

Glides, Vowels, and Features

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Abstract

Generative phonologists usually take high vowels like [i,u] and glides like [j,w] to be identical (respectively) in terms of distinctive features. The main argument for this assumption comes from theoretical economy: since syllable theory independently provides us with a means of distinguishing between vowels and glides – as syllable nuclei and margins respectively – there is no need for a featural distinction. This paper shows that in fact vowels must be featurally distinct from glides. Evidence for this comes from phonological processes that distinguish between the segment types, in a way that specifically diagnoses a difference of *constriction degree*. I further show that the vowel vs. glide distinction is part of a larger hierarchy of segmental distinctions based on constriction degree, as indicated by cross-linguistic generalizations. The implications of these conclusions for cases of high vowel vs. glide contrast are explored.

keywords: Glide, Syllabicity contrast, Palatalization, Constriction degree

1. Introduction

Since the advent of syllable theory in generative phonology, many researchers have assumed that high vowels like [i,u] are featurally identical to their respective glides [j,w]. The main reason for this is theoretical economy: glides are regarded as nonsyllabic realizations of vowels; since syllable theory provides an independent means of specifying the (non)syllabicity of a segment, using a feature to indicate this distinction would be redundant.

In this paper I reconsider this view. At the phonetic level, glides can differ from vowels in constriction degree. And the fact is, these differences have phonological consequences. In particular, cross-linguistic implicational generalizations rooted in *constriction degree* or *frication* distinguish glides from vowels. An explanatory theory of phonology must make room for this difference. Furthermore, the only impediment to doing so, the argument from economy, carries little weight today, at least in the context of theories employing output-based constraints.

The sections that follow first provide phonetic and phonological background on the glide-vowel distinction. Included here is a discussion of cases where glides and vowels contrast, and the implications of this fact for the theory. The paper then turns to the argument that vowels and glides differ in featural terms. The main focus here is on cases of palatalizing mutation, as when [kj] becomes [tʃ]. Across languages, this kind of change treats vowels and glides differently, and in a way that specifically suggests a *featural* distinction. The paper concludes with a discussion of the markedness of glide-vowel contrasts, and of the meaning of this for phonological theory.

2. Phonetic distinctions between vowels and glides

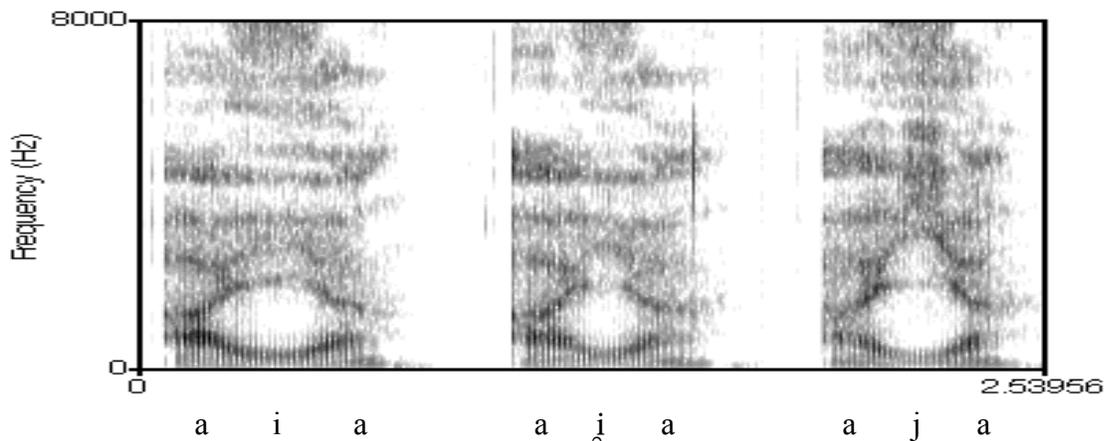
As a great deal of descriptive and instrumental literature makes clear, glides can differ from vowels in at least two ways, summarized in (1). They can differ in *dynamics*, and they can differ in *constriction degree*. Some descriptions emphasize the former difference (e.g., Catford 1988), others the latter (e.g., Ladefoged & Maddieson 1996).

(1) Two ways in which glides and vowels can differ

	Vowels	Glides
<i>Dynamics</i>	slow formant transitions, possible steady state	fast transitions, always changing
<i>Stricture</i>	intense formants, no frication	less intense, possible frication

These differences are illustrated by means of the spectrogram in (2), pronounced by the author. Comparing first trisyllabic [aia] to disyllabic [a_̣ia], one can see a difference in duration of the high vocoid portions: that of [aia] has more of what might be described as a steady state portion. The glide in [a_̣ia] has little of this, being mostly formant transitions, and so [i] might even be regarded as inherently dynamic or changing. The second formant transitions in [a_̣ia] also appear to be steeper, indicating a faster rate of change. Comparing next [a_̣ia] and [aja], one can see evidence of a difference in constriction degree or frication: the [j] of [aja] has more turbulence noise in higher frequencies, and seems to have less intensity at low frequencies, compared to [i]. (This discussion is not meant to rule out that [aia] and [a_̣ia] differ in constriction degree or that [a_̣ia] and [aja] differ in dynamics.)

(2) Spectrogram of [aia], [a_̣ia], and [aja]



For descriptive purposes I have introduced a three-way distinction above. Harnessing traditional terms and symbols, let us call glides that differ from vowels only in dynamics *semivocalic* glides, and those that differ in constriction degree or frication *consonantal* glides, symbolizing these as [i/ɨ] and [j/w] respectively. Distinguishing these categories raises some questions, the most obvious being: are semivocalic and consonantal glides in fact distinguishable objects even descriptively?

In an instrumental comparison of glides and vowels in Romanian, Chitoran (2002, 2003) finds no difference in constriction degree or frication. Rather, vowels differ from glides only dynamically: they are longer, as well as more variably timed with respect to a preceding vowel. On the other hand, Maddieson and Emmorey (1985) report a clear difference in constriction degree between vowels and glides in three languages. Observations of the latter sort, and the evidence from palatalizing mutations considered below, show that glides can sometimes differ

from vowels in constriction degree or frication. From a purely descriptive standpoint, then, it is useful to distinguish semivocalic and consonantal glides.

Another question is how independent dynamics is from constriction degree and vice versa. Consider the diagram in (3). The term ‘steady state’ (cf. the feature [long] of Hamann 2003) refers to the dynamic difference, the presence or absence of a steady state formants. ‘Vocalic stricture’ refers to the relatively open constriction degree of vowels, implying high intensity and an absence of any frication. This chart assumes that consonantal glides lack a steady state, as semivocalic glides do. However, greater constriction degree and a steady state target are not at all incompatible properties. Possible candidates for such segments include geminate glides (see Maddieson this issue), and the superhigh vowels of Proto-Bantu (Zoll 1996).

(3) Descriptive classification of vowels and glides

	i/u	i̇/u̇	j/w	j:/w:
steady state	✓			✓
vocalic stricture	✓	✓		

Within a language a glide might be realized as either semivocalic or consonantal, according to context and other factors. According to Avanesov (1972, pp. 89-94), for example, the Russian glide “j” is consonantal at the beginning of a stressed syllable and semivocalic elsewhere, e.g., [ˈjabləkə] ‘apple’, [mɐˈjo] ‘my (neut.sg.)’ versus [jɪrˈzʲɪk] ‘language’, [ˈmoj] ‘my (masc.sg.)’.¹ (Though Avanesov does not use these terms, his descriptions are very precise.) But these patterns are variable and subject to speech style. In addition it is very plausible, even likely, that this variability between semivocalic and consonantal realizations is gradient. (Compare for instance Gick’s (2003) account of English [l,w,j].) Indeed, such variability in glide realizations could be the rule in languages. Therefore, though “semivocalic” and “consonantal” might be useful descriptive terms for glides, there is no clear evidence that this distinction – the distinction between [i̇] and [j] – is important to a theory of phonology.

However, I will argue that the theory *should* make a featural distinction between high vowels like [i] and [u] on the one hand, and consonantal glides like [j] and [w] on the other. To capture this distinction I propose a feature [vocalic], shown in (4). In this chart the feature [consonantal] is familiar from Chomsky and Halle (1968). A feature [vocalic] has sometimes been used instead of [consonantal], where [αvocalic] is equivalent to [–αconsonantal] (Clements 1990). The proposal here is different: [vocalic] and [consonantal] exist together to define a more nuanced constriction degree hierarchy, with consonantal glides occupying a place between vowels and true consonants.

¹ A somewhat more complicated picture of their distribution is offered by Kasatkin and Kasatkina (2004).

(4) Featural classification of vowels and glides

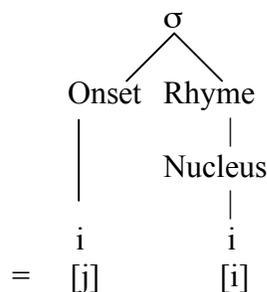
	i/u	<u>i</u> / <u>u</u>	j/w	l,r
vocalic	+	?	-	-
consonantal	-	-	-	+

It is not obvious a priori whether semivocalic glides should be treated as featurally equivalent to vowels or consonantal glides in this scheme. If the feature value [+vocalic] is understood to imply steady state dynamics as well as vocalic constriction degree, then [i/u] count as [-vocalic]; otherwise they are [+vocalic]. As we will see below, the strongest argument for a featural distinction between vowels and glides comes from glides that appear to differ from vowels specifically in constriction degree. Yet it may be useful to treat even semivocalic glides as featurally distinct from glides, a matter discussed in the next section. I ultimately leave this question open.

3. Contrast and syllabicity

Far from making a three-way distinction between [i], [i̯], and [j], generative phonologists today largely assume *none* of these distinctions. In particular, many assume that glides and vowels are featurally identical. This was not always the case, of course. Glides were distinguished from corresponding high vowels by the feature [syllabic] in Chomsky and Halle (1968). But since the adoption of syllable theory in generative phonology, many have advocated we dispense with such a feature (Clements & Keyser 1983, Kaye & Lowenstamm 1984, Levin 1985, Selkirk 1982, 1984). The reasoning is well known: given a theory of representations that distinguishes nuclear from non-nuclear syllable roles, as shown in (5), we can interpret nuclear vocoids as vowels and other vocoids as glides, even if they are featurally the same.

(5) Glide versus vowel status by syllable position



In many languages, high vowels and glides are in complementary distribution just as suggested by (5). The French data in (6)a (from Kaye and Lowenstamm 1984) are typical. As (6)b illustrates, a high vocoid will surface as a vowel or glide depending on how it is syllabified.

(6) French glide-vowel allophony according to syllable role

a.	Nucleus	Non-nucleus	b.	
	ty 'kills'	tʃe 'to kill'		σ Onset Rhyme l Nucleus u ← /lu/
	li 'ties'	lje 'to tie'		σ Onset Rhyme / l Nucleus w e ← /lu+e/
	lu 'rents'	lwe 'to rent'		

However common such complementary distribution may be, it is important to note that cases of vowel versus glide contrast do exist. Even for some who proposed to eliminate [syllabic], the claim was *not* that syllabicity can never be contrastive. The point was rather that such cases could be handled by prespecifying vocoids with (non-)nuclear status, as in the following example from Levin (1985).

(7) Vowel versus glide contrast in Usarufa (New Guinea)

N	
/a u e/	/a u e/
[aue] 'it is flesh'	[awe] 'wait'

An underlying distinction of this sort has been assumed for a range of languages, including Spanish, French, Romanian, Klamath, and Berber (Guerssel 1986, Harris 1983, Harris & Kaisse 1999, Levin 1985, Steriade 1984). The examples in (8) are from Iberian Spanish (Cabr e & Prieto 2006, Hualde & Chitoran 2003, Hualde & Prieto 2002). In Spanish, the sequences /iV/ and /uV/ typically surface as [jV] and [wV] – as they would in French. Hence cases like [su'iθa] and [mi'axa] are termed 'exceptional hiatus'.

(8) Exceptional hiatus in Iberian Spanish

Nuclear		Non-nuclear	
su'iθa	'Swiss'	'lwisa	'Luisa'
mi'axa	'small piece'	'vjaxe	'trip'

Though exceptional hiatus is real and found in a significant number of common words, it does not seem very robust, by more than one criterion. First, its use is subject to significant dialectal and individual variation. Second, the contrast is largely restricted to prominent

positions, specifically to word-initial or stressed syllables. Third, as the name implies, it is the less common realization of /iV/ or /uV/ sequences. Chitoran's (2002, 2003) experimental results for a parallel contrast in Romanian illustrate another way in which the contrast is not robust in that language: [iV] and [jV] sequences do differ systematically; but there is significant overlap in their realizations. The apparent weakness of syllabicity contrasts raises interesting questions for phonological theory, which we return to later.

Exceptional hiatus occurs in Russian too, as the examples below show (see discussion in Avanesov 1972, pp. 79-80, from which some examples are taken). Just as in Spanish, contrasts like [pi'astr] versus ['pjanstvə] cannot be explained away as due to differing stress (the relevant stressed vowel is the same in all cases) or any other properties of these words.²

(9) Exceptional hiatus in Russian

Nuclear		Non-nuclear	
i'on	'ion'	'jomkəstʲ	'capaciousness'
i'udə	'Judas'	'jugə	'south (gen)'
pi'astr	'piaster'	'pjanstvə	'drunkenness'
di'agnəs	'diagnosis'	'djakən	'deacon'
xrʲisti'anstvə	'Christianity'	krʲist'janstvə	'peasantry'

The examples of Russian exceptional hiatus above, and many others, come from words of foreign origin. (Examples having [uV] also exist, but since Russian lacks [w], there is no contrast as in (9).) But many are everyday words incorporated into Russian long ago, and otherwise showing no sign of their foreign origins. I therefore take the contrast to be real. On the other hand, as in Spanish, the contrast does not appear to be very robust. The sequence [iV] tends toward [jV] or [ɹiV] the further it is from the stressed syllable. Further, there are examples of historical exceptional hiatus disappearing in some words like ['pjəsə] < [pi'esə] 'theatrical play'.

There are also examples of the surface contrast [Vi] versus [Vj], in historically native Russian words, as shown in (10). Forms like ['vojn] are disyllabic. This form and [ge'roi] are underlyingly /voi+in/ and /geroi+i/. In such cases, one might avoid an *underlying* syllabicity contrast by appealing to a kind of serial analysis: /geroi+i/ → ge.ro.ji by normal syllabification, and then this form reduces to [ge.ro.i]. This loss of [j] before [i] is independently motivated in Russian.

(10) Surface [Vi] versus [Vj] in historically native words

Nuclear		Non-nuclear	
'vojn	'warrior'	'vojn	'wars (gen.)'
ge'roi	'heroes'	ge'roj	'hero'

² With its contrastive palatalization, Russian even has a remarkable three-way contrast between forms like [pʲastʲ] 'metacarpus', ['pjanstvə] 'drunkenness', and [pi'astr] 'piaster'.

But no such account is possible for the forms in (9), which are monomorphemic. Russian therefore provides another example of a pure syllabicity contrast. Accounting for this contrast via syllable theory, we have something like the following:

(11) Underlying syllabicity contrast in Russian – prosodic representation

N / d i a g n o z /		/ d i a k o n /
[di'agnəs]	‘diagnosis’	[ˈdjakən] ‘deacon’

Summing up so far: the argument against the feature [syllabic] rests not on a lack of syllabicity contrasts; these are not hard to find. Rather, the argument is one of theoretical economy: since we have an independent way of specifying such a contrast, as shown in (11), there is no need for a feature [syllabic].

Of course, if [+syllabic] means only “associated with N” and [-syllabic] “not associated with N”, and we want syllable role representations like Nucleus in the theory, this argument seems rather straightforward. But the main question raised in this article is whether the theory might benefit from a genuine featural distinction between glides and high vowels, one that is *definitionally independent* of syllable role. The proposed feature [vocalic] is just such a feature. Like other features, it is defined according to the articulatory and acoustic properties that segments have, *not* according to syllable position. In the following section I will motivate a featural distinction between vowels and glides. Given evidence for [-vocalic] glides, and given the definitional independence of [vocalic] from syllabicity, what becomes of the argument from redundancy?

In fact, representational redundancy in itself is not a very compelling problem. One might worry: generative phonology has generally held that representational distinctions entail contrast. If this is true, and we have both the feature [vocalic] on the one hand, and prespecification of structure like N (nucleus) on the other, we might expect contrasts such as those below. In this diagram transcriptions reflect [vocalic] values: [i] is [+vocalic] and [j] is [-vocalic]. Syllable role specification occurs independently of these values. The worry is that beside [+vocalic] nuclei and [-vocalic] onsets ((12)a-b) we will have [+vocalic] onsets and [-vocalic] nuclei ((12)c-d). The latter two are extremely marked if they occur at all, because these segment types are incompatible with these respective positions.³

(12) Four-way contrast?

a.	N	b.	O	c.	O	d.	N
	/ a i a /		/ a j a /		/ a i a /		/ a j a /

³ It is not [-vocalic] in itself that is incompatible with nuclear position, since syllabic nasals, laterals, and so on, are [-vocalic]. However, syllabicity seems to be cued in good part by duration (Price 1980). Adding duration to a glide by definition makes it more like a [+vocalic] sound (see section 2).

But of course, any principled theory of phonology must have ways to regulate the association between segment types and syllable positions. Some of these fall under the familiar ‘sonority’ rubric, while others, such as the assignment of English aspiration and glottalization according to syllable position, do not. The problematic (12)c-d fall into the former category, and there is surely no serious impediment to ruling them out accordingly. Within Optimality Theory, for example, Prince and Smolensky (1993 [2004]) propose Peak and Margin hierarchies to do this work. Given our understanding of [vocalic], glides are less sonorous than corresponding high vowels: [j,w] < [i,u]. These differences are projected onto the Peak and Margin hierarchies as shown in (13). The use of ‘,’ in (13) reflects empirical questions I leave open about the markedness of peak and margin glides vis-a-vis other consonant types.

(13) High vocoids and the Peak (P) and Margin (M) hierarchies

*P/t, *P/j >> ... >> *P/i >> ... >> *P/a
 *M/a >> ... >> *M/i >> ... >> *M/j, *M/t

Constraints like *P/j operate in the familiar way to rule out illicit syllable assignments. As shown in (14), an input having /j/ prespecified as a nucleus is disfavored by the markedness hierarchy. In both of the candidates, the high vocoid is taken to be syllabic, and ‘.’ indicates a syllable boundary.

(14) Suppression of illicit syllable role assignment

	N /j t a/	*P/j	Ident(vocalic)	*P/i
a.	j.ta	*!		
b.	i.ta		*	*

Though the proposed hierarchy *P/j >> *P/i makes nuclear glides more marked than nuclear vowels, it does not rule them out. As the reader can discern, reranking Ident(voc) and *P/j in (14) would predict that (14)a wins. Should this be undesirable, proposals already exist within Optimality Theory for ruling out structures universally. For example, *P/j might be incorporated into Gen so that candidates such as (14)a are never considered. Or, we might posit a universal ranking *P/j >> Ident(voc) (cf. Pater 2003).

The conclusion all of this leads to is that there is an alternative way to represent a syllabicity contrast as in Spanish or Russian, one relying on an underlying featural distinction, as in (15). Given richness of the base, nothing rules out inputs like these next to those in (11), or even those in (12) redundantly combining prosodic and featural representations. Given a principled approach to syllable role assignment, such as the Peak and Margin hierarchies above, nothing *need* rule them out as inputs either.

(15) Underlying syllabicity contrast in Russian – featural representation

[+voc]		[-voc]	
/d i a g n o z/		/d j a k o n/	(or /d j̣ a k o n/)
[di'agnəs]	‘diagnosis’	['djakən]	‘deacon’

As is evident from (15), I am remaining agnostic about whether the [–vocalic] glide in languages like Spanish or Russian is realized as ‘semivocalic’ or ‘consonantal’, to use the terms employed before, or indeed whether it is consistently one or the other. (Recall that Chitoran 2002, 2003 finds analogous glides in Romanian to be semivocalic.) The strongest evidence for a featural distinction between high vowels and glides comes from facts implicating constriction degree, as we will see in the next section. There is no such direct argument here, but I can think of one possible advantage of understanding contrasts between glides and exceptional hiatus as featural: as many have observed, differences of syllabification are not generally contrastive. To capture this generalization, McCarthy (1999, 2002) suggests that there are no faithfulness constraints protecting syllable affiliation in Optimality Theory. The use of prespecification of nuclear (or margin) status to capture exceptional hiatus contradicts this assumption, and makes nuclear vs. non-nuclear status oddly unlike other kinds of syllable affiliation. If exceptional hiatus is instead a featural matter – even if it has consequences for syllabification, as featural matters normally do – then this apparent contradiction disappears.

The point of the last argument is simply that a feature like [vocalic] can be entertained, without inevitably overgenerating contrasts or causing other obvious harm to the theory. The next section argues directly that [–vocalic] glides are necessary to the theory.

4. An argument from implicational hierarchies

Even after the advent of syllable representations in generative phonology, the claimed featural identity of glides and high vowels has not sat entirely easily with the field. It is not very hard to find processes that treat glides and high vowels differently, and researchers have occasionally invoked a featural (or geometric) distinction for this purpose, e.g., Hyman (1985), Cohn (1989), Walker (1993), Herman (1994), Hume (1995), Kawahara (2004), Nevins and Vaux (2004), and Levi (2004 and this issue).

There has been no consensus that glides must be featurally different, though. Perhaps this is because, for any isolated process distinguishing vowels and glides, one can always invoke the difference in syllable roles to account for the difference in behavior. Of course, there are times when this is exactly what should be done. But some differences between high vowels and glides must be featural, I argue, and *not* based on syllable role. The general argument is this: such facts are part of a larger family of facts which depend on constriction degree and are orthogonal to syllable position; to view the glide-vowel difference as prosodic misses a generalization.

4.1 Slavic mutation

Consider the palatalizing mutations that affected Common Slavic roughly between the 5th and 8th centuries. The best known of these is the “First Velar Palatalization”, by which velar consonants mutated to palato-alveolars before front vowels and the glide [j]. Examples are given below. (Data here and below from Townsend & Janda 1996.)

(16) Common Slavic First Velar Palatalization (FVP)

	Early Proto-Slavic	Late Common Slavic	
k > tʃ ^j	*pla:kja:m	platʃ ^j õ	‘I weep’
g > ʒ ^j	*gen-	ʒ ^j ena	‘woman’
x > ʃ ^j	*du:xe:tei	diʃ ^j ati	‘breathe’

Other mutations, commonly referred to as “Jotation”, occurred only before [j]; front vowels did not trigger them. Examples of Jotation are given in (17). Dental obstruents ((17)a) became palatoalveolars, as velars did. Dental sonorants ((17)b) were palatalized. Labials ((17)c) underwent a more puzzling change involving the insertion of a palatalized lateral. (Data from the third row to the end show the reflexes that occur in Modern Russian. Though all of these changes were initiated in the Common Slavic period, they continued to develop in independent ways in the later languages, and there is not always agreement on their realization in Common Slavic.)

(17) Common Slavic Jotation

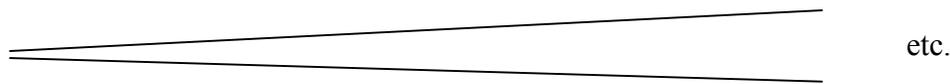
	Early Proto-Slavic	Late Common Slavic		
a.	s > ʃ ^j	*p(e)is-ja:m	piʃ ^j õ	‘I write’
	z > ʒ ^j	*ma:z-ja:m	maʒ ^j õ	‘I smear’
	Common Slavic	Modern Russian		
	t > tʃ ^j	světja	svjɪ'tʃ ^j a	‘candle’
	d > dʒ ^j	medja	mɪ'ɹʒa	‘boundary’
b.	n > n ^j	*kan-ja:d	kɐ'n ^j a	‘horse (gen.)’
	l > l ^j	*val-ja:	'vol ^j ə	‘will’
	r > r ^j	*mar-jas	'mor ^j ə	‘sea’
c.	p > p ^l ^j	kupjenu	'kup ^l ^j ɪn	‘bought’
	m > m ^l ^j	zemja	zɪm ^l ^j ɪ'a	‘earth’

FVP and Jotation have much in common: both involve mutation to palatal(-alveolar) place; both are triggered by a front vocoid; both lead in addition to affrication of input stops. Rather than view these as coincidences, we should seek to link up the accounts of FVP and Jotation to the extent possible. I will refer to these processes together as the Palatalizing Mutation (PM).

In theory, it is possible to formally isolate Jotation from FVP by appealing to the syllable position of [j]: while FVP affected consonants before any front vocoid, Jotation occurred only if the front vocoid occupied onset position, as shown below.

(21) A scale of constriction degree

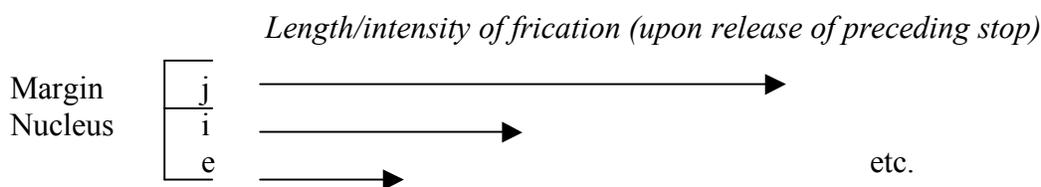
less aperture.....more aperture



j	i	e	
-	+	+	[vocalic]
+	+	-	[high]

These constriction degree differences, along with (20), predict a scale of frication or turbulence, assuming constant air flow:

(22) A scale of frication



Though this scale is indirectly related to syllable position, since more sonorous segments prefer the nucleus, it cannot be reduced to syllable position: while [j] occupies a margin, both [i] and [e] (not to mention more open vowels still) occupy the nucleus. As should be obvious, this scale is a matter not of syllable position, but of constriction degree and its consequences. It is therefore a matter for features.

Consider first how to formalize velar stop mutation while capitalizing on these ideas. I assume that velars before front vocoids can be fronted to something like palatal position, giving [kj], [k̟e], etc. Following Guion (1998) and Johnson (2003:147-8), I also assume that such fronting is a prerequisite to velar mutation to [tʃ]. The idea is that velar mutation occurs in two stages. First, velar fronting happens for articulatory reasons. But as these authors note, articulatory reasons alone cannot explain a further shift to [tʃ], because the latter sound is not palatal but palatoalveolar. Why does the further change to [tʃ] occur?

According to Guion and Johnson, the change is made available by the perceptual similarity between fronted velars and palatoalveolars. According to Guion's (1998) experimental results, listeners are more apt to misperceive [ki] as [tʃi] than they are [ka] as [tʃa]. In a learning generalization task involving made-up language games, Wilson (2006) finds that subjects generalize palatalizing mutation of velars before [e] to mutation before [i], but not the reverse.⁴ Both researchers assume that mutation as a sound change is motivated in part by perceptual similarities of the sort shown in (23). Neither work considers pairs like [kj]-[tʃ]; but the reasoning above and just below strongly suggests they would be perceptually closest of all.

⁴ In a study of rhymes in Japanese rap songs, Kawahara (to appear) finds that lyricists frequently rhyme [kʰ] and [tʃ], a finding in support of the general similarity of these segment types.

(23) Perceptual distance

$\underset{\ddagger}{k}jV \dots \underset{\ddagger}{t}jV$
 $\underset{\ddagger}{k}i \dots \underset{\ddagger}{t}i$
 $\underset{\ddagger}{k}e \dots \underset{\ddagger}{t}e$
 $\underset{\ddagger}{k}\text{æ} \dots \underset{\ddagger}{t}\text{æ}$

The similarities shown in (23) are due in part to the frontness of the postvelar trigger: the spectrum of the velar release before a vowel resembles that of [ʃ] increasingly as that vowel moves forward from [æ] to [i], for example. But other factors contributing to the similarity include the *intensity* and *duration* of the fricative release: the louder and longer the release, the more it resembles [ʃ]. And as indicated in (22), this is a matter not of frontness but of height or constriction degree. In other words, the scale in (22) provides an articulatory basis for (23).

Within Optimality Theory, one way to formalize the relationship between similarity and sound change follows Steriade (2001b, 2001a): project a family of faithfulness constraints in a fixed universal ranking, as in (24). The ranking captures the generalizations noted above: the more perceptually similar the input and output, the more likely the change. Rather than consider the features involved – a topic that would require another paper – I use ‘ $\underset{\ddagger}{k}e \rightarrow \underset{\ddagger}{t}e$ ’ to stand in for the features altered when / $\underset{\ddagger}{k}$ / surfaces as [tʃe], and so on. For convenience, I use subscripts to identify these constraints in the tableaux below.

(24) Ident constraint family projected from perceptual distance: velar mutation

$\text{Ident}_4(\underset{\ddagger}{k}\text{æ} \rightarrow \underset{\ddagger}{t}\text{æ}) \gg \text{Ident}_3(\underset{\ddagger}{k}e \rightarrow \underset{\ddagger}{t}e) \gg \text{Ident}_2(\underset{\ddagger}{k}i \rightarrow \underset{\ddagger}{t}i) \gg \text{Ident}_1(\underset{\ddagger}{k}jV \rightarrow \underset{\ddagger}{t}jV)$

The hierarchy above explains why some changes might be tolerated better than others. Nothing so far explains why a change to [tʃ] is *necessary*. I assume that fronted velars are articulatorily disfavored. As palatals they are arguably complex segments, both [dorsal] and [coronal] (Keating 1988). Assuming palatoalveolars have only one major place specification, [coronal], a change to [tʃ] represents a simplification (Zoll 1997).

Tableaux (25) and (26) show how the account works for the Slavic velar mutations. All fronted velars violate *Complex. Assuming this constraint outranks $\text{Ident}_4(\underset{\ddagger}{k}\text{æ} \rightarrow \underset{\ddagger}{t}\text{æ})$, then mutation occurs before [æ]. But given the universal ranking of the faithfulness hierarchy, this implies that mutation will occur before all front vocoids, up to and including [j]. (For convenience, the Ident hierarchy is collapsed in these tableaux.)^{5,6}

⁵ I assume that / $\underset{\ddagger}{k}$ / → [k] is ruled out by a separate constraint. Note how the account assumes fronted velars as input, taking seriously the view that mutation happens in stages. This view assumes an approach to sound change allowing for serial derivationality, such as one distinguishing lexical and postlexical levels. Such an approach is necessary in any case. See Padgett (2003) for discussion.

⁶ As is well known, some palatalizing mutations of velars lead to results that are unexpected from the point of view of this account. These include cases where the outputs are affricated dentals like [ts, dz], as in the second and third velar palatalizations of Slavic. Why such sounds should result from assimilation to palatal vocoids is not understood.

(25) Velar mutation before [æ]

	/k̥æ/	*Complex	*Ident(k̥→tʃ) ₄₋₁
a.	k̥æ	*!	
b.	tʃæ		*

(26) Velar mutation before [j]

	/k̥ja/	*Complex	Ident(k̥→tʃ) ₄₋₁
a.	k̥ja	*!	
b.	tʃa		*

As seen at the outset, however, PM also affected other places of articulation. Of specific concern for us are the mutations of [t,d] to [tʃ,dʒ]. We would like the account for velar mutations to carry over to these as much as possible. I assume that coronal mutations, like velar ones, are triggered by *Complex as well. This seems straightforward in the case of [tʃ,dʒ], and coronals in Slavic indeed mutated only before the glide. But since in other languages coronal mutation happens before front vowels as well, the account above implies that coronals even in [ti], [te], and so on, can be complex. Pursuing this account in a way analogous to the velars, I assume that coronal mutation is licensed by perceptual similarity, but that similarity is contingent on a strong degree of coarticulation with the front vocoid. Coronals in this preliminary stage will incorporate an active palatal gesture, leading to greater tongue blade contact with the roof of the mouth, a greater chance of perceived affrication, and so on. These coronals are given here as [ti], [te], etc.

I likewise assume there is a perceptual hierarchy governing coronal mutations analogous to that for velars, shown in (27).

(27) Ident constraint family: coronal mutations

Ident₄(t̥æ→tʃæ) >> Ident₃(te→tʃe) >> Ident₂(ti→tʃi) >> Ident₁(tjV→tʃV)

Coronal mutation before only [j] requires the ranking Ident₄₋₂(t→tʃ) >> *Complex >> Ident₁(t→tʃ). The workings of this ranking are shown in (28) and (29).

(28) Coronal mutation before [j]

	/t̥ja/	*Ident(t→tʃ) ₄₋₂	*Complex	Ident(t→tʃ) ₁
a.	t̥ja		*!	
b.	tʃa			*

Žygis (2006) makes the intriguing argument that dentals result when the language already has palato-alveolars, a kind of neutralization avoidance.

(29) Coronal mutation before [i]

	/ti/	*Ident(t→tʃ) ₄₋₂	*Complex	Ident(t→tʃ) ₁
a.	tʃi		*	
b.	tʃi	*!		

The rankings needed for the coronal and velar stop mutations of Slavic PM are shown in (30).

(30) Ranking for Slavic velar and coronal stop mutations

$$\text{Ident}_{4-2}(t \rightarrow tʃ) \gg *Complex \gg \text{Ident}_{4-1}(k \rightarrow tʃ), \text{Ident}_1(t \rightarrow tʃ)$$

The account laid out above assumes that coronal and velar mutations are fundamentally similar processes, though they are governed by separate perceptual faithfulness constraint families. In particular, both are triggered by the front vocoids [j,i,e,...], and both are more likely to be triggered the greater the constriction degree of that vocoid. An anonymous reviewer points to a different claim made by Bhat (1978) in his survey of palatalization processes. Bhat argues that velar mutations are more likely to be triggered by front vowels but not [j], while coronal mutations are more likely to be triggered by [j]. But it is not actually clear that Bhat's data support this claim. For example, he cites languages in which [j] mutates dentals but not velars, such as Zoque. Such cases show that velars are not necessarily mutated if coronals are, but they do not show that [j] is less likely to trigger mutation of velars than front vowels are. Bhat does cite one language (Nupe) in which front vowels but not [j] are said to trigger velar mutation. This is unexpected in the account here, but once again it does not demonstrate a difference between velars and coronals in their preferred mutation triggers. There is still much to be learned about cross-linguistic patterns of palatalizing mutations.

To return to the larger point concerning glides: an important component of the explanation for mutations is the perceptual similarity between [tʃ] and strongly coarticulated stops. This similarity is to a significant degree due to the presence of strong friction in the release of those stops. But the similarity, and the friction that contributes to it, is not the same in all contexts. Mutation is more likely the greater the constriction degree of the following front vocoid. Because they are different in constriction degree, high vowels and glides do not always pattern together in triggering mutation, as Slavic shows. Though we might capture this distinction technically by appealing to the different syllable roles of glides and vowels, such an account would make no contact at all with the larger account of mutation discussed above, one that is orthogonal to syllable role and is motivated independently by experimental work. Once the behavior of glides is viewed in this larger empirical and theoretical context, the argument for a difference in stricture becomes compelling.

4.2 Sundanese nasal harmony

Because of the similar argument it presents, this section briefly discusses the role of glides in Sundanese nasal harmony (see Cohn 1989, Levi to appear, Robins 1957, Walker 1998). Representative data are given below. Nasality spreads rightward from a nasal consonant throughout a word, unless it is stopped by a consonant. As can be seen here, obstruents, liquids, and glides ((31)c) all block harmony. (The laryngeals [h,ʔ] are transparent.)

(31) Sundanese nasal harmony

a.	/ɲiar/	[ɲiãr]	‘seek’
	/ɲaur/	[ɲãũr]	‘say’
b.	/ɲatur/	[ɲãtur]	‘arrange’
	/ɲudag/	[ɲũdag]	‘pursue’
	/ɲuliat/	[ɲũliat]	‘stretch’
	/marios/	[mãrios]	‘examine’
c.	/ɲiwat/	[ɲiãwat]	‘elope’
	/ɲajak/	[ɲãjak]	‘sift’

The obvious difficulty involves how to capture the divergent behavior of vowels, which undergo harmony, and glides, which block it. To capture this difference, Cohn (1989) specifies Sundanese glides as [+consonantal]. We can adopt Cohn’s approach while recasting glides instead as [–vocalic].⁷ Again, a consideration of the larger picture of nasal harmony in languages provides an independent argument that this is correct.

Building on previous work, including Cohn’s, Walker (1998) motivates the “nasal compatibility hierarchy” shown in (32), based on a survey of more than 75 languages. If nasal harmony is blocked by any category in this hierarchy, then it is blocked by all categories to the right as well. Languages like Sundanese that treat vowels and glides differently motivate their separation on this hierarchy.

(32) Nasal compatibility hierarchy

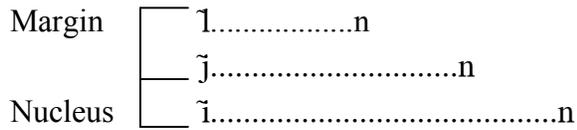
Most compatible.....least compatible

Vowels > Glides > Liquids > Fricatives > Stops

What is the basis of this hierarchy? Articulatory incompatibility may form part of the answer, but seems insufficient to explain the dispreference for nasalized glides and liquids, which (unlike nasalized stops and fricatives) present no obvious aerodynamic or articulatory hardship. Flemming (2004) suggests that perceptual distance of contrast plays an important role here: the closer the oral constriction of the sound in question is to that of a stop, the more like a nasal the sound will be if nasalized. Nasalized vowels do not sound unduly like nasal consonants, but according to this account, nasalized glides sound more like them, and nasalized liquids more like them still. This is depicted in the diagram below. Because the issues are more complicated in the case of fricatives and stops, I focus only on vowels through liquids.

⁷ Treating consonantal glides as [+consonantal] equates them with liquids in terms of major class features. This is an approach to consonantal glides worth considering, since it requires no new feature like [vocalic] and is otherwise fully in the spirit of the proposal in this paper. The crucial question, of course, is whether a language that distinguishes glides from vowels can or cannot simultaneously distinguish them (in major class terms) from liquids. If not, then we expect glides to pattern just as liquids do in processes involving sonority and syllabification, for example. Whether this will work for languages like Sundanese or Proto-Slavic is unclear to me; it will certainly *not* work for languages like Spanish having exceptional hiatus (see, e.g., Harris 1983 on Spanish syllabification).

(33) Perceptual similarity: nasals and nasalized sounds



As indicated in the diagram, syllable position is orthogonal to this scale of similarity and its cross-linguistic consequences, just as it is irrelevant for understanding the larger patterns of palatalizing mutations. Vowels and glides differ in syllable role, but glides and liquids do not. One can nevertheless achieve a language-specific solution to the vowel-glide distinction in Sundanese by appealing to this difference in syllable role (e.g., harmony applies only to syllable nuclei). This misses the larger picture, in which glides take an intermediate place on the constriction degree hierarchy underpinning (33).

A good deal of attention to the question of glides in nasal harmony is given by Levi (to appear). Levi notes that glottal consonants exhibit variable behavior with respect to the hierarchy above: in some languages, glides undergo harmony while glottals block; in others, the reverse is true. She suggests a solution to the problem: translated into our terms, in the former languages the glides are semivocalic (like [i]), while in the latter they are consonantal (like [j]). If this turns out to be true, then the “variable” status of glottals in nasal harmony is explained. Notice that this implies a *three-way* featural distinction between vowels, semivocalic glides, and consonantal glides.

(34) Elaborated Nasal compatibility hierarchy

Vowels > Semivocalic Glides > Glottals > Consonantal glides > Liquids > Fricatives > Stops

5. Conclusion

At the phonetic level, high vowels can be distinguished from glides. In addition, it can be useful to distinguish two types of glide: the semivocalic and the consonantal. This paper has argued for a *phonological* (featural) distinction between vowels and glides, based on their behavior in palatalizing mutations and nasal harmony. In each case, this behavior must be understood as rooted in constriction degree. The case studies seen here motivate specifically consonantal glides ([j,w] = [-vocalic]) as distinct from vowels. In addition, we have seen that glides and vowels can contrast phonemically. Whether this is captured by means of prespecified syllable role or by treating glides in these cases as [-vocalic] also, the overgeneration of contrasts and of syllable types can be avoided by principles of phonology already in place. By way of conclusion I consider some further consequences of syllabicity contrasts such as Russian [djakən] ‘deacon’ versus [diagnəs] ‘diagnosis’.

Pure syllabicity contrasts like this seem dispreferred in more than one way. First, they seem relatively uncommon in languages. Second, they seem relatively weak and unstable: in the cases we have discussed, the contrast may be confined to a small portion of the vocabulary; it is subject to much speaker variability; it can erode with time; and it is limited to phonetically strong positions, while remaining phonetically rather weak. Though syllabicity contrasts exist, they do not seem to be very good. Why is that?

An obvious hypothesis is that syllabicity contrasts are hard to perceive. (Adaptive) Dispersion Theory (within OT Flemming 1995 [2002], Lindblom 1986, 1990) explains limitations on contrast in just such terms. In that theory, contrast is regulated by output constraints independently of the inventory of phonological features. This idea is illustrated in (35) using a Space constraint (Ní Chiosáin & Padgett 2001, Padgett 1997). Within the space occupied by high vocoids, differences in duration, frication, formant movement, and intensity play a role in distinguishing sounds (see section 2). Assuming that a contrast between [i] and [j] represents some perceptual difficulty, the constraint Space \geq 1 (which requires each sound to have the entire space to itself) disfavors such a contrast. Satisfaction of this constraint is possible only in the absence of any contrast in this area, as in the bottom row of (35), where the realization of a high vocoid is left to other constraints. (For the sake of discussion I ignore the intermediate possibility of [i̠] and the question whether in the case of a contrast the glide is actually consonantal or semivocalic, or can vary between the two.)

(35) Perceptual distance and high vocoid contrasts

<i>Spacing</i>	<i>Violates</i>
.....i.....j.....	Space \geq 1
.....i ~ j.....	–

In a language like Spanish or Russian, where a syllabicity contrast occurs, Space \geq 1 is dominated by faithfulness. The tableau in (36) shows how this works. If Ident(vocalic) outranks Space \geq 1, then a Russian-like contrast will surface. Of course, languages lacking a contrast like this rank Space \geq 1 above these Ident constraints. In such cases, whether the vocoid is realized as a glide or a vowel will depend on other constraints, as discussed in section 3.

(36) Syllabicity contrast in Dispersion Theory

	dia ₁	dja ₂	Ident(vocalic)	Space \geq 1
a.	dia ₁	dja ₂		*
b.	dia _{1,2}		*!	
c.	dja _{1,2}		*!	

Both Dispersion Theory and Distinctive Feature Theory can explain *possible* versus *impossible* contrasts. The lack of a phonemic contrast between semivocalic and consonantal glides, for example, follows in Distinctive Feature Theory from the absence of any feature making such a distinction. Within Dispersion Theory, we can likewise assume the lack of such a feature; even if the feature existed (for example, were the phonology required to make reference to it), the perceptual crowding implied could be ruled out universally by Space constraints in Gen. A more interesting question is how to explain the *weakness* of a contrast like the syllabicity one. Here it seems that Distinctive Feature Theory is at a big disadvantage, since this difference cannot be captured by adopting or excluding a particular feature from the theory.⁸ With its intrinsic appeal to perceptual distance, Dispersion Theory is in a better position. An interesting,

⁸ Kirchner's (1997) proposal to regulate contrast has a similar difficulty here, since it depends on the presence versus absence of Ident constraints referring to a particular feature.

testable prediction suggests itself: differences in the cross-linguistic frequency or robustness of a contrast will correlate with the perceptual distinctiveness of that contrast (as determined by perceptual and acoustic experiments). How tightly this prediction holds up, and how to make a connection between the formal theory and these facts is a matter for future research.

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