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Phonemic vs. derived glides

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Abstract

Previous accounts of glides have argued that all glides are derived from vowels. In this paper, we examine data from Karuk, Sundanese, and Pulaar which reveal the existence of two types of phonologically distinct glides both cross-linguistically and within a single language. ''Phonemic'' glides are distinct from underlying vowels and pattern with other sonorant consonants, while ''derived'' glides are non-syllabic, positional variants of underlying vowels and exhibit vowel-like behavior. It is argued that the phonological difference between these two types of glides lies in their different underlying featural representations. Derived glides are positional variants of vowels and therefore featurally identical. In contrast, phonemic glides are featurally distinct from underlying vowels and therefore pattern differently. Though a phonological distinction between these two types of glides is evident in these three languages, a reliable phonetic distinction does not appear to exist.

Keywords: Glides; Sundanese; Karuk; Pulaar

> ''Perhaps the most problematic segment type for all theories of phonology is the class of glides.'' (Hyman, 1985)

1. Introduction

Glides pose a problem for phonology because of their apparent dual behavior. On the one hand, glides exhibit a close relationship with vowels by alternating with them in several languages. On the other hand, glides pattern with consonants by occupying syllable-peripheral positions. The problem of classifying glides is evident in the variable names for them. Along with

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"glide", one also finds terms such as "semi-vowel" and "semi-consonant," illustrating the fact that people variably elect to highlight either the vocalic or consonantal behavior of these segments. Though the presence of surface or output glides is not disputed, their existence as underlying, phonemic segments has been.

In many languages such as Sanskrit, Latin, Kimatuumbi, and Malay, the surface realization of an underlying vowel as either a syllabic vowel or a non-syllabic glide is predictable. This type of regular and natural alternation has been used as evidence to argue for an extreme view that glides are never phonemic segments; rather, underlying vowels are the only source for surface glides (e.g., Kaye and Lowenstamm, 1984; Steriade, 1984; Levin, 1985; Durand, 1987; Deligiorgis, 1988; Rosenthall, 1994). Under this type of account, vowels and glides are not contrastive at an underlying level, but only in the output as a structural or syllabic distinction. The implicit, and sometimes explicit claim, is that underlying or *phonemic* glides do not exist because all glides are simply positional variants of vowels.[1]

One issue faced by this extreme view is the varied behavior of glides. Previous accounts of glides have largely focused on either the syllabic or vocalic status of these segments. For example, Clements and Keyser (1983) represented glides as vowels linked to a C-slot, thereby explaining both their non-syllabic status and their transparency to vocalic processes which only targeted segments dominated by a V-slot. Another previous attempt to represent two distinct types of glides comes from Hume (1995) who argued that "consonantal" glides have place features under the C-place node while "vocalic" glides have place features under V-place (Clements and Hume, 1995). Though some have recognized the need to posit different types of glides, no explanation has been offered as to why glides appear to pattern both with vowels and consonants.

In this paper, we will see that the varied behavior of glides arises from differences in phonological status; some glides are derived from vowels ("derived" glides) and therefore exhibit vowel-like behavior, while other glides are underlying ("phonemic" glides) and therefore can pattern with consonants. The difference between this account and the one offered by Hume (1995) is the addition of an explanation of the source of the different behavior. Furthermore, this account makes specific predictions about differences in glide behavior with respect to both syllabification and segmental processes. A problem that arises in determining the inter- and intra-language status of glides (phonemic versus derived) is the lack of clear phonetic differences between these two types of glides. This phonetic equality is part of what has caused confusion about the phonological status of glides. The argument here is that it is necessary to examine how glides function in the phonology of a language. We will see that we can determine the status of glides – phonemic or derived – based on language-internal data.

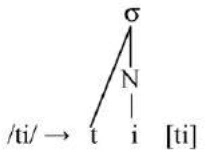
This paper focuses on languages in which each of the phonologically distinct glides occurs. In particular, we will examine the behavior of phonemic and derived glides co-occurring in Karuk, Sundanese, and Pulaar. I will argue that an account which distinguishes phonemic and derived glides strictly in structural (i.e., syllabic) terms cannot account for the data in these three languages; rather, only an account in which different place features are assigned to phonemic and derived glides can account for all the typological facts. Finally, I will present evidence indicating that the phonological distinction between phonemic and derived glides does not map onto a reliable phonetic distinction.

[1] While Rosenthall (1994) states explicitly that all glides are derived from underlying vowels, he is forced to acknowledge the need for a contrast in several dialects of Berber where he invokes the feature [consonantal] to explain the different behavior of glides and vowels.

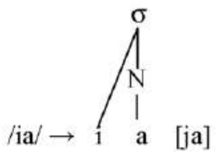
2. Representations

Derived glides, being positional variants of underlying vowels, are featurally identical to vowels, just as syllabic [m̩] and non-syllabic [m] are assumed to be featurally identical and to merely be positional variants of one another. If an underlying vowel is the most sonorous segment in a particular domain, it will surface as syllabic, as in (1a). However, if a more sonorous segment exists, and if the parameters of the language allow it, an underlying vowel can be parsed in a syllable margin as in (1b). In this situation, the underlying vowel will surface as a glide. Though the surface realization of /i/ is different in (1a) and (1b), featurally these two segments are identical.

(1) a. Underlying Vowel → Surface Vowel

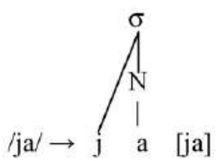


b. Underlying Vowel → Surface, Derived Glide



In contrast to the derived glide in (1b), phonemic glides as in (2) exist as underlying segments and are distinct from underlying vowels.[2] Though the phonetic outputs of both (1b) and (2) are glide-vowel sequences, they differ in their featural representation. The glide-vowel sequence resulting from /ia/ in (1b) maintains its vowel features, while the sequence derived from /ja/ in (2) is featurally distinct.

(2) Phonemic Glide → Surface Glide



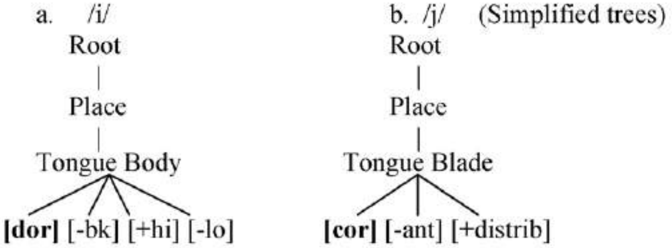
The featural difference between phonemic and derived glides is best represented in Revised Articulator Theory (RAT; Halle, 1995; Halle et al., 2000). In RAT, phonological features are represented within a single layer (in contrast to the two-tiered Vowel-Place Theory of Clements and Hume, 1995) and the primary difference between the two types of glides lies in their designated articulator (Halle, 1995).[3] Underlying vowels and derived glides (as in (3a) and (4a)) have the designated articulator dorsal and are expected to alternate and pattern with dorsal

[2] In addition to these terms above, the term ‘‘underlying vowel’’ will be used to refer to an underlying vocoid that surfaces either as a vowel or a glide depending on the segmental context and on the parameters of the language.

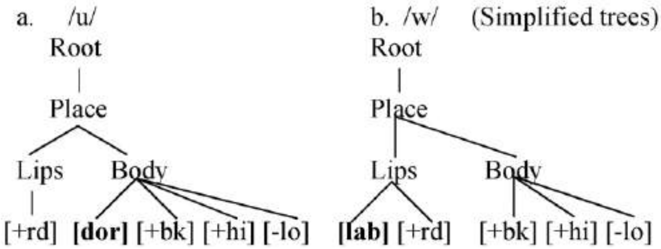
[3] A full description of the differences between Vowel-Place Theory and RAT is beyond the scope of this paper (but see Halle et al., 2000 for a comparison). The difference in their predictions lies mainly in the data from Pulaar (section 3.3) where Unified Feature Theory (Clements, 1989), an integral part of Vowel-Place Theory, cannot account for the difference in place alternations of the two types of glides.

segments. Phonemic glides (as in (3b) and (4b)) have the designated articulators coronal and labial, respectively. In this account, both underlying glides and underlying vowels are [−consonantal].

(3) Revised Articulator Theory: Front vocoids

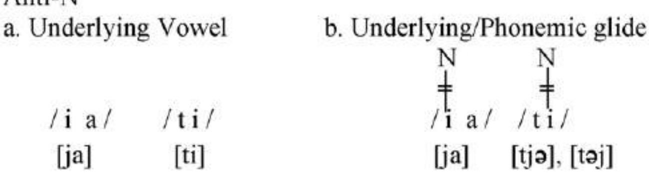


(4) Revised Articulator Theory: Back vocoids



Alternative representations that do not rely on extensive featural differences between underlying vowels (and derived glides) and phonemic glides are also possible. One such alternative, referred to here as "Anti-N," represents this difference as structural or syllabic. Here, the difference is that underlying vowels are unmarked for syllabic affiliation (5a) whereas phonemic glides are forced to surface in a syllable-peripheral or non-nuclear position (5b). Crucially, the features of the two types of glides are identical, and the sole difference is structural. This type of lexical marking contrasts with lexically marking some vowels as nuclear (Levin, 1985) where they are forced to surface as syllabic, resulting in hiatus (e.g., /ia/ → [i.a], *[ja]). In fact, Levin argues against such a lexical *un*linking to a nuclear position (1985:2). However, representations similar to (5b) have been contemplated in other work, such as CV-theory where some underlying vowels can be linked to a C (or non-nuclear) position (Clements and Keyser, 1983). In (5a), the plain high vowel /i/ surfaces as a glide in the first example because a more sonorous segment /a/ can be parsed as the nucleus. In the second example where /i/ is the most sonorous segment, it surfaces as syllabic. In (5b), the high vowel surfaces as a glide in both cases and must trigger some repair such as vowel epenthesis in the second example. Because the difference between phonemic and derived glides is purely structural, any differences between them are eliminated once they have been syllabified.

(5) Anti-N



A second alternative is to assume that the difference between phonemic glides and underlying vowels (and derived glides) is in the feature [±consonantal] ([CONS]). This account is perhaps the most common method of differentiating vowels from glides (e.g., Hyman, 1985; Deligiorgis, 1988; Hayes, 1989; Waksler, 1990; Rosenthall, 1994). Under this account, the only difference between glides and vowels lies in the feature [consonantal]. Underlying, phonemic glides are [+consonantal] vowels, while underlying vowels and derived glides are [−consonantal] with their syllabic realization dependent upon the phonological context. All other features remain the same, whether they are represented in the SPE-style of unordered features or with a more richly detailed feature geometry as in Revised Articulator Theory or Vowel-Place Theory (Clements and Hume, 1995). In particular, the primary place features of both phonemic and derived glides is identical. This method of distinguishing vowels from glides is not without criticism. Hume and Odden (1996) argue that using [consonantal] in this way goes against the very definition of this feature and should be avoided. Using data from lenition and fortition, they argue for the elimination of [consonantal] altogether in favor of the C-place and V-place representations of Hume (1995).

In this section, we considered three ways to represent the difference between phonemic and derived glides. The first, RAT, targeted featural differences between phonemic glides on the one hand and underlying vowels and derived glides on the other. In particular, differences were in the designated articulators where vowels and derived glides were [dorsal] and phonemic glides were either [coronal] or [labial]. The second, Anti-N, focused on a syllabic, structural difference where a phonemic glide was simply a vowel forced into a syllable-peripheral position. Finally, [CONS] represented phonemic glides as [+consonantal] vowels.

In the next section, data from Karuk, Sundanese, and Pulaar will show that the latter two accounts are unable to explain the different behavior of phonemic and derived glides. Instead, the more detailed featural differences represented in RAT account for all of the phonological differences between these two types of glides. More detailed arguments against Anti-N and [CONS] as viable representations for phonemic and derived glides are given in Levi (2004).

3. Phonological distinctions

In this section, we will examine three languages with a contrast between phonemic and derived glides. Evidence for the existence of this contrast comes from syllabification, morpheme-boundary alternations, and vowel harmony in Karuk, from nasal harmony in Sundanese, and from consonant gradation, vowel harmony, and syllabification in Pulaar.

3.1. Karuk

Karuk is a Hokan language spoken in northwestern California (Bright, 1957). In this section, I will show that Karuk contains both phonemic and derived glides. Evidence for this contrast comes from differences in: syllabification, behavior across morpheme boundaries, and vowel harmony. Although both labial (i.e., [w]) and palatal glides (i.e., [j]) surface in Karuk, only the labial glide exhibits a phonemic/derived contrast whereas all palatal glides are derived. Examination of the two types of labial glides is also discussed in Herman (1994) and Hume (1995) though their discussion is limited to morpheme-boundary alternations and vowel harmony. The phoneme inventory is provided in (6).

(6) a. Consonant phonemes of Karuk (adapted from Bright, 1957)[4]

	Labial	Dental/Alveolar	Palatal	Velar	Laryngeal
Obstruents	p	t	t͡ʃ	k	
	f	θ s		x	
Sonorants	m	n			
	w	r			ʔ h

b. Vowel phonemes of Karuk

i iː u uː
eː oː
a aː

3.1.1. Syllabification

Data from syllabification in Karuk is the first piece of evidence we present for the existence of a contrast between two types of glides. This data provides new evidence for this contrast which has not previously been brought to bear on this issue. The syllable structure of Karuk bans tautosyllabic consonant clusters and has the maximal syllable template CVC (Bright, 1957). This is evidenced by the lack of word-initial and word-final sequences of two or more consonants. Word medially, only sequences of two consonants may occur. Thus, medial CC sequences must be syllabified as VC.CV. Additionally, the absence of sequences containing two consonants and a glide (e.g., *VCCGV and *VGCCV) demonstrates that glides must occupy syllable-peripheral positions and do not form nuclear diphthongs. Hiatus is also banned in Karuk. In the analysis presented here, although underlying sequences of vowels occur, vowel sequences are avoided on the surface. If the adjacent vowels cross a morpheme boundary then either deletion (7a) or coalescence (7b) is used to satisfy this constraint. If the adjacent vowels occur within a morpheme, then high vowels surface as glides as in (8).

(7) a. Deletion
[ʔáhoː] [-a] → [ʔáhoː] 'the act of walking'
to walk – deverbative

b. Coalescence
[jêːpʃa] [-iʃiːp] → [jeːpʃéːʃiːp] 'best ones'
good ones – best

(8) High vowels adjacent to non-high vowels
a. /t͡ʃakai/ → [t͡ʃakaj] 'to be disgusted by
b. /t͡ʃupiau/ → [t͡ʃupjaw] 'to sort'
c. /taiau/ → [tajaw] 'to choose'

A survey of the 1706 forms glossed in Bright (1957) shows that all medial and final vocoid sequences can be explained with simple syllabification constraints, which avoid clusters and hiatus, disallow gliding long vowels, and ban non-high glides. An analysis of syllabification in Karuk couched in Optimality Theory (Prince and Smolensky, 1993) is presented below with the relevant constraints provided in (9). The status of vowel-initial and [ʔ]-initial words

[4] Bright (1957) also lists <ʃ> as a phoneme of the language. However, he points out that the output [ʃ] is completely predictable by a general rule that palatalizes /s/ after front vowels and [j].

is unclear; thus, the analysis presented here applies only to medial and final vocoid sequences.

(9) a. MAXSEG: Segments in the input must have a corresponding segment in the output. (Do not delete.)
b. DEPSEG: Segments in the output must have a corresponding segment in the input. (Do not epenthesize.)[5]
c. *COMPLEX: Complex onsets and codas are disallowed.
d. *STRUC: All syllabic structure is banned (one violation is incurred for each syllable).
e. ONSET: Syllables must have onsets.
f. {A}=V: Non-high vowels must be parsed as syllabic (Rosenthall, 1994).
g. VOWEL-MORA (V-μ): For every vocalic root node, there exists a mora (Rosenthall, 1994:26). (Underlying vowels should not surface as glides.)

The tableau in (10) provides an example of an underlying vowel sequence which includes a non-high vowel. Candidates (10b,c) incur fatal violations of ONSET due to the presence of hiatus and are therefore eliminated. Candidate (10d) incurs two violations of MAX and is eliminated. Candidate (10e), with a non-high glide [[a̯]] is eliminated by the fatal violation of {A}=V. The remaining candidate (10a) violates none of the highly ranked constraints and surfaces as the winner. Thus, the only possible output for an input containing a sequence of a high and non-high vowel is for the high vowel to surface as a glide. V-μ will not be included in subsequent tableaux because of its low ranking.

(10) /t͡ʃupiau/ →[t͡ʃupjaw] 'to sort'

/t͡ʃupiau/	*COMPLEX	ONSET	{A}=V	DEP	MAX	*STRUC	V-μ
☞ a. t͡ʃup.jaw						**	**
b. t͡ʃu.pi.a.u		*!*				***	
c. t͡ʃu.p_a.u		*!			*	**	
d. t͡ʃu.p_a_					*!*	**	
e. t͡ʃu.pi.a̯u			*!			***	*

Word-medial sequences of two high vowels are consistently syllabified as GV where the first high vowel surfaces as a glide (11a). The only examples of VG sequences where V is a high vowel and where a glide is in the second position are those in which this latter segment is a labial glide as in (11b). If the form in (11b) contained an underlying sequence of two high vowels /uiri**iu**sau/ then it would surface as [wirjusaw], parallel to the second example in (11a).

(11) a. First vowel surfaces as a glide
/im**ui**ra/ → [im**wi**ra] 'fishery'
/im**iu**ha/ → [im**jú**ha] 'soap plant'
/sun**ii**θih/ → [sun**jí**θih] 'nut of a giant chinquapin'

b. Second vowel surfaces as a glide
/uiri**w**saw/ → [wíri**w**ʃaw] 'to bequeath to'

[5] The constraints MAXSEG and DEPSEG serve as cover constraints for MAXC, MAXV, DEPC, and DEPV.

The forms in (11a) show that syllabification in Karuk is right-to-left. In cases like (11a) which contain sonority plateaus, the rightmost segment surfaces as syllabic and the leftmost as a syllable onset. Left-to-right syllabification would produce vowel-glide sequences which do not occur, except in cases like (11b) which are the result of underlying /VG/ sequences. The addition of the alignment constraint in (12) captures this directional syllabification (Mester and Padgett, 1994).

(12) ALIGN(σ, R, PrWd, R): Align the right edge of each syllable with the right edge of the prosodic word. One violation is incurred for each segment that intervenes between the right edge of the syllable and the right edge of the prosodic word.

The tableau in (13) provides an example where the alignment constraint distinguishes between gliding the first and gliding the second high vowel. Candidates (13c,d) are eliminated due to violations of the highly ranked constraints MAX and ONSET. Candidates (13a,b) both incur three violations of *STRUC; however, candidate (13a) incurs fewer violations of ALIGNR than candidate (13b). In the optimal (13a), gliding the first high vowel forces the preceding nasal into the coda of the preceding syllable. Thus, the edge of the first syllable in (13a) is only four segments from the right edge of the prosodic word, resulting in four violations of ALIGNR(σ1). By contrast, the first syllable of candidate (13b), which has gliding of the second high vowel, is five segments from the right edge of the word, providing the fatal violation. Thus candidate (13a), in which the first vowel has glided, is the optimal output.

(13) /im**iu**ha/ → [imjúha] ‘soap plant’ *[imiwha]

/im**iu**ha/	*COMPLEX	ONSET	DEP	MAX	*STRUC	ALIGNR σ1	σ2	σ3
☞ a. im.ju.ha					***	****	**	
b. i.miw.ha					***	*****!	**	
c. i.mi_.ha				*!	***	****	**	
d. i.mi.u.ha		*!			****	*****	***	**

ALIGNR is active in the optimization for forms that contain two high vowels such as those in (11a) in which it favors gliding of the first high vowel. In contrast, ALIGNR is not active in the optimization for forms with a phonemic labial glide such as those in (11b) because these forms do not contain a sequence of high vowels. The only way to realize the bolded /i/ in (14) is as a vowel. The constraint that rules out vocalization of the underlying glide /w/ is *NUCLEUS/GLIDE, which disallows a phonemic glide from surfacing as a syllabic nucleus.[6] In Karuk, the constraint *NUC/GLIDE is highly ranked since underlying glides are never allowed to surface as syllabic. This highly ranked constraint eliminates candidate (14e), the candidate analogous to the winner in (13a). Candidates (14b,c,d) are eliminated due to violations of *COMPLEX and MAX. Thus, the output of a form with an underlying glide is (14a) where the phonemic glide surfaces as a glide and the high vowel as a vowel.

[6] The *NUC constraints, based on the sonority hierarchy, are universally ordered as *NUC/STOP » *NUC/FRIC . . . *NUC/GLIDE » *NUC/VOWEL (McCarthy, 2002:22).

(14) /uiriwsaw/ → [wíriwʃaw] 'to bequeath to'

/uiriwsaw/	*NUC GLIDE	*COMPLEX	ONSET	DEP	MAX	*STRUC	ALIGNR σ1	σ2
☞ a. wi.riw.ʃaw						***	******	***
b. wirj.wʃaw		*!*				**	****	
c. wi.ri_.ʃaw					*!	***	*****	***
d. wir._wʃaw		*!			*	**	****	
e. wir.ju.ʃaw	*!					***	*****	***

Unlike word-medial sonority plateaus, word-final plateaus surface as VG as in (15), captured by an additional markedness constraint *V#. The alignment constraint from (12) would favor (17b) over (17a) because its first syllable is closer to the right edge of the word and therefore incurs only two violations of ALIGNR. However, (17b) incurs a fatal violation of the higher ranked *V#, allowing (17a) to surface as the winner.

(15) /afiu/ [ʔafiw] *[ʔafju] 'to make the bottom of a basket'
/tatui/ [tátuj] *[tátwi] 'to sweep'

(16) *V#: Words should not end in a vowel.[7]

(17) /tatui/ → [tátuj] 'to make the bottom of a basket'

/tatui/	ONSET	DEP	MAX	*V#	*STRUC	ALIGNR σ1	σ2
☞ a. tá.tuj					**	***	
b. tát.wi				*!	**	**	
c. tá.tu.i	*!				***	***	*
d. tá.tu			*!	*	**	**	

The inclusion of *V# does not generate anomalous outputs when only a single vowel occurs in final position because *COMPLEX, DEP, and MAX are all ranked higher. Thus, in forms with a single vowel in final position, the winning candidate will simply be the form with a word-final vowel.

Given the basic syllabification of Karuk and the distribution of high vowels and glides, it is clear that the surface realization of an underlying high vowel is fully predictable based on the ranking of the constraints. When it is adjacent to a non-high vowel, it surfaces as a glide. When it is surrounded by consonants, it surfaces as a vowel. Word-medial syllabification favors a right-to-left parse captured by ALIGNR and vowel-final words are dispreferred. Thus, underlying high vowels predictably surface as vowels or glides in line with the constraint ranking of Karuk. Under the assumption that all surface glides are derived, predictable syllabification fails in word-medial sequences such as (11b) where a labial glide surfaces in a VG sequence. However, under the account in which some labial glides are phonemic, the realization of the glide in forms such as (11b) is entirely predictable. Thus, syllabification provides one piece of evidence for a difference between two types of labial glides, phonemic and derived.

[7] A similar constraint barring only high vowels in word-final position is used in Chitoran's (1997) analysis of Romanian.

3.1.2. Morpheme boundary alternations

In addition to distributional evidence, the difference between the two types of labial glides in Karuk is illustrated by different behavior across morpheme boundaries. Before consonant-initial suffixes, supralaryngeal, non-nasal sonorants (phonemic glides and r) alternate with nasals (18a,b). In this Sonorant Nasalization, phonemic glides pattern with the other sonorants in surfacing as a nasal.

(18)	a.	Phonemic glide: /w/		
		/apiw/ → [ʔápiw]	‘to seek’	
		[ʔápim-tih]	‘to be seeking’	*[ʔápiw-tih]
		/asiw/ → [ʔásiw]	‘to sleep’	
		[ʔasím-t͡ʃak]	‘to close one’s eyes’	*[ʔasíw-t͡ʃak]
		/ʔiw/ → [ʔiw]	‘to die’	
		[ʔiːm-kara]	‘to drown’	*[ʔíːw-kara]
		/ʔu-ʔaw/ → [ʔu-ʔaw]	‘he eats’	
		[ʔam-kira]	‘place for eating’	*[ʔaw-kira]
	b.	Sonorant /r/		
		/kuːr/ → [kûːr]	‘to sit’	
		[kûːn-taku]	‘to sit on’	*[kûːr-taku]
		/sir/ → [sir]	‘to disappear’	
		[síːn-kara]	‘to swallow’	*[síːr-kara]

However, as shown in (19), derived glides do not participate in this process. Instead, derived glides simply surface as glides before consonant-initial suffixes.

(19)	Derived glide: /u/		
	/asuu/ → [ʔásuw]	‘to grumble’	
	[ʔásuw-tih]	‘to be grumbling’	*[ʔásum-tih]
	/ikriu/ → [ikriw]	‘to sit’	
	[ikríw-t͡ʃak]	‘to sit in the way’	*[ikrím-t͡ʃak]

Phonemic and derived glides also behave differently before vowel-initial suffixes. Phonemic /w/ patterns with /r/ (and the other consonants) and surfaces before vowel-initial suffixes as in (20).

(20)	a. Phonemic glide: /w/	
	/ikiiw/ → [ikjiw]	‘to fall’
	[ikjíw-iʃ(rih)]	‘to fall down’
	[ikjiw-fiːr]	‘to fall for a long time’
	/iw/ → [ʔiw]	‘to die’
	[ʔíw-apuh]	‘dead’
	(c.f. [ʔíːm-kara] ‘to drown’)	
	b. Other consonants	
	/ist͡ʃur-ahi/ → [iʃt͡ʃur-ahi]	‘to be cracked’
	/paθrih-a/ → [paθrih-a]	‘rain (noun)’

In contrast to morpheme-final phonemic glides which surface before vowel-initial suffixes, morpheme-final derived glides pattern with other vocalic segments and are subject to deletion and coalescence before vowel initial suffixes, as illustrated in (21).

(21)	Final /u/ → [w]		
	/ikriu/ → [ikriw]	'to sit'	
	/ikr**iu-i**s(rih)/ → [ikr**îː**ʃ(rih)]	'to sit down'	*[ikriw-iʃ(rih)]
	/ikr**iu-a**t/ → [ikr**êː**t]	'lived'	*[ikriw-at]
	/ihiiu/ → [ihjiw]	'to shout'	
	/ih**iiu-u**nis/ → [ihj**ûː**niʃ]	'to shout at'	*[ihjiw-uniʃ]

The exact nature of coalescence and deletion of vowels across morpheme boundaries is not understood. Generally, the stem-final vowel deletes and the remaining vowels coalesce. For example, /i**u**-a/ from 'lived' surfaces as [eː] with the length (number of moras) intact. Coalescing /i/ and /u/ results in [uː] as in 'to shout at.'

3.1.3. Vowel harmony

The third difference between phonemic and derived glides in Karuk is their effect on suffixes that participate in vowel harmony. Several suffixes contain an initial vowel which harmonizes to the final vowel in the stem. If the stem-final vowel is front (/i/ or /e/), the harmonizing vowel is [i]. If it is back and round (/u/ or /o/), the harmonic vowel is [u]. If the stem final vowel is low (/a/), then the harmonizing vowel is [a].

As expected, phonemic glides pattern with consonants in being transparent to vowel harmony, as shown in (22). Here, the harmonic vowel is symbolized by <V>. Notice that the stem-final phonemic glide does not require the harmonic vowel to surface as [u].

(22)	a.	Transparency of consonants	
		/taknih-Vθuna/ → [takníh-iθuna]	'to roll around'
		/ikfuk-Vwraː/ → [ikfúk-uwraː]	'to climb over'
	b.	Transparency of phonemic glides	
		/ikiiw-Vwraθ/ → [ikjíw-iwraθ]	'to fall into a sweathouse (sg.)'
		/pikiiw-Vwra/ → [pikjíw-iwra]	'to fall backwards'

If the stem ends in a derived glide the familiar processes of vowel deletion and coalescence occur. In (23), the stem-final vowel surfaces as a glide when no suffix is attached. However, when the vowel-initial harmonic suffix is added, the final vowel is deleted and the remaining vowels (/a/ and V) coalesce. The vowel harmony data provide another line of evidence suggesting the existence of two types of labial glides in Karuk, phonemic and derived.

(23) /axau-Vwruk/ [ʔaxawruk] 'to slide down a bank'
(c.f. [axaw] 'to collapse')

3.1.4. Summary

This section discussed three sources of evidence that establish the existence of two different labial glides in Karuk. Derived glides – which are by definition derived from underlying vowels – exhibit a predictable distribution and syllabification, surface as glides before consonant-initial suffixes, and delete before all vowel-initial suffixes, including those that begin with a harmonic vowel. In contrast, phonemic glides exhibit an unpredictable distribution, surface as nasals before consonant-initial suffixes and as glides before vowel-initial suffixes, and are transparent to vowel harmony. Thus, these two types of glides exhibit different behavior with respect to Karuk phonology.

A featural distinction, such as RAT (discussed in section 2), accounts for the different behavior of these two glides in Karuk. Derived glides, being featurally identical to vowels, pattern with them with respect to syllabification and their behavior across morpheme boundaries. Phonemic glides pattern with other consonants in the language. In addition, the process of Sonorant Nasalization (section 3.1.2) in which the labial glide alternates with the labial nasal is also readily explained in RAT, as the designated articulator of a phonemic labial glide is [labial]. Finally, RAT also accounts for the transparency of phonemic glides to vowel harmony because the relevant harmonic features are not available in phonemic glides.

A structural approach such as Anti-N cannot account for all the Karuk data without additional stipulations. Specifically, although Anti-N can account for differences in syllabification, an account of Sonorant Nasalization would require rule ordering or some equivalent OT mechanism (e.g., Sympathy Theory; McCarthy, 1999) to be invoked. This type of solution requires nasalization to apply to non-nuclear sonorants before syllabification. However, this would require a rule to make reference to syllable structure before syllabification has occurred, which may present additional problems. Accounting for the transparency of the phonemic glide in vowel harmony would require reference to its non-nuclear status, something that is argued to only take place in stress-based harmony (Kaisse and Levi, 2004).

It is worth noting that an account that relies on the feature [consonantal] can account for part of the different behavior of the two types of glides. Specifically, distributional differences can be accounted for by exploiting the feature [consonantal] as the source of the syllabic differences. Likewise, Sonorant Nasalization can also be accounted for by targeting only [+consonantal] sonorants. The one issue faced by an account that represents the difference between these two types of glides as a difference in [consonantal] is vowel harmony. It is possible that harmony only apply to [−consonantal] segments, but this type of analysis has been questioned on the grounds that vowel harmony is expected to apply to any segment with the relevant features which would include phonemic glides (Kaisse and Levi, 2004).

3.2. Sundanese

Sundanese is an Austronesian language of Indonesia spoken in West Java (Schourup, 1972; Cohn, 1990). Like Karuk, Sundanese exhibits a phonological distinction between phonemic and derived glides. Evidence for these two kinds of glides comes from their different behavior in nasal harmony.

3.2.1. Nasal harmony

In Sundanese, nasal harmony spreads nasalization rightward from a nasal consonant onto following vowels. Nasalization is blocked by supralaryngeal consonants and by phonemic glides (24a), but passes through laryngeal consonants, vowels, and derived glides (24b).

(24) Sundanese nasal harmony (Cohn, 1990)

a.	/ŋatur/	[ŋãtur]	‘arrange (active)’
	/ŋisər/	[ŋĩsər]	‘displace (active)’
	/ŋaluhuran/	[ŋãluhuran]	‘be in a high position (active)’
	/ŋarahɨtan/	[ŋãrahɨtan]	‘wound (active)’

	/ŋawih/	[ŋãwih]	‘sing (active)’
	/mawur/	[mãwur]	‘spread (active)’
	/ŋajak/	[ŋãjak]	‘sift (active)’
b.	/ɲiar/	[ɲĩj̃ãr̃]	‘seek (active)’
	/mi-asih/	[mĩʔ̃ãsih]	‘love (active)’
	/nuus/	[nũʔ̃ũs]	‘dry (active)’
	/mahal/	[mãɦ̃ãl]	‘expensive’
	/mihak/	[mĩɦ̃ãk]	‘take sides (active)’

OT provides a means to account for the segments that allow or block the spread of nasalization (Walker, 1998/2003). The analysis uses a universal ranking of nasal markedness constraints, motivated by cross-linguistic comparisons of nasal harmony systems which establish a scale of nasal compatibility (Schourup, 1972; Cohn, 1993; Walker, 1998/2003). The nasal markedness constraints ban the cooccurrence of the feature [nasal] with other features that define a particular class of segments. For example, the addition of the feature [+nasal] on [−sonorant, −continuant] segments (i.e., stops) is highly marked, whereas [+nasal] with [+low, −consonantal] is not. The spreading constraint (SpreadNasal) requires all segments within a particular domain to surface with the feature [nasal]. Interleaving the spreading constraint throughout this universal markedness hierarchy yields a factorial typology that provides a cross-linguistic account of nasal harmony. This set of possible systems, along with an example language, is provided in (25).

(25) Typology of Nasal Harmony Systems (adapted from Walker, 2003)

a. No Nasal Harmony (e.g., Spanish)
*NasObsStop » *NasFric » *NasLiq » *NasGlide » *NasV » **SpreadNas**

b. NH spreads through vowels (e.g., Barasano)
*NasObsStop » *NasFric » *NasLiq » *NasGlide » **SpreadNas** » *NasV

c. NH spreads through vocoids (e.g., Malay)
*NasObsStop » *NasFric » *NasLiq» **SpreadNas** » *NasGlide » *NasV

d. NH spreads through sonorants (e.g., Ijo)
*NasObsStop » *NasFric» **SpreadNas** » *NasLiq » *NasGlide » *NasV

e. NH spreads through fricatives and sonorants (e.g., Scottish Gaelic)
*NasObsStop» **SpreadNas** » *NasFric » *NasLiq » *NasGlide » *NasV

f. No segments block NH (e.g., Tuyuca)
SpreadNas »*NasObsStop » *NasFric » *NasLiq » *NasGlide » *NasV

Based on evidence from the cross-linguistic behavior of glottal segments in nasal harmony, Levi (in press) argues that the nasalization hierarchy should be expanded to include two types of glides. The revised ranking is provided in (26).

(26) Revised Nasal Markedness Constraints (Levi, in press)
. . .*NasLiq » *NasPhonemicGlide » *NasGlottal » *Nas/Vowel/DerivedGlide

The markedness constraints in (26) are based on feature cooccurrence restrictions. Thus, the fact that derived glides and vowels are featurally identical predicts that they pattern together in nasal harmony systems. This prediction is borne out, as non-phonemic glides exhibit the highest tolerance for nasalization along with vowels. In contrast, the separation of *NasPhonemicGlide from *NasVowel/DerivedGlide suggests that phonemic glides may pattern independently. Sundanese provides an example of this different behavior of phonemic and derived glides with respect to nasal harmony. The constraint ranking of Sundanese nasal harmony is given in (27).

(27) Constraint Ranking for Sundanese
*NasStop » *NasFric » *NasLiq » *NasGlide » **SprdNas** » *NasGlot » *NasV/DerGl

An example of a form with a derived glide is provided in (28). Candidate (28d) incurs only low ranking violations of *NasV/DerGlide, as well as a single violation of SpreadNasal. The remaining candidates either incur more violations of SpreadNasal (28a,b,c) or violations of higher ranked markedness constraints (28e). Spreading through phonemic glides, as in (29), does not occur because SpreadNasal is ranked below the markedness constraint banning nasalization of phonemic glides (*NasGlide). In this case, candidate (29b) emerges as the winner.

(28) /ɲaur/ → [ɲãw̃ũr] 'say (active)' (derived glide)

/ɲaur/	*Nas Stop	*Nas Fric	*Nas Liq	*Nas Glide	Sprd Nas	*Nas Glot	*NasV/ DerGl
a. ɲawur					**!**		
b. ɲãwur					**!*		*
c. ɲãw̃ur					**!		**
☞ d. ɲãw̃ũr					*		***
e. ɲãw̃ũr̃			*!				

(29) /mawur/ → [mãwur] 'spread' (phonemic glide)

/mawur/	*Nas Stop	*Nas Fric	*Nas Liq	*Nas Glide	Sprd Nas	*Nas Glot	*NasV/ DerGl
a. mawur					****!		
☞ b. mãwur					***		*
c. mãw̃ur				*!	**		*
d. mãw̃ũr				*!	*		**
e. mãw̃ũr̃			*!				

3.2.2. Summary

The Sundanese data illustrate that phonemic and derived glides can behave differently with respect to nasal harmony. The derived, non-phonemic glides pattern with vowels in being highly compatible with nasalization. This is not surprising, given that these glides are derived from vowels and have identical featural representations. In contrast, phonemic glides block nasal harmony.

The data in Sundanese are compatible with both a detailed featural representation such as RAT and with [CONS]. Because featural differences exist between phonemic and derived glides under these accounts, the markedness constraint that bans nasalization on phonemic glides (*NasGlide) and the constraint that bans nasalization on derived glides (*NasV/DerGl) can be ranked separately with respect to SpeardNasal. This allows us to account for the spreading though a derived glide, as well as the lack of spreading through phonemic glides. Crucially, both RAT and [CONS] represent the difference between these two types of glides in terms of features, thereby allowing the markedness constraints on feature cooccurrence to treat them differently.

In contrast, Anti-N cannot account for the different behavior of these two glides because they are featurally identical and therefore should both satisfy or violate the markedness constraints. In this case, the Anti-N analysis cannot be salvaged by appealing to differences in rule ordering (or an equivalent OT mechanism). Nasal harmony in Sundanese is not sensitive to syllabic representation, as shown by its ability to spread nasality through glottal segments occupying a syllable onset. Thus, even if derived glides were analyzed as a late process of glide insertion (see (24b) and (28)) the lack of nasalization through phonemic glides (represented as featurally identical to vowels but unlinkable to a nuclear position) would remain unexplained; the markedness constraints act as restrictions on feature cooccurrence, not on subsyllabic constituency.

3.3. Pulaar

The data in this section come from Kaédi Pulaar, a Western dialect of Fula spoken in the Futa Toro region of Mauritania (Paradis, 1992:5).[8] Like Karuk and Sundanese, Pulaar contains both phonemic and derived glides. Evidence for these two glides comes from their different behavior in consonant gradation, vowel harmony, and vowel epenthesis.

3.3.1. Consonant gradation

The Fula dialects are well-known for a process of stem-initial consonant alternations where consonants alternate between three different *grades*: continuant, non-continuant, and nasalized.[9] Class-marker suffixes determine the grade of stem-initial consonants. Effect 0 suffixes cause no change in the initial consonant. Effect 1 markers require the initial consonant to be [−continuant]. Effect 2 markers add prenasalization to the initial consonant if it is a voiced stop.[10] A schematized picture of the gradation is given in (30). Segments which alternate are all [+continuant], and alternate with [−continuant] consonants. The remaining consonants (stops, affricates, nasals, and /l/) are [−continuant] and do not show any alternation in word-initial position.

(30) Consonant Gradation (Paradis, 1992)

Effect 0	rV	sV	fV	wV	jV	wɔ/wu jɛ/i	hV	V
Effect 1	dV	t͡ʃV	pV	bV	d͡ʒV	gV	kV	V
Effect 2	^{n}dV	t͡ʃV	pV	^{m}bV	^{ɲ}d͡ʒV	^{ŋ}gV	kV	V

[8] Reference to the Eastern dialects (e.g., Anderson, 1976a, 1976b; Sagey, 1986; Halle, 1995) also exists but only patterns found for this Western dialect will be discussed.

[9] The discussion here of consonant gradation only applies to Stratum I nouns.

[10] Paradis argues that the nasal grade is not a separate grade, but is simply the addition of a nasal prefix (Paradis, 1992:51). The nasal prefix cannot surface unless the following segment is a voiced stop, which explains the lack of nasalization on [t͡ʃ] and [k].

The different behavior of phonemic and derived glides is evident from the schematic in (30) and the data in (31). In particular, the phonemic labial glide which alternates with [b] occurs before all vowels (31a), while the derived labial glide that alternates with [g] occurs only before back rounded vowels (31b). The phonemic palatal glide which alternates with [d͡ʒ] occurs before all vowels (31c), while the derived palatal glide that alternates with [g] occurs only before front vowels (31d).

(31)

		Effect 0	Effect 1	Effect 2		
	a.	w ~ b				
		wɔd͡ʒ-ɛrɛ	bɔd͡ʒ-ɛ	ᵐbɔd͡ʒ-ɔn	‘hare’	(Paradis, 1992: 41)
		wukk-uru	bukk-i	ᵐbukk-ɔn	‘pompom’	(Paradis, 1992: 41)
		wibd͡ʒ-ɔ	bibd͡ʒ-el		‘wing’	(Paradis, 1987b: 329)
		wil-dɛ	bil-ɛ		‘trap’	(Paradis, 1987b: 329)
		waad-ɛrɛ	baad-ɛ		‘drop (of rain)’	(Paradis, 1987b: 330)
	b.	w ~ g				
		wɔr-ɓɛ	gɔr-k-ɔ	ᵑgɔr-ɔn	‘man’	(Paradis, 1992: 41)
		wur-ɔ	gur-ɛ	ᵑgur-ɔn	‘village’	(Paradis, 1992: 41)
		woot-uru	gott-um		‘same’	(Paradis, 1987b: 331)
		wuuf-rɛ	guuf-ɛ		‘mouthful’	(Paradis, 1987b: 331)
	c.	j ~ d͡ʒ				
		jɛɓ-rɛ	d͡ʒeɓ-el	ⁿd͡ʒɛɓ-ɔn	‘seed’	(Paradis, 1992: 41)
		jim-rɛ	d͡ʒim-el	ⁿd͡ʒim-ɔn	‘poem’	(Paradis, 1992: 41)
		juɓɓ-ɔ	d͡ʒuɓɓ-ɛ		‘system’	(Paradis, 1987b: 330)
		jamir-ɔɔ-rɛ	d͡ʒamir-ɔɔ-ɟ-ɛ		‘order’	(Paradis, 1987b: 330)
	d.	j ~ g				
		jiit-ɛrɛ	giit-ɛ	ᵑgiit-ɔn	‘eye’	(Paradis, 1992: 42)
		jɛrt-ɛrɛ	gɛrt-ɛ	ᵑgɛrt-ɔn	‘peanut’	(Paradis, 1992: 42)
		jiɗ-ɓɛ	giɗ-ɔ		‘friend’	(Paradis, 1987b: 331)
		jɛɛnaa-ⁿdɛ	gɛɛnaa-lɛ		‘tomb’	(Paradis, 1987b: 331)

Following Paradis (1992), the data in (31b,d) are analyzed as containing an initial empty slot. In the continuant grade (Effect 0 suffixes), this slot is filled by spreading the vocalic features of the following vowel to the empty slot, resulting in either a back rounded glide (in the case of /u/ and /ɔ/) or a palatal unrounded glide (in the case of /i/ and /ɛ/). This derived glide alternates with a [−continuant] voiced velar stop in the non-continuant grade (Effect 1 suffixes). Because the stops that surface in these forms are derived from spreading the vocalic features of the following vowel onto the empty slot, according to RAT the realization of the non-continuant grade must be velar since the designated articulator of vowels and derived glides is [dorsal]. In contrast, the phonemic glides in (31a,c) are distinct segments, not resulting from the spread of vocalic features. In RAT, these phonemic glides are represented by the designated articulators [labial] and [coronal] and therefore alternate with labial and coronal stops in the [−continuant] (Effect 1) grade.

3.3.2. Vowel harmony

The second type of evidence for phonemic glides in Pulaar comes from their behavior in vowel harmony. Vowel harmony in Pulaar spreads [+ATR] from suffix vowels (e.g., /i/ and /u/) leftward to preceding suffixes and stems. Examples of [ATR] harmony triggered by suffixal vowels are provided in (32). Vowel harmony is blocked by intervening low vowels (e.g., /a/), as shown in (33).

(32)	[+ATR]	[-ATR]	Gloss (Paradis, 1992: 87)
	sof-ru	t͡ʃɔf-ɔn	‘chick’
	ser-du	cɛr-kɔn	‘rifle butt’
	peet͡ʃ-i	pɛɛt͡ʃ-ɔn	‘slits’
	dog-oo-ru	dɔg-ɔ-w-ɔn	‘runner’

(33)	bɔɔt-aa-ri	*boot-aa-ri	‘lunch’ (Paradis, 1992: 88)
	nɔdd-aa-li	*nodd-aa-li	‘call’

Glides neither trigger nor block ATR harmony. In (34a), the glide does not cause the preceding vowels to surface as [+ATR]. In (34b), the glide does not block the harmony from the suffix vowel.

(34)	a.	Non-trigger			
		dɔg-ɔɔ-w-ɔ	*dog-oo-w-ɔ	‘one who runs’	(Paradis, 1992:35)
		t͡ʃɔɔj-kɔn	* t͡ʃooj-kɔn	‘spinster (dim. pl.)’	(Paradis, 1992:90)
		hɔw	*how	‘to enclose’	(Paradis, 1992:93)
		dɛw-al	*dew-al	‘fat woman’	(Paradis, 1992:27)
		ɔtɔ-j-ɔn	*oto-j-ɔn	‘small cars’	(Paradis, 1992:1)
	b.	Non-blocker			
		oto-j-el	*ɔtɔ-j-el	‘small car’	(Paradis, 1992:1)
		looto-w-el	*lɔɔtɔ-w-el	‘small washer’	(Paradis, 1992:1)
		kejn-iraa-gel	*kɛjn-iraa-gel	‘brother in law (dim)’	(Paradis, 1992:100)

Paradis (1992) argues that some vowel-sonorant sequences should be treated as *nuclear diphthongs* because they do not trigger ‘‘suffix marker shortening,’’ where a suffix-initial consonant is deleted or lenited when the stem ends in a coda consonant. In these vowel-sonorant final stems, the strong form of the suffix (stop-initial) surfaces (as in (35)). Because the strong form surfaces in certain sonorant-final stems, Paradis argues that the stem-final consonants in these forms are not in the coda, but instead form complex nuclei. Even in these *nuclear diphthongs*, glides do not trigger or block harmony. If this analysis of nuclear sonorants is correct, the data in (35) show that harmony in Pulaar is not merely a relation between nuclear segments, but instead that harmony involves only segments with the relevant features. This is also consistent with the notion that harmony is always a case of feature spreading in non-stress induced harmonies, and is not dependent upon syllabic affiliation (Kaisse and Levi, 2004).

(35)	a.	Non-trigger			
		kɔj-ɗɛ	*koj-ɗɛ	‘feet’	(Paradis, 1992:173)
		pɛɛw-ɗɔ	*peew-ɗɔ	‘person’	(Paradis, 1992:173)

b.	Non-blocker			
	ɓo̱w-ɗi	*ɓɔ̱w-ɗi	'mosquitoes'	(Paradis, 1992:173)
	t͡ʃe̱w-ɗi	* t͡ʃɛ̱w-ɓi	'panthers'	(Paradis, 1992:173)

These data provide strong evidence for two types of glides in Pulaar. If all glides in Pulaar were derived from vowels, then they should all participate in harmony, as they would be featurally identical to vowels. Even if one were to appeal to an account of harmony in which only nuclear elements participate, the fact that the nuclear diphthongs do not participate would be problematic. However, these vowel harmony data are consistent with the claim that some glides in Pulaar are phonemic and therefore distinct from vowels. Because the derived glides in Pulaar only occur in initial position as the result of spreading to an empty slot, we do not see the effects of these derived glides in vowel harmony.

3.3.3. Vowel epenthesis

The third type of evidence for phonemic glides in Pulaar comes from vowel epenthesis. When a sequence of three consonants arises, [u] is epenthesized after the second consonant as in (36). When the inchoative suffix /w/ is attached, it also forces vowel epenthesis as in (37). If this suffix were actually an underlying vowel /u/, then there would be no impetus to epenthesize a vowel, as basic syllabification would create the forms in the third column of (37). Thus, [u] epenthesis in these forms suggests the existence of phonemic /w/.

(36)	/lɔrl-dɛ/	lorl-**u**-dɛ	*lorl-dɛ	'to torture'	(Paradis, 1992:128)
	/wɔrs-dɛ/	wors-**u**-dɛ	*wors-dɛ	'to knot'	(Paradis, 1992:128)
(37)	/ɓal-w-dɛ/	ɓal-w-**u**-dɛ	*ɓal-u-dɛ	'to blacken'	(Paradis, 1992:196)
	/ran-w-dɛ/	ran-w-**u**-dɛ	*ran-u-dɛ	'to whiten'	(Paradis, 1987a:131)
	/naj-w-dɛ/	naj-w-**u**-dɛ	*naj-u-ɛ	'to grow old'	(Paradis, 1987a:131)
	/tun-w-dɛ/	tun-w-**u**-dɛ	*tun-u-dɛ	'to dirty'	(Paradis, 1987a:131)

3.3.4. Summary

In RAT, the behavior of glides in both consonant gradation and vowel harmony is readily explained. The underlying glides /j/ and /w/ have the designated articulators [coronal] and [labial], respectively and therefore alternate with labial and coronal stops in consonant gradation. Derived glides, being derived from spreading vowel features to an empty slot, have the designated articulator [dorsal] and therefore alternate with dorsal stops. The transparency of phonemic glides in vowel harmony is also explained. Harmony targets only those segments with the relevant harmonic features. Because phonemic glides are featurally distinct from vowels, they lack the harmonic feature and are transparent to vowel harmony. Vowel epenthesis after the inchoative suffix is also readily explained in RAT by allowing only vowels to surface as nuclear segments.

The two alternative representations face problems in accounting for the data from Pulaar. Because Anti-N does not incorporate a featural difference between phonemic and derived glides, their different behavior in consonant gradation cannot be explained. Similarly, the distinction between these types of glides in [CONS] is not sufficient to explain this process. There is no way to motivate why a [+consonantal] glide should alternate with a coronal or labial stop, while a [−consonantal] glide should alternate with a velar stop. Although [CONS] could explain the transparency of phonemic glides in vowel harmony by differentiating between [−consonantal] targets and triggers and [+consonantal] transparent segments, such an account of harmony has been question (as mentioned in section 3.1.4). Both Anti-N and [CONS] are able to explain the need for vowel epenthesis after the inchoative suffix.

3.4. Summary

This section examined data from three languages indicating the existence of two types of phonologically distinct glides within a single language. Phonemic glides pattern with consonants in Karuk, Sundanese, and Pulaar in a variety of phonological phenomena such as syllabification, Sonorant Nasalization, vowel harmony, nasal harmony, and consonant gradation. In contrast, derived glides pattern with vowels in these three languages. The difference between phonemic and derived glides must be featural and can neither be purely structural nor depend entirely on the feature [consonantal] (see Levi, 2004 for a more developed argument to this effect). The next section will review evidence suggesting that a reliable phonetic difference does not accompany this phonological distinction.

4. Phonetic distinctions?

The previous section examined evidence regarding the phonological status of surface glides in three languages (Karuk, Sundanese, and Pulaar). The evidence pointed towards the existence of two types of surface glides, phonemic and derived. This section explores the phonetic realization of glides, which varies considerably cross-linguistically and is not always *vocalic*. For example, glides in Sanskrit and Latin are derived, being positional variants of high vowels (e.g., Whitney, 1879; Steriade, 1984), although their phonetic realization is generally described not as vocalic, but as consonantalized, using the symbol [v] for the segment that alternates with [u].[11] Thus, the phonetic realization of a glide does not indicate whether it is phonemic or derived. In the following sections, we review evidence from quantitative acoustic descriptions, as well as impressionistic auditory observations made by the source authors.

4.1. Karuk

According to Bright (1957), both of the two labial glides in Karuk (phonemic and derived) are phonetically realized as bilabial spirants (IPA [β]) (Bright, 1957; personal communication). Despite their phonetic realization as obstruents, these two types of glides do not pattern as obstruents in terms of the phonology.

Evidence that the phonemic glide /w/ is a sonorant comes from its behavior in three phenomena. The first piece of evidence comes from its distribution. If this glide were the voiced bilabial spirant β – a fricative – then it would be the only voiced fricative in the inventory (and also the only voiced obstruent). According to Maddieson (1984) when languages include a voicing contrast, it is generally used across all fricatives, and is most likely to include the voiced counterpart of /s/. The absence of other voiced fricatives, and in particular the absence of /z/, makes it unlikely that this segment is an underlying fricative.

Second, Karuk differentiates length among consonants. One degree of length is the result of an allophonic process triggered by the preceding or following vowel. In this case, the consonant is slightly longer than a simple singleton consonant and is marked C·. The second degree of length is even longer and is phonemic (e.g., [núkuh] 'deep', [súkkux] 'a woman's name'). The segments

[11] Goldman and Goldman (2002) describe the production of [v] as having a slight contact between the upper teeth and lower lip.

[ʔ, h, w, r, j] are "nongeminable," and never occur with either degree of lengthening (Bright, 1957:17). These segments form the natural class of non-nasal sonorants. If the labial glide were a fricative, then its presence in this group would be anomalous.

Finally, surface [r] (from /r/) and surface [β] (from /w/) participate in Sonorant Nasalization and become nasal stops when followed by another consonant at a morpheme boundary. These two segments form the class of underlying supralaryngeal non-nasal sonorants.[12] Once again, it is unlikely that a fricative would participate in this alternation, suggesting that [β] is a sonorant.

As discussed in section 3.1, the derived glides – also realized as [β] – pattern with vowels in the language. In particular, across morpheme boundaries, stem-final derived glides participate in vowel deletion and coalescence. In this case as well, it is unlikely that they would participate in these alternations if they were derived from a fricative.

Both glides in Karuk pattern as sonorants, either exhibiting their affiliation with sonorant consonants in the case of phonemic glides or with vowels in the case of derived glides. Despite the clear phonological contrast between these segments, an accompanying phonetic contrast does not appear to exist; both glides are realized identically, and as the spirant [β]. Thus, Karuk appears to be a language in which the difference between the two types of glides can only be uncovered by examining the phonology.

4.2. Sundanese

Unlike Karuk, Sundanese maintains a phonetic distinction along with the phonological difference between its phonemic and derived glides. According to Cohn (1990), visual examination of the spectrograms shows slight weakening of formant structure during the derived glides, while "definite weakening of the formant structure and a prolonged transition" is observed during phonemic glides (Cohn, 1990:65). Furthermore, Cohn reports that the duration of VGV sequences is longer when the glide is phonemic (278 ms) than when it is derived (244 ms). Unfortunately, these acoustic measurements were made with only a small number of tokens (five tokens each) and no statistical analyses were reported, making it is unclear how reliable and robust these differences are. Nonetheless, it appears plausible that phonetic differences exist between phonemic and derived glides in Sundanese.

4.3. Pulaar

Unfortunately, the phonetic realization of the two glides in Pulaar is not discussed explicitly by Paradis. The two glides are not differentiated in the description and no indication is made as to the vocalic or consonantal realization of these segments Thus, like Karuk, we may infer that these two glides are phonetically identical and that no reliable phonetic contrast accompanies the phonological difference between the two types of glides in Pulaar.

4.4. Summary

In the three languages examined here, only Sundanese exhibited a phonetic difference matching the phonological difference of the two types of glides. In Pulaar, the glides are not

[12] The absence of the other non-nasal sonorants /h, ʔ/ from this process may be related to their (in)ability to be nasalized. Because the acoustic difference between oral and nasal [ʔ] is null during the segment, it remains possible that ʔ is actually nasalized. Similarly, oral and nasal [h] is a difficult contrast to maintain, though apparently it does exist in a few languages (Walker and Pullum, 1999).

reported to be phonetically distinct, though further research is required to verify this conclusion. In Karuk, glides are described as phonetically identical, and are realized as [β]. Though consonantalized, these segments pattern phonologically as sonorants in the language despite their phonetic realization.

5. Other phonological and phonetic mismatches

The lack of a phonetic analogue to the phonological contrast between the two types of glides is neither unique to glides, nor is this type of mismatch a new concept to phonologists. Cases of phonetic neutralization, whether contextual or absolute, are well-documented in the literature (e.g., Kiparsky, 1968). Well-known examples include the neutral vowels found in many harmony systems where some trigger front- and others back-vowel harmony. A more recent example of this type of phenomenon is found in Nuu-chah-nulth (previously referred to as Nootka) where two classes of phonologically distinct fricatives, which are phonetically identical, exist (Kim and Pulleyblank, 2004). Their OT analysis explains the dual behavior of fricatives in morphological environments triggering glottalization and lenition.

As these cases of phonetic neutralization show, one-to-one mappings between phonological contrasts and phonetic distinctions are not necessary and the lack of such mappings is relatively common in natural languages. These well-known cases of neutralization exhibit a many-to-one mapping either among vowels (as in harmony) or consonants (as in Nuu-chah-nulth). As we have seen here, neutralization can cross the syllabic/non-syllabic divide; a vowel can surface as a non-syllabic glide, thereby neutralizing the distinction between an underlying vowel and a phonemic glide.

Vocalic segments (vowels and glides) exhibit the full range of phonological-to-phonetic mappings that exist for other segments. Data from Sundanese illustrates a one-to-one mapping where two phonologically contrastive glides are phonetically distinct. Both Pulaar and Karuk exhibit a many-to-one mapping where two phonologically contrastive glides neutralize phonetically. In Pulaar, the phonetic realization of the two phonologically distinct glides is vocalic [j], while in Karuk it is [β]. Data from Argentinian Spanish shows a standard, allophonic one-to-many mapping of vocoids where an underlying high vowel has multiple phonetic realizations depending on its phonological environment (e.g., Harris and Kaisse, 1999). It surfaces as a vowel between two consonants (e.g., p[í]so 'I step'), as a glide post-consonantally (e.g., bon[já]to 'sweet potato'), and as an obstruent in onset (e.g., clarabo[ʒ]a 'skylight'). Thus glides and vocoids pattern like other segments in the way phonology can map to phonetics.

6. Conclusion

The data presented here show that a phonological contrast between phonemic and derived glides can exist within a single language and that this contrast is best represented as a featural difference. Data from Karuk, Sundanese, and Pulaar show that appealing to a structural difference (''Anti-N'') is not sufficient to distinguish phonemic from derived glides because they are indistinguishable once they are syllabified. Furthermore, data from Pulaar show that using the feature [consonantal] to distinguish these two glides is also insufficient. Using this feature does not explain why the phonemic (and therefore [+consonantal] glides) alternate with labial and coronal stops while the derived (and therefore [−consonantal] glides) alternate with velars (section 3.3.1). If all other features were identical, this difference in the place of articulation of the [−continuant] grade segments would remain unexplained. In contrast, representing the distinction between phonemic and derived glides with a featural difference such as RAT can explain both syllabically motivated differences (e.g., Karuk syllabification and Pulaar epenthesis) and featurally motivated phenomena (e.g., Pulaar consonant gradation, Sundanese nasal harmony, and Karuk Sonorant Nasalization).

Although a phonological contrast exists among glides in these languages, these distinctions do not necessarily translate into phonetic differences. Phonemic and derived glides show the same matches and mismatches between phonology and phonetics that other segments do. The existence of a functional contrast must therefore be rooted in phonology. Neither the absence of phonetic differences (e.g., Karuk, Pulaar), nor the presence of phonetic differences (e.g., Sundanese, Argentinian Spanish) can establish a phonological contrast. Phonological differences must be based on phonological, not phonetic, behavior.

Taken together, the data presented here show that two types of phonologically distinct glides exist and that a featural difference explains their different behavior. Given that reliable phonetic distinctions between these two types of glides do not exist, and that 'consonantalized' glides can be derived from vowels, it is necessary to examine the phonology in order to establish the underlying identity of surface glides.

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