 1$ and *ONSET/LATERAL–$\sigma 1$ are ranked high enough to have an effect, then the even higher-ranking *ONSET/GLIDE–$\sigma 1$ should have an effect as well. Contrary to this prediction, however, Korean does allow word-initial glides, as seen above in (6a).

Fortunately, the proposal defended in §3, that Korean prepeak glides are actually rimal onglides, provides a way to account for why glides are unexpectedly exempt from restrictions on high-sonority 'onsets.' As defined in (17) above, *ONSET/X constraints are crucially different from the ONSET constraint in that they do refer explicitly to subsyllabic position: they assign violations for segments of a certain sonority class only when those segments are in the true structural onset position. The idea here is that *ONSET/X constraints connect an actual structural role in the syllable – the onset – with requirements pertaining to sonority level. *ONSET/X is therefore formally quite different from (the now inconveniently named) ONSET constraint, which, according to the definition in §2, requires the presence of some prepeak segment but does not make reference to any syllable position for that segment. (Additional implications of this difference between ONSET and *ONSET/X for our understanding of the phonology-phonetics interface are taken up in §5 below.)

Once we have recognized the two possible structural positions for prepeak glides, and *ONSET/X has been defined so that it enforces sonority requirements specifically on true onset segments, an explanation becomes possible for why glides are able to escape onset sonority restrictions. Namely, syllable-initial glides in languages that otherwise show the effects of bans on high-sonority onsets avoid violating *ONSET/GLIDE because they are rimal onglides.

This general approach can be applied to the specific case of Korean as follows. Liquid-related constraints of the *ONSET/X–$\sigma 1$ family are responsible for the nasal realization of the liquid phoneme because they are ranked above the faithfulness constraint IDENT[nasal], which is violated when inputs and outputs differ with respect to [±nasal] (McCarthy & Prince 1995). Specifically, *ONSET/RHOTIC–$\sigma 1$ dominates IDENT[nasal], prohibiting the rhotic [ɾ] in word-initial position. It may be the case that *ONSET/LATERAL–$\sigma 1$ dominates IDENT[nasal] as well, but the allophonic alternation between [l] and [ɾ] already restricts [l] to coda position, so the ranking of *ONSET/LATERAL–$\sigma 1$ cannot be definitively determined. Finally, the fact that word-initial nasal onsets are tolerated shows that *ONSET/NASAL–$\sigma 1$ is ranked below all relevant faithfulness constraints, including IDENT[nasal]. This ranking is summarized in (22) and exemplified in (23) and (24) below.

(22)   Constraint ranking for the Korean word-initial liquid/nasal alternation

$$*\text{O}_{\text{NSET}}/\text{GLIDE}–\sigma 1$$
$$|$$
$$*\text{O}_{\text{NSET}}/\text{RHOTIC}–\sigma 1$$
$$/ \qquad \backslash$$
$$*\text{O}_{\text{NSET}}/\text{LATERAL}–\sigma 1 \qquad \text{I}_{\text{DENT}}[\text{nasal}]$$
$$\backslash \qquad /$$
$$*\text{O}_{\text{NSET}}/\text{NASAL}–\sigma 1$$
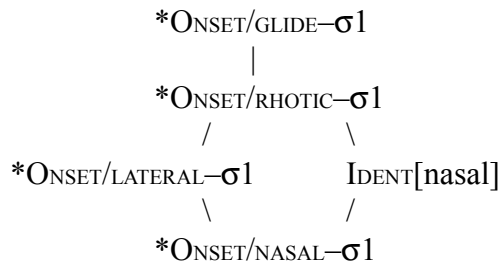
The form /lɛ-il/ [nɛ.il] 'tomorrow' demonstrates the effects of this ranking. The initial liquid is realized as a nasal because a violation of *O$_{\text{NSET}}$/RHOTIC–$\sigma 1$ (23-i) is worse than a violation of the faithfulness constraint I$_{\text{DENT}}$[nasal] (23-ii). Other liquids do surface as liquids (except in environments where the high-ranking syllable-contact constraints, not discussed here, are relevant; see Davis & Shin for an OT analysis of the syllable-contact effects) because I$_{\text{DENT}}$[nasal] is violated only if a higher-ranking constraint is at stake (23-iii).

(23)   Avoidance of word-initial liquid onsets in Korean

/lɛ-il/ 'tomorrow'	*O$_{\text{NS}}$/ GLI–$\sigma 1$	*O$_{\text{NS}}$/ RHO–$\sigma 1$	*O$_{\text{NS}}$/ LAT–$\sigma 1$	I$_{\text{DENT}}$ [nas]	*O$_{\text{NS}}$/ NAS–$\sigma 1$
i. rɛ.il		*!			
☞ ii. nɛ.il				*	*
iii. nɛ.in				**!	*

For glides, however, there is another option. Syllabifying a glide as a true onset does lead to a violation of *O$_{\text{NSET}}$/GLIDE–$\sigma 1$, which is a fatal violation, as expected from the sonority-based ranking of the *O$_{\text{NSET}}$/X constraints. However, syllabifying a word-initial glide as a rimal onglide results in a candidate that satisfies *O$_{\text{NSET}}$/GLIDE–$\sigma 1$ without violating any faithfulness constraints.[9] Thus, word-initial glides are tolerated even though other sonorous onsets are prohibited.

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9   The rimal onglide candidate does violate constraints against diphthongs, and constraints against rising diphthongs, so a language that allows rimal onglide syllabification must rank those constraints below the relevant faithfulness constraints. In languages like Sestu Campidanian, that do not use the rimal onglide syllabification, constraints against (rising) diphthongs are ranked higher in the hierarchy. As expected from factorial typology (Prince & Smolensky 2004: 103), languages vary with respect to this choice; languages may even use different structures for different glides (Davis & Hammond 1995) or under different circumstances (Harris & Kaisse 1999), according to the fine details of the constraint ranking.

(24)   Word-initial glides tolerated

/jaŋ/ 'sheep'	*Ons/ GLI–σ1	*Ons/ RHO–σ1	*Ons/ LAT–σ1	Ident [nas]	*Ons/ NAS–σ1
i. j{aŋ}	*!				
☞ ii. {jaŋ}					
iii. naŋ				*!	*

For Seoul Korean, the rimal-onglide analysis is not the only possible account for the appearance of word-initial glides despite a general ban on high-sonority onsets in word-initial position. For example, a glide-nasal alternation violates Ident[cons], while a liquid-nasal alternation does not, so ranking Ident[cons] above *Onset/glide–σ1 would allow for the faithful realization of word-initial glides even if they were syllabified in true onset position (Smith 1997; Flack 2006). However, settling the controversy over the syllabification of Korean glides (§3) by giving them the structure of rimal onglides – a development made possible by the new definition of Onset adopted here – automatically accounts for the ability of glides to be exempt from sonority-based restrictions on word-initial onsets.

In summary, the availability of the rimal onglide candidate, and the sensitivity of *Onset/X constraints to subsyllabic structure, explains why glides are sometimes exempt from bans on high-sonority onsets in Seoul Korean and other languages. Treating this alternation as a sonority-based onset restriction relates it to the crosslinguistic preference for low-sonority onsets, particularly in word-initial position. As a result, for the first time, a connection is made between glide and liquid behavior in Korean.

5   Implications for the phonetics/phonology interface

The discussion thus far has shown that the head-based definition of Onset resolves a controversy about how prepeak glides in Korean are syllabified. Moreover, the claim that Onset makes no reference to syllable-internal structure, while the sonority-based constraint family *Onset/X does make crucial reference to true onset segments only, allows for an account of the pattern seen in Seoul Korean and other, unrelated languages, in which high-sonority word-initial segments are generally prohibited, but word-initial glides are allowed – an account that relies only on constraints that have phonetically plausible motivations.

Intuitively, Onset and *Onset/X constraints have something in common. Crosslinguistically, syllables with onsets are preferred to syllables without onsets, and low-sonority onsets are preferred to high-sonority onsets, as noted in §4.2. These two preferences share a functional basis. Namely, there is a perceptual advantage when the speech stream modulates between low and high sonority (e.g., Delgutte 1997; Ohala & Kawasaki-Fukumori 1997; Wright 2004). This is true because, given a constant stimulus, auditory-nerve response decays, a phenomenon known as adaptation. However, adaptation is lessened if spectrally different segments alternate. This happens when vowels are separated by onset consonants; and, the lower the sonority of those

consonants the better. (On the high perceptual salience of rapid spectral changes, see also Ohala 1992; Silverman 1995; Warner 1998.)

In other words, the functional motivation behind Onset is the perceptual advantage gained by interspersing consonants between syllable peaks. It follows that the best onset is a low-sonority onset, so the same functional motivation also underlies *Onset/X. However, as has been shown above, the two constraints are formally distinct; in particular, they refer to completely separate aspects of syllable structure.

This point turns out to be of interest, because the separation of Onset and *Onset/X as formally distinct constraints seems to be a problem for direct-phonetics models of the phonological constraint set. Direct-phonetics models (e.g., Flemming 2001; Kirchner 2000; Boersma 1998; Zhang 2004), which make a fundamental assumption that phonology is not distinct from phonetics, often propose families of constraints reflecting values along a continuum of some phonetic property. One example is the direct-phonetics constraint Lazy, defined as follows by Kirchner (2004).

> Formally, I assume that for each candidate provided by GEN...the effort cost (a
> mental estimate of the biomechanical energy required for articulatory production
> of the candidate) is computed; and Lazy violations are assessed for the candidate
> based on this effort cost. (314)

Since the complete lack of an onset consonant is even less useful, perceptually speaking, than the presence of a very high-sonority onset, the direct-phonetics approach predicts that Onset should be formalized as the highest-ranked member of the *Onset/X family, '*Onset/Ø'.

However, the attempt to reformulate Onset as '*Onset/Ø' fails if, as argued here, Onset and *Onset/X evaluate different phonological structures. The head-based Onset constraint simply cannot be viewed as part of the *Onset/X family, which evaluates specifically true onset segments.[10] From this, we conclude that Onset and *Onset/X are formally distinct, and thus that the mapping from phonetics to constraints is indirect.

It is important to note that evidence against a direct-phonetics view of the universal constraint set is not automatically evidence against a model that incorporates phonetic grounding or phonetic motivation for the constraints in the constraint set. That is, it is logically possible to have a phonetically motivated grammar that is not the same as 'direct phonetics.' For example, phonetic information might be used either to rank, or to filter out from the set of actual constraints, constraints that are stated over formal phonological categories (Archangeli & Pulleyblank 1994; Hayes 1999; Steriade 2001 [though Hayes & Steriade 2004 take a somewhat different perspective]; Smith 2002). For additional evidence that the effect of phonetics on phonology is indirect or symbolically mediated, see (e.g.) Howe & Pulleyblank (2001); Gerfen (2001); Cohn (2003); Gordon (2004); Flack (2006).

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10 Another argument that Onset and *Onset/X constraints are formally different is presented in
   Smith (2008). To summarize briefly, the ranking of Onset with respect to the different
   members of the *Onset/X constraint family varies from language to language; thus, Onset
   cannot be a member of that constraint family.

6 Conclusions

The head-based definition of the ONSET constraint allows this constraint to be satisfied both by true structural onsets and by rimal onglides. This formal development in turn makes possible a new approach to the syllabification of Korean glides that is able to account for both their 'consonant'-like and their 'vowel'-like behavior, thereby resolving a long-standing controversy: Korean glides are rimal onglides, but this is nevertheless compatible with their ability to resolve hiatus (i.e., satisfy ONSET).

A second advantage to the rimal-onglide account of Korean glides is that an explanation for an apparently unrelated phenomenon – the prohibition on word-initial liquids in Seoul and other South Korean dialects – falls out for free. It is now straightforward to model the initial liquid ban as a sonority-based (which is to say phonetically motivated) restriction; given that glides are rimal, it is unsurprising that they are exempt from sonority-based restrictions on segments that are syllabified as true structural onsets.

In addition to the evidence from Korean that glides satisfy hiatus despite their status as rimal onglides, there is further crosslinguistic evidence that rimal onglides satisfy ONSET. Guugu Yimidhirr (Haviland 1979; Dixon 1980), mentioned in §4.2, bans initial liquids but not glides – indicating that glides are syllabified as rimal onglides, just as in Korean – while also banning vowel-initial words, due to high-ranking ONSET. If rimal onglides did not satisfy ONSET, we would expect to see glide-initial words banned just as vowel-initial words are. Pitta-Pitta is a similar example (see Smith 2008 for further discussion of both of these languages).

Finally, since ONSET is independent of syllable-internal structure beyond the head/nonhead distinction, but the *ONSET/X constraint family is sensitive to subsyllabic structure, this demonstrates that even constraints with the same fundamental phonetic motivation can be formally distinct entities, which in turn shows that the link between phonetic motivation and phonological constraint is indirect.

Acknowledgments

References

Ahn, S.-C. (1985) *The Interplay of Phonology and Morphology in Korean.* Doctoral dissertation, UIUC.

Archangeli, D. and Pulleyblank, D. (1994) *Grounded Phonology.* Cambridge, Mass.: MIT Press.

Baertsch, K. (1998) Onset sonority distance constraints through local conjunction. In M. C. Gruber, D. Higgins, K. S. Olson and T. Wysocki (eds.) *Chicago Linguistic Society 34* vol. 2, 1--15. Chicago: CLS.

Barlow, J. (1997) *A Constraint-Based Account of Syllable Onsets: Evidence from Developing Systems.* Doctoral dissertation, Indiana University.

Blake, B. J. (1979) Pitta-Pitta. In R.M.W. Dixon and B. J. Blake (eds.) *Handbook of Australian Languages* vol. 1, 183--242. Amsterdam: John Benjamins.

Blake, B. J. and Breen , J. G. (1971) *The Pitta-Pitta Dialects.* Melbourne: Monash University.

Blevins, J. (1994) A place for lateral in the feature geometry. *Journal of Linguistics* 30: 301--348.

Blevins, J. (1995) The syllable in phonological theory. In J. Goldsmith (ed.) *Handbook of Phonological Theory* 206--244. Oxford: Blackwell.

Boersma, P. (1998) *Functional Phonology.* The Hague: Holland Academic Graphics.

Bolognesi, R. (1998) *The Phonology of Campidanian Sardinian.* Amsterdam: HIL.

Cho, Y.-M. Y. (1997) Liquid specification in Korean as geminate alterability. In S. Kuno, J. Whitman, Y.-S. Kang, I.-H. Lee, Joan Maling and Y. Kim (eds.) *Harvard Studies in Korean Linguistics VII* 78--92. Cambridge, Mass: Harvard University and Seoul: Hanshin.

Cho, Y.-M. Y. (2000) Deriving optionality in Korean glide formation. In M. Nakayama and C. J. Quinn, Jr. (eds.) *Japanese/Korean Linguistics 9* 88--99. Stanford: CSLI.

Clements, G. N. (1990) The role of the sonority cycle in core syllabification. In J. C. Kingston and M. E. Beckman (eds.) *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech* 283--333. Cambridge: Cambridge University Press.

Clements, G. N. and Keyser, S. J. (1983) *CV Phonology: A Generative Theory of the Syllable.* Cambridge, Mass.: MIT Press.

Cohn, A. C. (2003) Phonological structure and phonetic duration: The role of the mora. *Working Papers of the Cornell Phonetics Laboratory* 15: 69--100.

Davis, S. and Hammond, M. (1995) On the status of onglides in American English. *Phonology* 12: 159--182.

Davis, S. and Shin, S.-H. (1999) The Syllable Contact Constraint in Korean: An Optimality-Theoretic analysis. *Journal of East Asian Linguistics* 8: 285--312.

de Lacy, P. (2001) Markedness in prominent positions. In O. Matushansky, A. Costa, J. Martín-González, L. Nathan and A. Szczegielniak (eds.), *Proceedings of HUMIT 2000.* MIT Working Papers in Linguistics 40, 53--66. Cambridge, Mass.: MITWPL.

de Lacy, P. (2004) Markedness conflation in Optimality Theory. *Phonology* 21: 145--199.

Delgutte, B. (1997) Auditory neural processing of speech. In W. J. Hardcastle and J. Laver (eds.) *The Handbook of Phonetic Sciences* 507–538. Oxford: Blackwell.

Dell, F. and Elmedlaoui, M. (1985) Syllabic consonants and syllabification in Imdlawn Tashlhiyt Berber. *Journal of African Languages and Linguistics* 7: 105--130.

Dell, F. and Elmedlaoui, M. (1988) Syllabic consonants in Berber: Some new evidence. *Journal of African Languages and Linguistics* 10: 1--17.

Dench, A. (1991) Panyjima. In R.M.W. Dixon and B. J. Blake (eds.) *Handbook of Australian Languages* vol. 4, 125--243. Melbourne: Oxford University Press.

Dixon, R.M.W. (1980) *The Languages of Australia.* Cambridge: Cambridge University Press.

Dixon, R.M.W. (1991) Mbabaram. In R.M.W. Dixon and B. J. Blake (eds.) *Handbook of Australian Languages* vol. 4, 348--402. Melbourne: Oxford University Press.

Duanmu, S. (1990) *A Formal Study of Syllable, Tone, Stress and Domain in Chinese Languages.* Doctoral dissertation, MIT.

Eisner, J. (1997) What constraints should OT allow? Paper presented at the LSA Annual Meeting; Chicago, January 4.

Flack, K. (2006) Lateral phonotactics in Australian languages. In L. Bateman and C. Ussery (eds.) *North East Linguistic Society 35* 187--199. Amherst, Mass.: GLSA.

Flemming, E. (2001) Scalar and categorical phenomena in a unified model of phonetics and phonology. *Phonology* 18: 7--44.

Gerfen, C. (2001) A critical view of Licensing by Cue: The case of Andalusian Spanish. In L. Lombardi (ed.) *Segmental Phonology in Optimality Theory* 183--205. Cambridge: Cambridge University Press.

Gnanadesikan, A. (2004) Markedness and faithfulness constraints in child phonology. In R. Kager, J. Pater and W. Zonneveld (eds.) *Constraints in Phonological Acquisition* 73--108. Cambridge: Cambridge University Press.

Gordon, M. (2003) The puzzle of onset-sensitive stress: A perceptually-driven approach. In G. Garding and M. Tsujimura (eds.) *Proceedings of the 22nd West Coast Conference on Formal Linguistics* 217--230. Somerville, Mass.: Cascadilla Press.

Gordon, M. (2004) Syllable weight. In B. Hayes, R. Kirchner and D. Steriade (eds.) *Phonetically Based Phonology* 277--312. Cambridge: Cambridge University Press.

Han, E. (1990) Glide formation in Korean. In H. Hoji (ed.) *Japanese/Korean Linguistics* 173--186. Stanford: CSLI.

Han, E. (1993) Resolving an ordering paradox: Lateralization and delateralization in Korean. In S. Kuno, J. Whitman, I.-H. Lee, J. Maling and Y. Kim (eds.) *Harvard Studies in Korean Linguistics V* 159--69. Cambridge, Mass.: Harvard University and Seoul: Hanshin.

Harris, J. W. and Kaisse, E. M. (1999) Palatal vowels, glides and obstruents in Argentinean Spanish. *Phonology* 16: 117--190.

Haviland, J. (1979) Guugu Yimidhirr. In R.M.W. Dixon and B. J. Blake (eds.) *Handbook of Australian Languages* vol. 1, 27--180. Amsterdam: John Benjamins.

Hayes, B. (1989) Compensatory lengthening in moraic phonology. *Linguistic Inquiry* 20: 253--306.

Hayes, B. (1999) Phonetically driven phonology: The role of Optimality Theory and inductive grounding. In M. Darnell, E. A. Moravcsik, F. Newmeyer, M. Noonan and K. M. Wheatley (eds.) *Formalism and Functionalism in Linguistics* vol. I, 243--85. Amsterdam: Benjamins.

Hayes, B. and Steriade, D. (2004) Introduction: The phonetic bases of phonological markedness. In B. Hayes, R. Kirchner and D. Steriade (eds.) *Phonetically Based Phonology* 1--33. Cambridge: Cambridge University Press.

Howe, D. and Pulleyblank, D. (2001) Patterns and timing of glottalisation. *Phonology* 18: 45--80.

Itô, J. (1986) *Syllable Theory in Prosodic Phonology.* Doctoral dissertation, University of Massachusetts, Amherst. [New York: Garland, 1988.]

Itô, J. (1989) A prosodic theory of epenthesis. *Natural Language and Linguistic Theory* 7: 217--259.

Iverson, G. K. and Kim, K.-H. (1987) Underspecification and hierarchical feature representation in Korean consonantal phonology. In A. Bosch, B. Need and E. Schiller (eds.) *Chicago Linguistic Society 23* vol. 2, 182--198. Chicago: CLS.

Iverson, G. and Sohn, H.-S. (1994) Liquid representation in Korean. In Y.-K. Kim-Renaud (ed.) *Theoretical Issues in Korean Linguistics* 77--100. Stanford: CSLI.

Kager, R. (1999) *Optimality Theory.* Cambridge: Cambridge University Press.

Kahn, D. (1976) *Syllable-Based Generalizations in English Phonology.* Doctoral dissertation, MIT. [New York: Garland, 1980.]

Kang, K.-S. (2003) The status of onglides in Korean: evidence from speech errors. *Studies in Phonetics, Phonology and Morphology* 9: 1--15.

Kang, S. K. (1991) Moraic representation of ambisyllabicity: Evidence from Korean. *Studies in the Linguistic Sciences* 21: 89--100.

Karttunen, L. (1998) The proper treatment of optimality theory in computational phonology. In L. Karttunen and K. Oflazer (eds.) *Finite-State Methods in Natural Language Processing 1998* 1--12. Ankara: Meteksan A.Ş..

Kaye, J. D. and Lowenstamm, J. (1984) De la syllabicité. In F. Dell, D. Hirst and J.-R. Vergnaud (eds.) *Forme sonore du langage* 123--159. Paris: Hermann.

Kim, C.-W. (1968) The vowel system of Korean. *Language* 44: 516--527.

Kim, C.-W and Kim, H.-Y. (1991) The *character* of Korean glides. *Studies in the Linguistic Sciences* 21: 113--125.

Kim, H.-Y. (1998) Prenucleus glides in Korean. *Studies in the Linguistic Sciences* 28: 113--35.

Kim, K.-O. (1978) Vowel system in Korean revisited. In C.-W. Kim (ed.) *Papers in Korean Linguistics: Proceedings of the Symposium on Korean Linguistics* 75--83. Columbia, S.C. : Hornbeam Press.

Kim, Y.-S. (1984) *Aspects of Korean Morphology.* Doctoral dissertation, University of Texas, Austin.

Kim-Renaud, Y.-K. (1986) The syllable in Korean phonology. *Studies in Korean Linguistics.* Seoul: Hanshin, 31--44.

Kirchner, R. (2000) Geminate inalterability and lenition. *Language* 76: 509--545.

Kirchner, R. (2004) Consonant lenition. In B. Hayes, R. Kirchner and D. Steriade (eds.) *Phonetically Based Phonology* 313--345. Cambridge: Cambridge University Press.

Lee, B.-G. (1982) A well-formedness condition on syllable structure. In Linguistic Society of Korea (ed.) *Linguistics in the Morning Calm* 489--506. Seoul: Hanshin.

Lee, I. and Ramsey, S. R. (2000) *The Korean Language.* Albany: State University of New York Press.

Lee, Y. (1994) Onset analysis of Korean on-glides. In Y.-K. Kim-Renaud (ed.) *Theoretical Issues in Korean Linguistics* 133--156. Stanford: CSLI.

Lee, Y. (1997) Glide formation and compensatory lengthening in Korean verbal conjugation. *Studies in Phonetics, Phonology, and Morphology* 3: 223--246.

Levi, S. V. (2004) *The Representation of Underlying Glides: A Cross-Linguistic Study.* Doctoral dissertation, University of Washington.

Levin [Blevins], J. (1985) *A Metrical Theory of Syllabicity.* Doctoral dissertation, MIT.

Liberman, M. and Prince, A. (1977) On stress and linguistic rhythm. *Linguistic Inquiry* 8: 249--336.

Lynch, J. (1983) On the Kuman 'liquids'. *Languages and Linguistics in Melanesia* 14: 98--112.

Martin, S. E. (1954) *Korean Morphophonemics.* Baltimore: Linguistic Society of America.

Martin, S. E. (1992) *A Reference Grammar of Korean.* Rutland, Vt.: Tuttle.

McCarthy, J. (2003) Comparative markedness. *Theoretical Linguistics* 29: 1--51.

McCarthy, J. and Prince, A. (1986) *Prosodic Morphology.* Ms., University of Massachusetts and Brandeis University.

McCarthy, J. and Prince, A. (1993) Generalized alignment. *Yearbook of Morphology* 1993: 79--153.

McCarthy, J. and Prince, A. (1995) Faithfulness and reduplicative identity. In J. N. Beckman, L. Walsh Dickey and S. Urbanczyk (eds.) *Papers in Optimality Theory.* University of Massachusetts Occasional Papers 18, 250--384. Amherst, Mass.: GLSA.

McDonough, J. (1995) Gemination and the prosodic enhancement strategy. In J. N. Beckman
　　　　(ed.) *North East Linguistic Society 25* vol. 1, 347--359. Amherst: GLSA.

Murray, R. W. and Venneman, T. 1983. Sound change and syllable structure in Germanic
　　　　phonology. *Language* 59: 514--28.

Ohala, J. J. (1992) The segment: Primitive or derived? In G. J. Docherty and D. R. Ladd (eds.)
　　　　Papers in Laboratory Phonology II: Gesture, Segment, Prosody 166--183. Cambridge:
　　　　Cambridge University Press.

Ohala, J. and Kawasaki-Fukumori, H. (1997) Alternatives to the sonority hierarchy for
　　　　explaining segmental sequential constraints. In S. Eliasson and E. Jahr (eds.) *Language
　　　　and Its Ecology* 343--365. Berlin: Mouton.

Poppe, N. (1970) *Mongolian Language Handbook.* Washington, D.C.: Center for Applied
　　　　Linguistics.

Prince, A. (1997) Stringency and anti-Paninian hierarchies. Handout from LSA Linguistic
　　　　Institute, Cornell University.

Prince, A. and Smolensky, P. (2004) *Optimality Theory: Constraint Interaction in Generative
　　　　Grammar.* Oxford: Blackwell. [Ms., Rutgers University and University of Colorado,
　　　　Boulder, 1993.]

Ramsey, S. R. (1987) *The Languages of China.* Princeton: Princeton University Press.

Ridouane, R. (2008) Syllables without vowels: Phonetic and phonological evidence from
　　　　Tashlhiyt Berber. *Phonology* 25: 321--359.

Rosenthall, S. (1994) *Vowel/Glide Alternation in a Theory of Constraint Interaction.* Doctoral
　　　　dissertation, University of Massachusetts, Amherst.

Rubach, J. (1998) A Slovak argument for the onset/rime distinction. *Linguistic Inquiry* 29: 168–
　　　　179.

Selkirk, E. (1978) On prosodic structure and its relation to syntactic structure. In T. Fretheim
　　　　(ed.) *Nordic Prosody II* 111--140. Trondheim: Tapir.

Selkirk, E. (1982) The syllable. In H. van der Hulst and N. Smith (eds.) *The Structure of
　　　　Phonological Representations* vol. 2, 337--383. Dordrecht: Foris.

Selkirk, E. (1984) On the major class features and syllable theory. In M. Aronoff and R. T.
　　　　Oehrle (eds.) *Language Sound Structure* 107--136. Cambridge, Mass.: MIT Press.

Selkirk, E. (1995) The prosodic structure of function words. In J. N. Beckman, L. Walsh Dickey
　　　　and S. Urbanczyk (eds.) *Papers in Optimality Theory.* University of Massachusetts
　　　　Occasional Papers 18, 439--469. Amherst, Mass.: GLSA.

Shim, M. (1997) *The Vowel Phonology of the Kyongsang Dialect of Korean.* Doctoral
　　　　dissertation, Indiana University.

Silverman, D. (1995) *Phasing and Recoverability.* Doctoral dissertation, UCLA. [New York:
　　　　Garland, 1997.]

Smith, J. L. (1997) Markedness and liquid alternations in Korean: Implications for the
　　　　representation of ambisyllabicity. Poster presented at the Hopkins Optimality Workshop/
　　　　University of Maryland Mayfest; Baltimore, May 11.

Smith, J. L. (2002) *Phonological Augmentation in Prominent Positions.* Doctoral dissertation,
　　　　University of Massachusetts, Amherst. [New York: Routledge, 2005.]

Smith, J. L. (2003) Onset sonority constraints and subsyllabic structure. Ms., University of
　　　　North Carolina, Chapel Hill. [Revised version of a paper presented at Phonologica 2002,
　　　　University of Vienna, November 3, 2002.]

Smith, J. L. (2008) Phonological constraints are not directly phonetic. In R. L. Edwards, P. J. Midtlyng, C. L. Sprague and K. G. Stensrud (eds.) *Chicago Linguistic Society 41* vol. 1, 457--471.

Sohn, H.-M. (1994) *Korean.* London: Routledge.

Sohn, H.-M. (1999) *The Korean Language.* Cambridge: Cambridge University Press.

Sohn, H.-S. (1987a) On the representation of vowels and diphthongs and their merger in Korean. In A. Bosch, B. Need and E. Schiller (eds.) *Chicago Linguistic Society 23* vol. 2, 307--23.

Sohn, H.-S. (1987b) *Underspecification in Korean Phonology.* Doctoral dissertation, UIUC.

Steriade, D. (1982) *Greek Prosodies and the Nature of Syllabification.* Doctoral dissertation, MIT.

Steriade, D. (1988a) Reduplication and syllable transfer in Sanskrit and elsewhere. *Phonology* 5: 73--155.

Steriade, D. (1988b) Review of *CV Phonology: A Generative Theory of the Syllable. Language* 64: 118--129.

Steriade, D. (2001) Directional asymmetries in place assimilation: a perceptual account. In E. Hume and K. Johnson (eds.) *The Role of Speech Perception in Phonology* 219--250. New York: Academic Press.

Trefry, D. (1969) *A Comparative Study of Kuman and Pawaian.* Pacific Linguistics B-13. Canberra: ANU.

Um, Y. (2003) An ordering paradox as constraint interaction: Alternation of *n* and *l* in Korean. *Studies in Phonetics, Phonology and Morphology* 9: 111--133.

Warner, N. L. (1998) *The Role of Dynamic Cues in Speech Perception, Spoken Word Recognition, and Phonological Universals.* Doctoral dissertation, University of California, Berkeley.

Wright, R. (2004) A review of perceptual cues and cue robustness. In B. Hayes, R. Kirchner and D. Steriade (eds.) *Phonetically Based Phonology* 34--57. Cambridge: Cambridge University Press.

Yun, Y. (2001) Glides in Korean syllables. *University of Washington Working Papers in Linguistics* 20: 57--98.

Zec, D. (1988) *Sonority Constraints on Prosodic Structure.* Doctoral dissertation, Stanford University. [New York: Garland, 1994.]

Zhang, J. (2004) The role of contrast-specific and language-specific phonetics in contour tone distribution. In B. Hayes, R. Kirchner and D. Steriade (eds.) *Phonetically Based Phonology* 157--190. Cambridge: Cambridge University Press.