PHONOLOGICAL ANALYSIS

Phonological degrees of labiality

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A [+round] or [labial] feature is traditionally viewed as an elementary phonological unit that has different phonetic realizations depending on the height and backness of the segment that realizes it (McCarthy 1988, Clements & Hume 1995, Halle 1995, Kaun 1995, among others). In this article, I make two claims: (i) qualitatively different lip gestures are phonological in some languages, and (ii) there is more faithfulness to more extreme lip gestures.*

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1. Introduction. While it has long been known that rounding is not realized uniformly across vowel heights, this fact has been considered purely phonetic. This article proposes an analysis of a phonological phenomenon involving a transfer of labiality from a vowel to a consonant under certain conditions.[1] I argue that the Karata data I present here support the idea that differences in rounding can be phonological.

Karata ([kirʟː'i mat͡s̄'i], Russian *karatinskiy jazyk*) is an understudied Nakh-Daghestanian language originally spoken in ten 'auls' (i.e. mountain-top villages) in western Daghestan.[2] The available literature on Karata consists of a grammatical sketch (Magomedbekova 1971) and a dictionary (Magomedova & Khalidova 2001). The data presented in this article come from fieldwork that I carried out in June 2011 and July 2012 and from the above-mentioned sources.[3]

The structure of the article is as follows. I first give an overview of the phenomenon investigated and its proposed analysis (§2), and then provide background information on the phonology of Karata (§3). Section 4 is dedicated to an optimality-theoretic analysis of the Karata data. In §5, I motivate the idea that differences in rounding can be phonological. Finally, I show that other analyses fail to account for the Karata facts (§6).

2. Overview of the proposal. The purpose of this section is to introduce the core of the problem this article is about and to give an overview of the solution I propose. Because this section is meant to be a (brief) overview, some assumptions are made but

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[1] This idea was first presented in Pasquereau 2013, 2014.

[2] These villages are Karata, Archo, Anchikh, Rachabalda, Mashtada, Chabakoro (a.k.a. Verkhnee Enkhelo or Upper Enkhelo), Ratsitl', Nizhnee Enkhelo (or Lower Enkhelo), Siukh, and Tukita (Magomedbekova 1971). The territory inhabited by the Karatas is part of a larger homogeneous cultural area that is mostly Avar and traditionally associated with the use of Avar as the regional lingua franca. The Karatas are traditionally Sunni Muslims. The first and last census of their population as a distinct people (separate from the Avars) dates back to 1926 (Kolga & Tõnurist 2013). The number was then 5,305. Since then, the Karatas have been counted as Avars. Magomedova and Khalidova in their 2001 dictionary give an approximate number of 20,000 speakers. In the 2010 census (available at http://www.gks.ru/), the Karatas were counted as a subtype of Avars, and the number given is 4,787.

[3] The variety of Karata described in this article is the language as it is spoken in the aul of Karata, western Daghestan. Like the other Andic languages, Karata has no writing tradition, but can be written by means of an adaptation of the Avar version of the Cyrillic alphabet.

not yet justified (e.g. the recognition of the underlying form of verb stems). Certain elements of this section are taken up and argued for in more depth in later sections.

2.1. Problem. In Karata verb stems (-VC(V)...-),[4] the consonant must be labialized when both of the following conditions are met:

(i) the preceding vowel is underlyingly round and high, that is, /u/, and
(ii) this vowel becomes unround (as a result of its assimilation to the C prefix added to the stem).

In 1, both conditions (i) and (ii) are met; for instance, in 1a the consonant in the underlying stem /utʃ˜/[5] is realized as labialized once the stem-initial vowel has assimilated (delabialized) to the prefix *j-*. In these examples (and in the rest of the article), unless otherwise indicated, verbs are presented in the infinitival form, suffixed with the infinitival (INF) morpheme /aʟ̥a/.

(1) Labialization of stem consonant

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	j-utʃ˜-aʟ̥a	jitʃʷãŋʟ̥a	'bathe'
b.	j-utʃ'ã-aʟ̥a	jitʃ'ʷãːŋʟ̥a	'open'
c.	j-uƛ̥'˜-aʟ̥a	jiƛ̥'ʷãŋʟ̥a	'share'

Only a [+round] feature that is underlyingly linked to a high vowel can be linked to the following consonant. A [+round] feature that is underlyingly linked to a mid vowel is deleted (2).

(2) Nonlabialization of stem consonant

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	j-oχ̄a-aʟ̥a	jeχ̄aːʟ̥a	'thrust'
b.	j-oʔ˜-aʟ̥a	jeʔãŋʟ̥a	'go'
c.	j-oƛ̥'-aʟ̥a	jeƛ̥'aʟ̥a	'warm up'

As 1c and 2c show, whether the consonant can be labialized does not depend on the consonant (most consonants have labialized counterparts, as shown in §3),[6] but is purely a function of the preceding vowel: upon vowel delabialization, the adjacent consonant is labialized only if the underlying (round) vowel is high.

Traditionally, labialization (a.k.a. rounding) has been treated as categorical (McCarthy 1988, Clements & Hume 1995, Halle 1995, Kaun 1995, among others). For instance, as shown in 3, given a language with a five-vowel system /u, o, i, e, a/, as Karata happens to be, it is common to represent the difference between /u/ and /o/ as a difference in height—/u/ is specified as [+high], whereas /o/ is specified as [−high]—while both are specified as [+round].

[4] The majority of Karata verb stems that can undergo this process follow the pattern VC(V).

[5] The stem /-utʃ˜-/ 'bathe' (as well as other verb roots cited throughout this article) comes with a floating nasal feature. The nasal feature is realized on the first consonant of the suffix if it is one of /b, l, r/ (somewhat surprisingly, it never docks on /d/) or on the first vowel of the suffix if there is no such consonant.

[6] It is, however, difficult to find pairs of the form 'prefix-VC' like 1c and 2c, where C remains constant while V is either /u/ or /o/. It is not clear to me why, and it seems that there is no deeper explanation than just sheer randomness. Studying the distribution of [u] and [o] does not reveal any obvious restrictions on the consonant that can follow them: as far as I can tell, [u] and [o] can be followed by a consonant of any place or manner of articulation, central or lateral. It just so happens that, given a specific consonant C and a specific prefixal class marker, there are very few (known) pairs of words that meet the conditions of having [u]/[o] after the class marker and before C.

(3) Possible featural analysis of a five-vowel system

$$\begin{array}{ccccc} /u/ & /o/ & /i/ & /e/ & /a/ \\ \begin{bmatrix} +\text{high} \\ -\text{low} \\ +\text{round} \end{bmatrix} & \begin{bmatrix} -\text{high} \\ -\text{low} \\ +\text{round} \end{bmatrix} & \begin{bmatrix} +\text{high} \\ -\text{low} \\ -\text{round} \end{bmatrix} & \begin{bmatrix} -\text{high} \\ -\text{low} \\ -\text{round} \end{bmatrix} & \begin{bmatrix} -\text{high} \\ +\text{low} \\ -\text{round} \end{bmatrix} \end{array}$$

The analysis in 3 correctly captures the fact that /u/ and /o/ form a natural class in many languages: the class of [+round] vowels. And there is reason to think that in Karata, too, /u/ and /o/ form a natural class, as I show in §2.2. But under this view, the consonant-labialization asymmetry in 1 and 2 is mysterious.

2.2. Sketch of the proposal. There is general consensus on the fact that rounding varies as a function of height. In this article, I argue (i) that vowel aperture (a.k.a. height) is indexed on the [labial] feature, and (ii) that faithfulness to [labial*x*] is higher than to [labial*x*−1]. An idea of how vowel height in Karata can be mapped to degrees of aperture is given in 4.

(4) Karata has a three-aperture vowel system

aperture 3	i		u
aperture 2	e		o
aperture 1		a	

A way to formalize the dependency of the degree of rounding on the degree of aperture of the vowel is to posit that if a vowel is specified for the feature [labial*x*], [labial*x*] agrees in value with aperture *x*. Languages then vary in the extent to which they allow degree mismatching (e.g. cross-height and parasitic rounding harmony).

The analysis developed in most detail in this article hinges on the fact that there is particular faithfulness pressure to preserve the privative [labial] feature of a high vowel. In Karata, both high and nonhigh vowels become unrounded as a result of their assimilation in place of articulation to the preceding palatal glide: that is, the [labial] feature delinks from both /u/ and /o/. The claim is that because the rounding gesture that was realized on the high vowel /u/ is more salient (Steriade 2001; see §5.4), the output shows greater faithfulness to the input than is found for other labial features.

3. Overview of karata phonology. The purpose of this section is to give some relevant background on the phonology of Karata.

3.1. Segmental phonology.

Vowels. Karata has five 'basic' vowels, each of which has a long counterpart; see Table 1. In addition, any vowel, short or long, can be nasalized. The extent to which they are nasalized varies: from lightly nasalized and followed by a distinctly articulated nasal consonant to true nasal vowels with no trace of a consonantal constriction (as are found in French or Portuguese, for instance). Vowels are more or less nasalized depending on their position in the word. Clear nasal vowels occur word-finally. In all other positions, if the phonetic nasal vowel is followed by a consonant in the coda of the same syllable, a nasal consonant may still be perceived.

	FRONT			BACK	
HIGH	i	iː		u	uː
MID	e	eː		o	oː
LOW			a aː		

Table 1. Phonological table of Karata vowels.

Consonants. Karata has both central and lateral sounds. Central sounds are articulated in various places, whereas lateral sounds are all dental or velar. For the sake of conciseness, I present both central and lateral sounds in Table 2. In addition, all of the phonemes (except bilabials and palatals) have labialized counterparts that are separate phonemes; see Table 3. I justify the analysis of [Cw] sequences as complex phonemes in §3.1.

				CENTRAL									LATERAL	
				BILAB	DENT	ALV	POSTALV	PAL	VEL	UVUL	PHAR	GLOT	DENT	VEL
PLOSIVES	v-less	asp	W	p	t	ts	tʃ		k					
			S			t̄s	t̄ʃ		k̄	q̄				ʟ̥̄
		glot	W	p’	t’	ts’	tʃ’		k’			ʔ		ʟ̥’
			S			t̄s’	t̄ʃ’		k̄’	q̄’				ʟ̥̄’
	v-ed			b	d		ʤ		g					
FRICATIVES	v-less		W			s	ʃ			χ	ħ	h		ʟ̝̊
			S			s̄	ʃ̄		x̄	χ̄				ʟ̝̊̄
	v-ed					z	ʒ			ʁ	ʕ			
NASALS				m	n									
NONNASAL SONORANTS					r			j	w				l	

TABLE 2. Phonological table of Karata nonlabialized consonants (v-less: voiceless, v-ed: voiced; asp: aspirated, glot: glottalized; w: weak, s: strong).

				CENTRAL							LATERAL	
				DENT	ALV	POSTALV	VEL	UVUL	PHAR	GLOT	DENT	VEL
PLOSIVES	v-less	asp	W	t^{w}	ts^{w}	tʃ^{w}	k^{w}					
			S		t̄s^{w}	t̄ʃ^{w}	k̄^{w}	q̄^{w}				ʟ̥̄^{w}
		glot	W	t’^{w}	ts’^{w}	tʃ’^{w}	k’^{w}			ʔ^{w}		ʟ̥’^{w}
			S		t̄s’^{w}	t̄ʃ’^{w}	k̄’^{w}	q̄’^{w}				ʟ̥̄’^{w}
	v-ed			d^{w}		ʤ^{w}	g^{w}					
FRICATIVES	v-less		W		s^{w}	ʃ^{w}		χ^{w}	ħ^{w}	h^{w}		ʟ̝̊^{w}
			S		s̄^{w}	ʃ̄^{w}	x̄^{w}	χ̄^{w}				ʟ̝̊̄^{w}
	v-ed				z^{w}	ʒ^{w}		ʁ^{w}	ʕ^{w}			
NASALS				m	n	n^{w}						
NONNASAL SONORANTS					r	r^{w}					l^{w}	

TABLE 3. Phonological table of Karata labialized consonants.

A macron marks a consonant as FORTIS,[7] a feature that only voiceless consonants can have. The phonetic realization of the fortis characteristic or feature depends on the manner and place of articulation of the consonant that bears it. It can be realized as frication, gemination, or length, but for some consonants (e.g. affricates) its realization is better characterized as an increase in energy, in the sense that the articulators are more rigid. For simplicity, I use the macron to represent this feature throughout this article.[8]

THE ANALYSIS OF [Cw] SEQUENCES. In my presentation of the consonantal inventory of Karata above, I took for granted that Karata has labialized consonants, but [Cw] sequences could potentially be analyzed either as a sequence of two independent phonemes /Cw/ (5a) or indeed as one phoneme /C^{w}/ (5b).

[7] In the literature on Nakh-Daghestanian languages, these consonants are called ‘strong’. There is consensus that the strong character of a consonant is a phonological feature (Charachidzé 1981), though how it is realized is still to be investigated systematically.

[8] An anonymous referee suggests that it would be best to represent fortis consonants with either a length mark or a feature [tense]. Since no phonetic measurements have been performed on Karata consonants, I prefer to refrain from using a symbol that might suggest a potentially inaccurate realization of the fortis consonants.

(5) a. Sequence-of-phonemes hypothesis: A [Cw] sequence constitutes two phonemes underlyingly, that is, /Cw/.
b. Labialized-consonant hypothesis: A [Cw] sequence constitutes one phoneme underlyingly, that is, /Cʷ/.

In this section, I present arguments to justify the analysis of [Cw] sequences as labialized phonemes, which is crucial for the analysis of the phenomenon this article is mainly concerned with.

As illustrated in 6, in Karata the labial glide [w] occurs independently in onset position, word-initially (6a) or not (6b), and in coda position, word-finally (6c) or not (6d).

(6) Labio-velar glide /w/ in different positions

	UNDERLYING FORM	SURFACE FORM	MEANING	SYLLABLE POS
a.	waʃa	wa.ʃa	‘boy’	onset
b.	ħawuz	ħa.wuz	‘spring, well’[9]	
c.	ʃiʃaw	ʃi.ʃaw	‘bottle’	coda
d.	awlaq̄	aw.laq̄	‘lowland’	

It is also found after all consonants except bilabials (i.e. /p/, /p’/, /b/, and /m/). To my knowledge, there is no other restriction on place of articulation, manner, or properties such as voicing, glottalization, and the lenis/fortis opposition (7).

(7) [Cw] sequences regardless of place of articulation, manner, voicing, and the fortis/lenis distinction of C

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	ʃʷalja	ʃʷalja	‘river, stream’
b.	x̄ʷane	x̄ʷane	‘horse’
c.	t͡s̄ʷabdi	t͡s̄’ʷabdi	‘stars’
d.	dʷahã-al̝̊a	dʷahãːŋl̝̊a	‘to massage’

Two main arguments justify the recognition of complex labialized consonants in Karata. First, the distribution of [Cw] sequences is much more restricted than that of [w]: [Cw] sequences are found only preceding the low vowel [a], whereas [w] is found before additional vowels: mainly [u], [o], and [a] (8a) and exceptionally (mainly in loanwords) [i] and [e] (8b). It should be noted that while [wV] sequences are abundant when [w] is the class I prefix, [wV] sequences where [w] is not a morpheme, as in 8b, are much rarer.[10]

(8) Distribution of [w]

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	The prefix /w/		
	w-iʃãq̄-al̝̊a	wuʃãq̄al̝̊a	‘work’
	w-uʧ˜-al̝̊a	wuʧãŋl̝̊a	‘bathe’
	w-eʟ̥̄’˜-a-al̝̊a	woʟ̥̄’ãːŋl̝̊a	‘make fit’
	w-oʟ̥̄-al̝̊a	woʟ̥̄al̝̊a	‘walk’
	w-aʃa-al̝̊a	waʃaːl̝̊a	‘assess’

[9] Loan; see Khalikov & Efendiev 2002.

[10] I am aware of only one word with the sequence [wi], *witru* ‘witr prayer’, which is a loanword. Words with [we] are also few and far between; I am aware of only two: the word for ‘plowman’ in 8b, and the word *sewer* ‘north’, which is clearly a loan from Russian. Surprisingly, words with [wu], where [w] is not the class I prefix, are, as far as I know, all loanwords. At this point I do not have an explanation for why these [wu] sequences are not more attested in Karata.

b. Nonprefixal occurrences of [w]

witru	witru	‘witr prayer’ (loan)
kawu	kawu	‘gate’ (loan)
weı̥̄’aruq̄an	weı̥̄’aruq̄an	‘plowman’
wore	wore	‘watch out!’
warʧ’ami	warʧ’ami	‘hello’

Before all other vowels, [w] in the sequence [Cw] assimilates with the following vowel as follows:

- If the following vowel is [−low]: the [+round] feature attaches to the vowel, thus making it round.
- If the following vowel is [+low]: the [+round] feature does not attach to the vowel since the language has no [+low, +round] vowel in its inventory. Therefore, the [+round] feature remains attached to the consonant.

These processes are visible when the [Cw] sequence is at a morpheme boundary and a morpheme (suffix) is added to it (9).

(9) Assimilation of suffix-initial vowels to stem-final consonant of verb

	UNDERLYING FORM	SURFACE FORM
a. ʦ’ĩk’ʷaı̝̊a ‘hurt, sting (for a tooth)’		
future	ʦ’ĩk’ʷ-as̄	ʦ’ĩŋk’ʷas̄
imperfective	ʦ’ĩk’ʷ-ida	ʦ’ĩŋk’uda
perfective	ʦ’ĩk’ʷ-e	ʦ’ĩŋk’o
imperative	ʦ’ĩk’ʷ-ej	ʦ’ĩŋk’oj
b. biʁʷãı̝̊a ‘be upset’		
future	biʁʷ˜-as̄	biʁʷãs̄
imperfective	biʁʷ˜-ida	biʁũnda
perfective	biʁʷ˜-a	biʁʷã
imperative	biʁʷ˜-i	biʁũ
c. biʔʷaı̝̊a ‘break’		
future	b-iʔʷ-as̄	biʔʷas̄
imperfective	b-iʔʷ-ida	biʔuda
perfective	b-iʔʷ-i	biʔu
imperative	b-iʔʷ-i	biʔu

By comparison, when the verb root ends in a consonant with no [w], the suffixes are transparently added (10).

(10) Nonassimilation of suffix-initial vowels to stem-final consonant of verb

	UNDERLYING FORM	SURFACE FORM
a. bak’ãı̝̊a ‘bend’		
future	b-ak’˜-as̄	bak’ãs̄
imperfective	b-ak’˜-ida	bak’ĩnda
perfective	b-ak’˜-a	bak’ã
imperative	b-ak’˜-i	bak’ĩ
b. biʁaı̝̊a ‘stop’		
future	biʁ-as̄	biʁas̄
imperfective	biʁ-ida	biʁida
perfective	biʁ-e	biʁe
imperative	biʁ-i	biʁi

c. biʔaḻ̊a 'know'		
future	b-iʔ-as̄	biʔas̄
imperfective	b-iʔ-ida	biʔida
perfective	b-iʔ-a	biʔa
imperative	b-iʔ-i	biʔi

I have not found any occurrences of [Cw] sequences followed by a round vowel. Note that if [Cw] was a cluster, then the labialization of the suffixal vowels in 9 could be regarded as a case of coalescence of two segments (Casali 1996), [w] and [i] or [e]. There are clear cases of coalescence in Karata where two vowels are merged into one vowel that shares characteristics of both in order to resolve an underlying hiatus created by the suffixation of a vowel-initial suffix to a vowel-final verb stem.[11] In these cases (11), the resulting vowel is long. The (assimilation) phenomenon illustrated in 9, by contrast, does not give rise to such compensatory lengthening, unlike true cases of coalescence. This difference follows if we analyze [Cw] sequences as labialized consonants, as opposed to clusters of a consonants and the segment [w].

(11) Coalescence gives rise to compensatory lengthening in Karata

	UNDERLYING FORM	SURFACE FORM
a. bibaːḻ̊a 'yell'		
future	biba-as̄	bibaːs̄
imperfective	biba-ida	bibeːda
perfective	biba-i	bibeː
imperative	biba-a	bibaː
b. bat͞ʃʷaːḻ̊a 'carry'		
future	b-at͞ʃʷa-as̄	bat͞ʃʷaːs̄
imperfective	b-at͞ʃʷa-ida	bat͞ʃoːda
perfective	b-at͞ʃʷa-e	bat͞ʃʷeː[12]
imperative	b-at͞ʃʷa-a	bat͞ʃʷaː

Second, in a language game I designed, speakers consistently treated [CwV] sequences in the same way they treated [CV] or [C'V] sequences. (Note that the argumentation behind the language game depends on the type of syllable allowed in Karata, which I discuss later in §3.3.)

I asked two adult native speakers of Karata to respond to questions by email after my last field trip in 2012.[13] These two speakers (a woman and a man) were born in Karata, spent their childhoods there, and went to school there where they learned to write and read Russian as well as Avar, the regional vehicular language. Both still speak Karata daily, being married to Karata speakers. Other than that, they have different backgrounds:

[11] My observations on the verb system of Karata have come to the following conclusion: if a verb stem ends in a vowel, this vowel is /a/. This could be due to the history of verbs in Karata, but more research is needed.

[12] Why the sequence /t͞ʃʷeː/ does not turn to /t͞ʃoː/ is not clear to me. It could be that long vowels behave differently from short vowels in word-final position when it comes to assimilation. This would be consistent with what is further observed in n. 16.

[13] Every person I have met in the village knows how to read and write at least Russian, and most middle-aged and older people also know how to read and write Avar. From their knowledge of the Avar writing system, they can read and write Karata. But how used they are to reading and writing Karata varies greatly. While a few Karatas write poetry and songs in the language, others do not have any use for it. For my (written) questionnaire, I chose two speakers who are very competent at writing in Karata. In addition, it should be pointed out that almost everyone in Karata has a smartphone with internet access and many households have (at least had in 2012) internet access with a computer.

the woman is a university professor in the Daghestanian capital (Makhachkala), while the man lives in Karata.

The speakers were instructed in Russian to look at existing words of Karata, take the last two sounds (not letters, because one sound may be rendered by more than one letter), and put those at the beginning of the word. The instructions are translated in 12.

(12) LANGUAGE GAME INSTRUCTIONS: Take the last two sounds of each word (and not letters) and put them at the beginning of the word. For example, according to the rules of this game, the word 'кекьи' becomes 'кьике' (not 'ьикек' since 'кь' is just one sound). Another example is the word 'берка' which becomes 'кабер'.

Four examples illustrating the instructions were provided (Table 4). They do not contain [Cw] sequences in the last/critical syllable, and there are words where the two critical sounds (at the end) are rendered by more than two Cyrillic symbols (Table 4c,d), thus making it clear that the instructions are not about the letters but about the sounds. Speakers saw only the Cyrillic columns.

		REAL WORDS		RESULTS	
	MEANING	IPA	CYRILLIC	IPA	CYRILLIC
a.	'closet'	q̄'ore	къоре	req̄'o	рекъо
b.	'hat'	q̄'wapa	къвапа	paq̄'wa	пакъва
c.	'glove'	kwaɬ̄a	квалъа	ɬ̄akwa	лъаква
d.	'something'	hedjaʧ'e	гьедйач1е	ʧ'ehedja	ч1егьедйа

TABLE 4. Language game examples given to speakers.

I gave the speakers eleven words to perform the task on; examples are provided in Table 5.

		REAL WORDS		RESULTS	
	MEANING	IPA	CYRILLIC	IPA	CYRILLIC
a.	'nail'	haŋk'wa	гьанк1ва	k'wahã	к1вагьан
b.	'ashes'	ɬ̥'eχwa	кьехва	χwaɬ̥'e	хвакье
c.	'end'	baq̄ẽn	бахъен	q̄ẽnba	хъенба
d.	'clean!'	beχ̄wãn	бехxван	χ̄wãnbe	хxванбе
e.	'bottle'	ʃiʃaw	шишав	awʃiʃ	авшиш

TABLE 5. Sample of language game test items given to speakers.

The predictions made by the two competing hypotheses (given in 5 above) concerning the status of [Cw] sequences are presented in 13.

(13) Predictions: Given the word гьанк1ва in Table 5a,

a. if Karata speakers analyze [Cw] sequences as one phoneme, we expect them to derive the word к1вагьан, but

b. if Karata speakers analyze [Cw] sequences as sequences of two phonemes, we expect them to derive the word вагьанк1.

As can be seen in the last cell of Table 5a, speakers derived к1вагьан, as predicted by the labialized-consonant hypothesis. This is confirmed by example (b) in Table 5. Example (c) further shows that speakers have the intuition that nasalized vowels count as one segment, even though a remnant nasal consonant can still be perceived (at least to my ears). Example (d) contains a [Cw] sequence and a nasalized vowel; speakers treated those as one segment each. Finally, example (e) shows that my informants did not just take the last (whole) syllable and put it at the beginning of the word, since they treated the sequence [aw] as a sequence of two sounds. Both speakers responded in exactly the same way, as reported in Table 5. The results clearly indicate that a consonant followed by the labio-velar semivowel is treated by Karata speakers as one segment.

In conclusion, I take the distribution facts and the language-game results to support an analysis of [Cw] sequences as complex phonemes.

3.2. Stress. Both the existing grammar (Magomedbekova 1971) and the dictionary (Magomedova & Khalidova 2001) describe Karata as having lexical stress. However, it is not obvious at this point in my research that this is indeed the case. There are a few ways in which Karata's seeming lack of stress (in opposition to what is described in the dictionary and grammar) is plausible. First, it is not just the linguist writing these lines who has failed to hear stress; colleagues too have not heard any obvious stress system in the language (although, of course, their opinions are based on listening to (just) one text and minimal pairs). Second, while the dictionary (Magomedova & Khalidova 2001) indicates a stressed syllable for each word, there are clear inconsistencies. Third, verifications of reported minimal pairs (in the grammar and dictionary) and conversations with the second author of the dictionary, who is a native speaker of the language, point toward a situation different from that found in other Daghestanian languages and more specifically in the more closely related Andi languages,[14] namely, a situation where prosody seems to be entirely dependent on intonation. For these reasons, I do not indicate stress in this article, though it is not a settled issue.

3.3. Phonotactics. Phonotactic restrictions give rise to morphophonological 're-pair' processes when these restrictions would otherwise be violated. In the next section, I give more details about some of these processes. In this section I limit myself to giving examples of the phonotactic restrictions relevant to the phenomenon analyzed in this article.

Syllable structure. The maximal template is: CGVGC(C). Complex codas are found in loanwords, as in example 14g from Russian.

(14) List of syllable types and examples

	SYLLABLE TYPE	UNDERLYING FORM	SURFACE FORM	MEANING
a.	CV	hane	ha.ne	'village'
b.	CGV	dunjal	du.ɲal	'world'
c.	GV	j-ah^{w}a-e	ja.h^{w}eː	'she played'
d.	CVC	bert'in	ber.t'in	'cheese'
e.	CVG	w-oʒ-ud-o-w	wo.ʒu.dow	'trustful'
f.	CVGC	ʕajb	ʕajb	'guilt'
g.	CVCC	port	port	'harbor'

Restrictions on sequences of consonants across syllables. Sequences of labialized consonants in onset positions are generally not allowed (15).

[14] For instance, the grammar of Bagvalal (Kibrik 2001) describes a situation in which Bagvalal words are divided into three sets when it comes to their behavior with respect to stress: (i) words with a clearly emphasized syllable ('as in Russian', according to speakers); (ii) words with a less clearly emphasized syllable, which speakers call 'weak stress'; and (iii) words with no stress whatsoever. It is of course possible that a similar partition exists in Karata and that I have missed it or just happened to tap into class (iii) when working on accentual minimal pairs according to the Karata dictionary (Magomedova & Khalidova 2001).

(15) Sequences of labialized onsets are not allowed

	UNDERLYING FORM	SURFACE FORM
a. -ax̄ʷ˜- 'tie'		
Class I	w-ax̄ʷ˜-ai̯a	wax̄ãŋi̯a
Class II	j-ax̄ʷ˜-ai̯a	jax̄ʷãŋi̯a
Class III	b-ax̄ʷ˜-ai̯a	bax̄ʷãŋi̯a
Class IV	b-ax̄ʷ˜-ai̯a	bax̄ʷãŋi̯a
Class V	r-ax̄ʷ˜-ai̯a	rax̄ʷãŋi̯a
b. -ahʷa- 'play'		
Class I	w-ahʷa-ai̯a	wahaːi̯a
Class II	j-ahʷa-ai̯a	jahʷaːi̯a
Class III	b-ahʷa-ai̯a	bahʷaːi̯a
Class IV	b-ahʷa-ai̯a	bahʷaːi̯a
Class V	r-ahʷa-ai̯a	rahʷaːi̯a

Such sequences do, however, arise in words that seem to be the result of reduplication, as in onomatopoeia and so-called 'iterative' forms (16).

(16) Reduplicated words

UNDERLYING FORM	SURFACE FORM	MEANING
a. Onomatopoeic words		
q̄'ʷãq̄'ʷa	q̄'ʷãq̄'ʷa	'throat'
gʷãgʷa	gʷãgʷa	'rattle'
b. Iterative forms of verbs		
be-χʷa-χʷai̯a	beχʷaχʷai̯a	'pull several times'
ĩ-kʷa-kʷaːi̯a	ĩŋkʷakʷaːi̯a	'feed (lit. make eat) several times'
re-kʷa-kʷai̯a	rekʷakʷai̯a	'burn several times'

More research is needed to determine what exactly is reduplicated, but there is evidence that the reduplication process applies to the surface form of the corresponding nonreduplicated verb. Take the verb *-eχʷ-* 'pull' in Table 6, for instance. If the reduplicated form with class I prefix *w-* and imperfective suffix *-ida* is derived from the surface form [woχuda], then the correct form [woχuχuda] is predicted (row a). If, however, the reduplicated form is derived from the underlying form—/w-eχʷ-ida/—we predict a wrong reduplicated surface form *[woχoχuda] (row b).

	SOURCE OF DERIVATION		RESULT OF DERIVATION	
			UNDERLYING FORM	SURFACE FORM
a.	[woχuda]	→	/wo-χu-χuda/	[woχuχuda]
b.	/w-eχʷ-ida/	→	/w-eχʷ-eχʷ-ida/	*[woχoχuda]

TABLE 6. Two possible source forms for iterative reduplication.

RESTRICTIONS ON SEQUENCES OF VOWELS AND CONSONANTS. Generally, a round vowel cannot be followed by a labialized consonant, whether coda or onset (i.e. I have not found any examples of a round vowel followed by a labialized consonant). A glide (/w/ or /j/) or a labialized consonant (/Cʷ/) cannot be followed by a vowel that disagrees in place of articulation. In such a configuration, the (nonlow) vowel assimilates in place of articulation to the preceding segment. This is illustrated in 17 for /w/, and in 18 for /j/.[15]

[15] These examples also show that only underlying /u/ induces labialization of the following C when it delabializes, while neither unchanged underlying /u/ nor /o/ (unchanged or changed) does so (nor any other vowel).

(17) The glide [w] cannot be followed by a heterorganic vowel

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	w-ut-aɺ̞̊a	wutaɺ̞̊a	‘untie’
	w-uɺ̥̄’˜-aɺ̞̊a	wuɺ̥̄’ãŋɺ̞̊a	‘share, divide’
b.	w-oɺ̥̄-aɺ̞̊a	woɺ̥̄aɺ̞̊a	‘walk’
	w-oɺ̥̄’-aɺ̞̊a	woɺ̥̄’aɺ̞̊a	‘heat up, become hot’
	w-oɺ̥’-aɺ̞̊a	woɺ̥’aɺ̞̊a	‘be ill’
c.	w-ak’˜-aɺ̞̊a	wak’ãŋɺ̞̊a	‘bend’
	w-aɺ̥’-aɺ̞̊a	waɺ̥’aɺ̞̊a	‘get dressed’
d.	w-eʁã-aɺ̞̊a	woʁãːŋɺ̞̊a	‘win over, beat’
	w-eɺ̥’ara-aɺ̞̊a	woɺ̥’araːɺ̞̊a	‘get thinner’
e.	w-itʃa-aɺ̞̊a	wutʃaːɺ̞̊a	‘soak’
	w-iɺ̥’-aɺ̞̊a	wuɺ̥’aɺ̞̊a	‘die (an animal)’

(18) The glide [j] cannot be followed by a heterorganic vowel

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	j-ut-aɺ̞̊a	jit^{w}aɺ̞̊a	‘untie’
	j-uɺ̥̄’˜-aɺ̞̊a	jiɺ̥̄’^{w}ãŋɺ̞̊a	‘share, divide’
b.	j-oɺ̥̄-aɺ̞̊a	jeɺ̥̄aɺ̞̊a	‘walk’
	j-oɺ̥̄’-aɺ̞̊a	jeɺ̥̄’aɺ̞̊a	‘heat up, become hot’
	j-oɺ̥’-aɺ̞̊a	jeɺ̥’aɺ̞̊a	‘be ill’
c.	j-ak’˜-aɺ̞̊a	jak’ãŋɺ̞̊a	‘bend’
	j-aɺ̥’-aɺ̞̊a	jaɺ̥’aɺ̞̊a	‘get dressed’
d.	j-eʁã-aɺ̞̊a	jeʁãːŋɺ̞̊a	‘win over, beat’
	j-eɺ̥’ara-aɺ̞̊a	jeɺ̥’araːɺ̞̊a	‘get thinner’
e.	j-itʃa-aɺ̞̊a	jitʃaːɺ̞̊a	‘soak’
	j-iɺ̥’-aɺ̞̊a	jiɺ̥’aɺ̞̊a	‘die (an animal)’

The fact that labialized consonants cannot be followed by heterorganic vowels predicts that if a stem-final consonant is labialized as a result of the prefixation of the class II marker *j-*, for example, and this consonant precedes a suffixal nonlow short heterorganic vowel (/i/ or /e/), then this vowel is labialized. This is what we find, as 19 shows.

(19) Labialized consonants cannot be followed by a heterorganic vowel: -utʃ˜- ‘wash’

	UNDERLYING FORM	‘INTERMEDIATE’ FORM	SURFACE FORM
Class I	w-utʃ˜-ida	wutʃ˜-ida	wutʃĩnda
Class II	j-utʃ˜-ida	jitʃ^w˜-ida	jitʃũnda
Class III	b-utʃ˜-ida	butʃ˜-ida	butʃĩnda
Class IV	b-utʃ˜-ida	batʃ^w˜-ida	batʃũnda
Class V	r-utʃ˜-ida	ratʃ^w˜-ida	ratʃũnda

In 19, the prefixation of the class II, IV, and V markers delabializes the stem-initial vowel, which triggers the labialization of the following consonant, which in turn triggers the labialization of the suffix-initial vowel.[16]

[16] Consistent with what goes on in 19 is the situation in (i) with *-ah^{w}a-* ‘play’, found in the dictionary.

(i) Morphology of *-ah^{w}a-* ‘play’

	UNDERLYING FORM	‘INTERMEDIATE’ FORM	SURFACE FORM
Class I	w-ah^{w}a-ida	w-ah^{w}eda	wahoda
Class II	j-ah^{w}a-ida	j-ah^{w}eda	jahoda
Class III	b-ah^{w}a-ida	b-ah^{w}eda	bahoda
Class IV	b-ah^{w}a-ida	b-ah^{w}eda	bahoda
Class V	r-ah^{w}a-ida	r-ah^{w}eda	rahoda

Notice that in 19 and in 20c the back vowel /u/ after the class IV and V prefixes undergoes lowering to [a]. The same occurs with /o/ (20d). For the front vowels /i/ and /e/, the situation is diverse: some verbs undergo lowering (20a–b), while others do not (21).

(20) Plural class markers /b/ and /r/ trigger lowering of the stem-initial vowel

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	b-iχ̄ʷ-al̪̊a	baχ̄ʷal̪̊a	‘untie’
b.	r-ek̄ʷa-al̪̊a	rak̄ʷaːl̪̊a	‘die (an animal)’
c.	b-utʃ˜-al̪̊a	batʃʷãŋl̪̊a	‘bathe’
d.	r-oq̄-al̪̊a	raq̄al̪̊a	‘remove’

(21) Plural class markers /b/ and /r/ do not trigger lowering of the stem-initial vowel

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	r-iʃ˜-al̪̊a	riʃãŋl̪̊a	‘defeat’
b.	b-el̥̄’ã-al̪̊a	bel̥̄’ãːŋl̪̊a	‘cross’

In other words, if the verb-initial vowel is /i/ or /e/, it does or does not undergo lowering depending on the verb. But if the verb-initial vowel is /u/ or /o/, it always lowers to [a]. Two analyses are possible. First, two stems could be posited for the majority of verbs; the fact that some verbs’ initial vowel does not lower would then be explained. The other possible analysis is that there are two kinds of plural prefixes: plural *b*- and *r*- with a floating [+low] feature, and plural *b*- and *r*- with no such feature; each stem would also be specified for taking one or the other class marker. Deciding on one of these analyses is not crucial for this article.

3.4. Morphophonology. The consonant-labialization process this article is concerned with can potentially occur with any stem that can be prefixed with a class (alias gender) marker. There are two such types of stems: verb stems and (underived) adjective stems.[17] Not all stems can be prefixed; this information is lexically specified. Unfortunately, I have not (yet) found any examples of an (underived) adjective stem beginning with /u/, which might let us observe consonant labialization in stems that are not verbs.

The verb stem ends in the low vowel [a]. Suffixing the imperfective morpheme *-ida* would result in hiatus, but this is avoiding by merging the low vowel [a] and the high front vowel [i] into the central front vowel [e]. The labialized consonant then labializes this vowel into [o].

The imperfective form [ahoda] is given in the dictionary with a short [o] vowel, contrary to what I described earlier (i.e. the result of coalescence gives a long vowel). I do not know whether this is a typo or whether the vowel is indeed short. If the transcription is correct, then there must be some cases of coalescence that result in a short vowel. If, however, the transcription is wrong and coalescence always results in a long vowel, then we must explain why this long vowel here can become round whereas it does not in the perfective form of 11b. Notice though that, under the assumption that there has been a typo, the sequence /hʷeː/ in (i) would not be word-final, which would be consistent with what we observed earlier in 11b, namely that (long) /eː/ does not assimilate with a previous labialized consonant in word-final position but does everywhere else. Here again more research is needed.

[17] Most prefixable adjectives in Karata look like past/present participles, that is, forms derived from verbs (with the suffix *-o* and a suffixal class marker), as in 23. What is more, it sometimes happens that a verb has a cognate adjective (or a cognate noun). In that case it is difficult to decide whether the verb derives from the adjective (or the noun), or whether the adjective (or the noun) derives from the verb (see Pasquereau 2011). Here too more descriptive work is needed.

(22) Example of prefixable underived adjective: -eχ̄ela- 'long'[18]

	UNDERLYING FORM	SURFACE FORM
Class I	w-eχ̄ela-w	weχ̄elaw
Class II	j-eχ̄ela-j	jeχ̄elaj
Class III	b-eχ̄ela-b	beχ̄elab
Class IV	b-eχ̄ela-baj	beχ̄elabaj
Class V	r-eχ̄ela-raj	reχ̄elaraj

There are, however, few underived adjective stems, that is, adjectives that cannot be analyzed synchronically as being derived participial forms of verbs. But verbs stems are productively derived into participial forms[19] (used like adjectives), as in 23, and into so-called 'masdar' forms (24), in the Caucasian terminology, that is, derived nouns that retain some syntactic properties of the verb they are derived from, like case assignment. In these derived forms, too, the consonant-labialization phenomenon we are interested in is at work.

(23) Examples of prefixable words derived from prefixable verb stems: participles

a. boʟ̥̄aʟ̩̊a 'walk'

	UNDERLYING FORM	SURFACE FORM
Class I	w-oʟ̥̄-o-w	woʟ̥̄ow
Class II	j-oʟ̥̄-o-j	jeʟ̥̄oj
Class III	b-oʟ̥̄-o-b	boʟ̥̄ob
Class IV	b-oʟ̥̄-o-baj	baʟ̥̄obaj
Class V	r-oʟ̥̄-o-raj	raʟ̥̄oraj

b. butʃãʟ̩̊a 'bathe'

	UNDERLYING FORM	SURFACE FORM
Class I	w-utʃ˜-id-o-w	wutʃĩndow
Class II	j-utʃ˜-id-o-j	jitʃũndoj
Class III	b-utʃ˜-id-o-b	butʃĩndob
Class IV	b-utʃ˜-id-o-baj	batʃũndobaj
Class V	r-utʃ˜-id-o-raj	ratʃũndoraj

(24) Examples of prefixable words derived from prefixable verb stems: masdars

a. boʟ̥̄aʟ̩̊a 'walk'

	UNDERLYING FORM	SURFACE FORM
Class I	w-oʟ̥̄-e-r	woʟ̥̄er
Class II	j-oʟ̥̄-e-r	jeʟ̥̄er
Class III	b-oʟ̥̄-e-r	boʟ̥̄er
Class IV	b-oʟ̥̄-e-r	baʟ̥̄er
Class V	r-oʟ̥̄-e-r	raʟ̥̄er

[18] Past participles are derived from verbs by adding the suffix *-o* to the stem followed by a class marker, as in 23. I treat the adjective in 22 as underived because the vowel before the suffixal class marker is not /o/. Therefore it seems that *b-eχ̄ela-b* is not a participle derived from a verb. Furthermore, the verb 'get longer' is *b-eχ̄ela-ʟ̩̊-aʟ̩̊a*, with the *-ʟ̩̊-* morpheme used to derive verbs from adjective and nouns (Pasquereau 2011). This morpheme is likely historically derived from the verb *beʟ̩̊aʟ̩̊a* 'become'. If the adjective were derived from the verb, this suffix should have been kept in the derived form. In particular, notice that it IS kept in the masdar form of this verb *b-eχ̄ela-ʟ̩̊-er* 'length' (*b-eχ̄ela-r). It therefore seems that the sequence of derivation is adjective-verb-masdar, in this order, and that the adjective is not derived from the verb. Again, the status of this adjective as nonderived is predicated on the accuracy of the reasoning just exposed. It could be that what I take to be the base stem *-eχ̄ela-* is in fact *-eχ̄el-*, with the causative suffix *-a*. More research is needed here too.

[19] Participles all end in a class marker that is identical to the prefixal class marker, except the class IV and class V markers, which are, respectively, *-baj* and *-raj*; see Table 8 for more details.

b. buʧã̊ɬ̠a ‘bathe’

	UNDERLYING FORM	‘INTERMEDIATE’ FORM[20]	SURFACE FORM
Class I	w-uʧ˜-a-r	w-uʧan	wuʧan
Class II	j-uʧ˜-a-r	j-uʧan	jiʧʷan
Class III	b-uʧ˜-a-r	b-uʧan	buʧan
Class IV	b-uʧ˜-a-r	b-uʧan	baʧʷan
Class V	r-uʧ˜-a-r	r-uʧan	raʧʷan

Because clear, unambiguously underived adjectives are (pending more research) difficult to come by and because at the moment I do not have an example of one whose first vowel is /u/, I focus my discussion on verbs. There are two types of verbal stems in Karata: consonant-initial and vowel-initial (Table 7). There is a lexical distinction between vowel-initial stems that have a morphological slot for a gender prefix and those that do not. Verb stems in Karata are overwhelmingly monosyllabic (VC or CVC), occasionally bisyllabic, and rarely longer. Tense-aspect-mood markers are suffixed to the stem.

VOWEL-INITIAL STEMS				CONSONANT-INITIAL STEMS	
_-VC-		VC-		CVC-	
_-ah-	‘buy’	aba-	‘sprinkle’	barka-	‘congratulate’
_-iʁ-	‘stop’	ij-	‘attach’	bih˜-	‘heat up’
_-eʔ-	‘ripen’	er-	‘lean on’	beɬ̥̄’-	‘plow’
_-ut’-	‘hollow out’	urʁ-	‘miss’	bur-	‘rise’
_-oq̄’-	‘remove’	ob-	‘shake’	borʃ̄˜-	‘peel’

Table 7. Verb stems in Karata (underlying forms).

Karata has ergative alignment, and the prefix (for stems that have them) marks the class (a.k.a. gender) of the unmarked absolutive argument. In 25, the verb ‘play’ shows the agreement prefix for ‘nonhuman plural’, which is the class of the unique argument *mak’i* ‘children’. In 26, the absolutive argument is the patient *ʦ’ãt’ur* ‘plate’, the gender of which, neuter, is reflected in the verb prefix.

(25) Intransitive construction
mak’-i r-ah-oda idja.
child-PL nH+-play-IPF COP
‘The children are playing.’

(26) Transitive construction
den-a urʁeːda b-iʔʷ-aː ʦ’ãt’ur.
1SG-ERG on.purpose N-break-CAUS.PF plate
‘I broke the plate on purpose.’

As shown in Table 8 (and seen in previous examples), there are five classes, thus five class markers: masculine singular (M), feminine singular (F), neuter singular (N), human plural (H^+), and nonhuman plural (nH^+).

SINGULAR				PLURAL		
CLASS	MORPHEME	GLOSS		CLASS	MORPHEME	GLOSS
I	w-	M	male human }	IV	b-, -b(aj)	H+
II	j-	F	female human }			
III	b-	N	remainder	V	r-, -r(aj)	nH+

Table 8. Class markers.

[20] The floating nasal feature docks on /r/, turning it into [n], which is very common.

As we have already seen, nonlow stem-initial vowels undergo a number of assimilation processes depending on the class marker that precedes them. Vowels following the class I marker *w*- are rounded, those following the class II marker *j*- are unrounded, and those following the class IV and V markers *b*- and *r*- are lowered to [a] with some verbs.[21] Because only the neuter singular marker *b*- (class III) can be followed by any of the five vowel qualities (Tables 9–10), the form of the verb stem following this marker is taken to be its underlying form. It is worth noting that the class III or singular neuter form is the citation form in the dictionary (Magomedova & Khalidova 2001). Prefixable stems never appear on their own without a class marker prefix.

	‘lay’	‘wilt’	‘clean’	‘untie’	‘appear’
	-il̪̊-	-eʧ’˜-	-aʦ̄’a-	-ut-	-oχ̄-
Class I	wul̪̊al̪̊a	woʧ’ãŋl̪̊a	waʦ̄’aːl̪̊a	wutal̪̊a	woχ̄al̪̊a
Class II	jil̪̊al̪̊a	jeʧ’ãŋl̪̊a	jaʦ̄’aːl̪̊a	jitʷal̪̊a	jeχ̄al̪̊a
Class III	bil̪̊al̪̊a	beʧ’ãŋl̪̊a	baʦ̄’aːl̪̊a	butal̪̊a	boχ̄al̪̊a
Class IV	bal̪̊al̪̊a	baʧ’ãŋl̪̊a	baʦ̄’aːl̪̊a	batʷal̪̊a	baχ̄al̪̊a
Class V	ral̪̊al̪̊a	raʧ’ãŋl̪̊a	raʦ̄’aːl̪̊a	ratʷal̪̊a	raχ̄al̪̊a

TABLE 9. Prefixable VC(V) stems.

	‘stay’	‘be’	‘play’	—	—
	-ixʷ-	-ek̄ʷ-	-ahʷa-	—	—
Class I	wuxal̪̊a	wok̄al̪̊a	wahaːl̪̊a	—	—
Class II	jixʷal̪̊a	jek̄ʷal̪̊a	jahʷaːl̪̊a	—	—
Class III	bixʷal̪̊a	bek̄ʷal̪̊a	bahʷaːl̪̊a	—	—
Class IV	baxʷal̪̊a	bak̄ʷal̪̊a	bahʷaːl̪̊a	—	—
Class V	raxʷal̪̊a	rak̄ʷal̪̊a	rahʷaːl̪̊a	—	—

TABLE 10. Prefixable VCʷ(V) stems.

In nonprefixable verb stems, the labialized consonant will only interact with suffixed morphemes (as described in §3.1).

(27) Nonprefixable VC(ʷ) stems

VC		VCʷ	
ital̪̊a	‘let’	ixʷaʧal̪̊a	‘feed’
eral̪̊a	‘freeze’	—	
ahãŋl̪̊a	‘boil’	ãʁʷaːl̪̊a	‘deafen’
urʁaːl̪̊a	‘think’	—	
obal̪̊a	‘shake’	—	

(28) Nonprefixable CVC(ʷ) stems

CVC		CVCʷ	
miʦ̄’aːl̪̊a	‘sweeten’	mik’ʷaːl̪̊a	‘reduce’
l̪̊’emaːl̪̊a	‘enlarge’	l̪̊’ek’ʷaːl̪̊a	‘economize’
gahal̪̊a	‘do’	gãːʁʷãŋl̪̊a	‘tighten’
gural̪̊a	‘bend’	—	
goʧal̪̊a	‘roam’	—	

Other nonprefixable verb stems are longer than just one syllable. There too, depending on whether the final consonant is labialized (29) or not (30), suffixes undergo assimilation.

[21] As noted above, which verbs get their initial vowel lowered when combined with these prefixes seems to be lexically specified.

(29) ʁiziχ̄ʷaʟ̟̊a ‘get dirty’

	UNDERLYING FORM	SURFACE FORM
future	ʁiziχ̄ʷ-as̄	ʁiziχ̄ʷas̄
imperfective	ʁiziχ̄ʷ-ida	ʁiziχ̄uda
perfective	ʁiziχ̄ʷ-i	ʁiziχ̄u
imperative	ʁiziχ̄ʷ-i	ʁiziχ̄u

When the verb root ends in a nonlabialized consonant, the suffixes are transparently added (30).

(30) reʟ̟̊eχ̄aʟ̟̊a ‘smile’

	UNDERLYING FORM	SURFACE FORM
future	reʟ̟̊eχ̄-as̄	reʟ̟̊eχ̄as̄
imperfective	reʟ̟̊eχ̄-ida	reʟ̟̊eχ̄ida
perfective	reʟ̟̊eχ̄-a	reʟ̟̊eχ̄a
imperative	reʟ̟̊eχ̄-i	reʟ̟̊eχ̄i

3.5. Conclusion and summary. When an underlying stem-initial round vowel has lost its round specification as a result of assimilation to the class prefix, its round feature reassociates to the next consonant. This reassociation happens only if the round feature comes from a vowel that is underlyingly high (i.e. /u/), as in 31–32.

(31) The adjacent consonant is labialized

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	j-uʧ˜-aʟ̟̊a	jiʧʷãŋʟ̟̊a	‘bathe’
b.	j-uʧ’ã-aʟ̟̊a	jiʧ’ʷãːŋʟ̟̊a	‘open’
c.	j-ut-aʟ̟̊a	jitʷaʟ̟̊a	‘untie’
d.	j-uʟ̥̄’˜-aʟ̟̊a	jiʟ̥̄’ʷãŋʟ̟̊a	‘share’

(32) The adjacent consonant remains unlabialized

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	j-oχ̄a-aʟ̟̊a	jeχ̄aːʟ̟̊a	‘thrust’
b.	j-oq̄-aʟ̟̊a	jeq̄aʟ̟̊a	‘remove’
c.	j-oχ̄-aʟ̟̊a	jeχ̄aʟ̟̊a	‘appear’
d.	j-oʟ̥̄’-aʟ̟̊a	jeʟ̥̄’aʟ̟̊a	‘warm up’

As 31d and 32d show, the difference in labialization patterns does not seem to be due to the consonant itself (though see n. 6 above). Furthermore, as shown above in §3.1, any nonlabial consonant can be labialized.

I therefore conclude that the only correlate of the possibility to labialize a consonant is the height of the vowel that precedes the consonant. When preceded by the palatal glide, the round feature of the high round vowel /u/ is detached and further reassociates to the adjacent consonant. While the round feature of the mid round vowel /o/ is also detached, however, it does not reassociate to the following consonant. In the remainder of this article, I propose a theoretical account of this phenomenon and motivate the existence of scalar [labial] features.

4. An optimality-theoretic analysis.

4.1. Some representational assumptions.

Feature geometry. I assume Clements and Hume’s (1995) unified feature-geometric representation for both consonants and vowels. In Figure 1, the phoneme /k/ has a C(onsonantal)-place node specified for the [dorsal] articulation. The phoneme /u/ has a C-place node specified for a vocalic articulation only; the vocalic node contains an aperture node specifying the degree to which the oral cavity is closed and a V(ocalic)-place node specifying the place of articulation of the vowel, here [dorsal] and [labial].

The complex segment /k^w/, which has a secondary articulation, contains both a place feature for the C-place articulation and a vocalic node. I discuss the aperture node below and the feature [labial*x*] in §5.

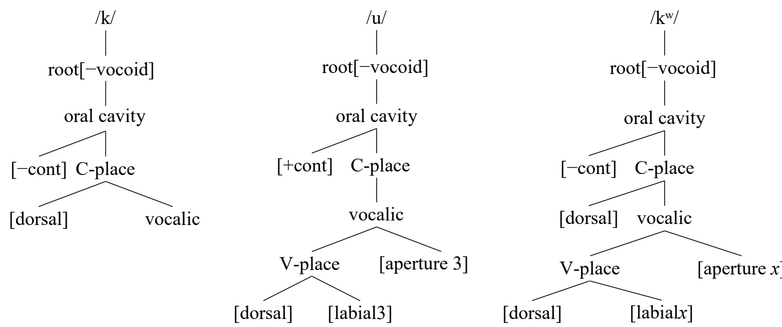


FIGURE 1. Feature-geometric representations of /k/, /u/, and /k^w/ in Karata (cont = continuant).[22]

The insight of such a representation is that vowels and consonants use the same constriction places. There are two kinds of features: place features are privative, whereas [±continuant] and [±sonorant], for instance, are binary.

The major articulation in any complex consonant is interpreted with the values of the stricture features [continuant, approximant, sonorant] present in the higher structure, and the minor articulation is assigned its noncontrastive degree of closure by independent phonetic rules and principles. In other words, when the C-place node has a place specification, the degree of closure indicated by the aperture node is purely phonetic, as opposed to segments in which the C-place node has no place specification, where the aperture node indicates contrastive degrees of closure.

VOWEL HEIGHT. I adopt a simplified version of Clements's view of vowel height (Clements 1991, Clements & Hume 1995). I first present Clements's system as developed to account for four-height vowel systems and assimilatory vowel raising in terms of autosegmental spreading. I then show the simplified version I adopt in my analysis.

Clements's theory of vowel height. Clements proposes a new formalization of vowel height in terms of the APERTURE of the oral cavity. To express various degrees of vowel height, the bivalent feature [±open] is arrayed on several rank-ordered tiers (or registers), as Figure 2 illustrates. Vowel height is thus characterized along a uniform phonetic and phonological dimension in a way that direct-realism theories like articulatory phonology advocate.

Natural classes are defined in terms of feature values on each tier: low vowels are those that are [+open] on tier 1; high vowels are [−open] on tier 2. Three-height vowel systems have two tiers, as in Figure 3, whereas four-height vowel systems have three such tiers. Such a system does away with the traditional [±high] and [±low] features, which make the false predictions that the combination [+high][+low] should pick out a natural class of vowels. It also eliminates the use of [±ATR] to describe four-height vowel systems.

[22] An anonymous referee asked whether the aperture node of /k^w/ in Fig. 1 should be 'aperture 3'. The answer I give to this question is 'no' because I do not make the claim that the degree of aperture of the secondary articulation of labialized consonants in Karata is phonologically specified. Likewise, I assume that the labial feature in the V-place node of a consonant is not specified. Rather, I assume that labialized consonants, having a primary place of articulation, have unspecified aperture for their secondary articulation.

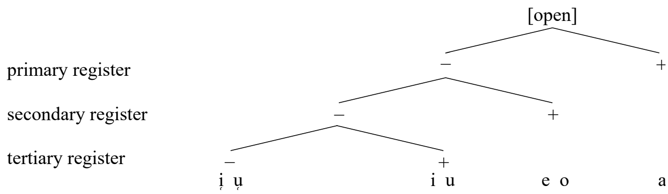


FIGURE 2. Vowel height (adapted from Clements 1991:27, figure 1).

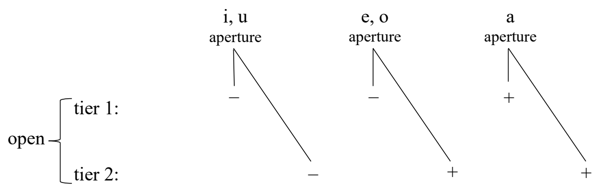


FIGURE 3. A three-height vowel system (adapted from Clements 1991:28, ex. 4).

Thus, Clements's representation of the high back round vowel /u/ in a three-height vowel system like Karata's is as in Figure 4.

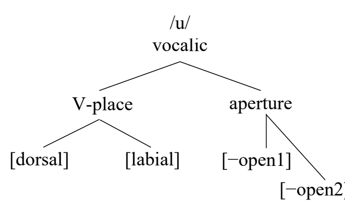


FIGURE 4. Representation of a high back round vowel /u/ in Clements's (1991) three-height vowel system.

In a system such as Clements's, each set of [±open] features corresponds to one vowel height, that is, to one degree of aperture. I make this explicit by numerically marking the aperture node with a degree index. Karata vowels are represented as in Table 11.

	i u	e o	a
[open] tier 1	−	−	+
[open] tier 2	−	+	+
	aperture 3	aperture 2	aperture 1

TABLE 11. Karata vowels in the Clements 1991 system.

Assuming Clements's system, to posit an index on the aperture node is redundant but remains consistent with his approach. It also makes sense articulatorily if we take 'aperture' as referring to the degree to which the oral cavity is closed as a function of the jaw position. In the remainder of this article, I do not represent the [±open] features below the aperture node.

(33) Representation of the degrees of vocalic aperture in Karata

aperture 3	i	u
aperture 2	e	o
aperture 1	a	

In this language, if a vowel has a [labial] feature (i.e. a round vowel), I propose that the [labial] feature agrees in degree with that vowel's aperture node (see Figure 5).

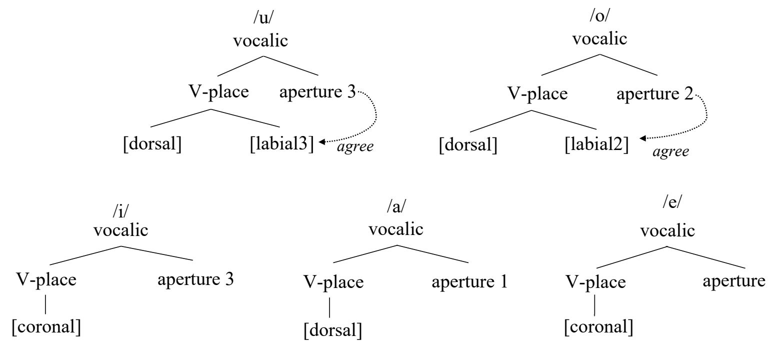


FIGURE 5. Representation of the degrees of vocalic aperture in Karata; top: rounded/labial vowels; bottom: unrounded vowels.

To enforce agreement between the aperture degree and the [labial*x*] feature, I posit the markedness constraint in 34. This constraint, like all other constraints in optimality theory, is violable, and languages differ in how high or low they rank it.

(34) ANTI-MISMATCH constraint: $*ap(erture)_{\alpha}/lab(ial)_{\neg\alpha}$: Assign a violation mark to each output rootnode that is linked to an aperture node and a labial feature that disagree in value.

$*\text{aperture}_{\alpha}$
|
x
|
$\text{labial}_{\neg\alpha}$

Kaun (1995) uses a constraint that might appear at first sight to be similar, which she calls the UNIFORMITY CONSTRAINT.

(35) UNIFORM[RD]: The autosegment [+round] may not be multiply linked to vowel positions that are distinctly specified for height.

Kaun is concerned with rounding harmony, and she does not assume that [labial] or [+round] may have different phonological degrees.[23] The constraint UNIFORM[RD] thus says nothing about individual vowels taken separately: it is only violated once the [+round] feature is linked to more than one vowel. The violable ANTI-MISMATCH constraint used in my analysis makes a broader claim: a [labial*x*] feature, whatever its degree, may only be linked to one or several vowels whose aperture degree matches the labial degree. That is, it regulates any linkage between a [labial*x*] feature and a segment specified for aperture. While this constraint is necessary for my analysis, no crucial candidate ever violates it, so it does not appear in the tableaux below.

4.2. ANALYSIS. My analysis is couched in OPTIMALITY THEORY (OT; Prince & Smolensky 1997). Specifically, I assume a cyclic application of OT (Kiparsky 2000). The same grammar applies first to roots (cycle 1), then to derived/inflected forms (cycle 2): each time a morpheme is added to a stem, the resulting form is evaluated.

I also assume that feature geometry is the result of restrictions on how GEN combines features. The GEN module produces candidate sets from an input by arranging features

[23] In fact, Kaun explicitly considers recognizing different [+round] features and rejects this possibility on account of the round vowels behaving as a natural class whatever their height. While Kaun's concern is reasonable, recognizing different [labial] features does not, in my opinion, challenge the idea of a round-vowel natural class; it just says that within this natural class there are smaller natural classes.

according to a supposedly universal pattern. As mentioned above, I only consider candidates whose [labial*x*] degree and aperture degree agree. I assume the inputs in Table 12 for cycle 2, and I explain later below how those inputs are obtained from cycle 1.

ik	ikʷ			uk	—
ek	ekʷ			ok	—
		ak	akʷ		

TABLE 12. Outputs of cycle 1/inputs to cycle 2.

ANALYSIS OF CONSONANT LABIALIZATION.

Assimilation is spreading and delinking. The nonround, nonlow vowels /i/ and /e/ become round and back when they are preceded by the masculine class marker /w/,[24] as in 36–37. The low vowel /a/ does not assimilate (38).

(36) The sequence /w-i/ becomes [wu]

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	w-il̝̊-al̝̊a	wul̝̊al̝̊a	‘lay’
b.	w-iʁ-al̝̊a	wuʁal̝̊a	‘stop’
c.	w-ik̄-al̝̊a	wuk̄al̝̊a	‘hold’
d.	w-is˜-al̝̊a	wusãŋl̝̊a	‘find’

(37) The sequence /w-e/ becomes [wo]

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	w-eʧ’˜-al̝̊a	woʧ’ãŋl̝̊a	‘shed hair’
b.	w-el̝̊-al̝̊a	wol̝̊al̝̊a	‘drive, walk something’
c.	w-ek̄-al̝̊a	wok̄al̝̊a	‘give’
d.	w-el̥̄’ã-al̝̊a	wol̥̄’ãːŋl̝̊a	‘cross’

(38) The low vowel /a/ does not assimilate

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	w-at̄s’a-al̝̊a	wat̄s’aːl̝̊a	‘clean’
b.	w-ahʷa-al̝̊a	wahaːl̝̊a	‘play’
c.	w-aʒara-al̝̊a	waʒaraːl̝̊a	‘manage’
d.	w-aʁ-al̝̊a	waʁal̝̊a	‘crumble’

The prefixation of the feminine singular class marker /j/ to a stem beginning with a rounded vowel triggers the delabialization of the vowel and its concomitant fronting, as in 39–40. The low vowel /a/ does not assimilate (41).

(39) The sequence /j-u/ becomes [ji]

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	j-uʧ˜-al̝̊a	jiʧʷãŋl̝̊a	‘bathe’
b.	j-uʧ’ã-al̝̊a	jiʧ’ʷãːŋl̝̊a	‘open’
c.	j-ut-al̝̊a	jitʷal̝̊a	‘untie’
d.	j-uʦa-al̝̊a	jiʦʷaːl̝̊a	‘knead’

(40) The sequence /j-o/ becomes [je]

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	j-oχ̄a-al̝̊a	jeχ̄aːl̝̊a	‘thrust’
b.	j-oq̄-al̝̊a	jeq̄al̝̊a	‘remove’
c.	j-oχ̄-al̝̊a	jeχ̄al̝̊a	‘appear’
d.	j-oʔ˜-al̝̊a	jeʔãŋl̝̊a	‘go’

[24] The spreading of the labial feature of /w/ to the vowels produces a violation of the ANTI-MISMATCH constraint (if we assume that /w/ is [labial3] and /o/ is aperture 2). I show later in the article that this violation is not fatal because it avoids the violation of a higher-ranked constraint.

(41) The low vowel /a/ does not assimilate

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	j-at͡s’a-aʟ̝̊a	jat͡s’aːʟ̝̊a	‘clean’
b.	j-aʔ-aʟ̝̊a	jaʔaʟ̝̊a	‘reach’
c.	j-aʃa-aʟ̝̊a	jaʃaːʟ̝̊a	‘count’
d.	j-aʧ-aʟ̝̊a	jaʧaʟ̝̊a	‘tidy up’

We can schematically summarize this pattern as in 42.

(42) /j-u/ → [ji] ≻ *[ju]
/w-i/ → [wu] ≻ *[wi]

In Karata an onset C with a V-place node (i.e. /j/, /w/, or /C^w/) cannot be followed by a nucleus whose V-place node is different (Figure 6).

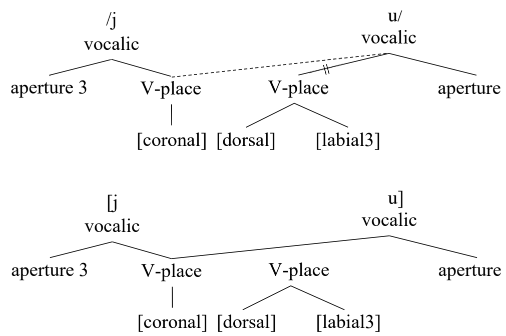
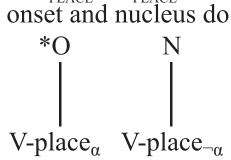


FIGURE 6. Place assimilation of verb-initial vowel to class marker.

To enforce this assimilation, I posit the markedness constraint $*O_{\alpha_{PLACE}}N_{\neg\alpha_{PLACE}}$, defined in 43. Undominated faithfulness constraints ensure that the initial class marker surfaces faithfully.

(43) $*O_{\alpha_{PLACE}}N_{\neg\alpha_{PLACE}}$ ($*O_{\alpha}N_{\neg\alpha_{PLACE}}$): Assign a violation mark to a syllable whose onset and nucleus do not share the same V-place node in the output.



Consonant labialization is the phonological process of docking the feature [labial*x*] to the next root node. The effect of docking a feature is thus the creation of an association line in the output that does not exist in the input. I posit the faithfulness constraint in 44.[25] This constraint applies to all labial features. Every time a feature [labial*x*] is linked to a root node to which it is not linked in the input, this constraint is violated.

[25] Other constraints could be posited to penalize spreading of the feature [labial*x*]. Two ideas come to mind. First, as I showed in Fig. 1, simplex consonants do not have an aperture node. A labialized consonant, however, must have an aperture node. Because in Karata labialization is only spreading of the feature [labial3], an aperture node—or rather [±open] features—must be epenthesized. A constraint forbidding the epenthesis of such features would de facto penalize the creation of a labialized consonant, thus having the same effect as IDENT-OI[labial*x*]. In fact, as mentioned in §4.1, the aperture node of a secondary constriction is ‘assigned its non-contrastive degree of closure by independent phonetic rules and principles’ (Clements & Hume 1995: 288). Second, it could be the case that a markedness constraint prevents the creation of complex consonants. For instance, some studies make use of the constraint *Cw. In the current framework, *Cw is a constraint that penalizes any consonant having a vocalic node containing [labial3] or [labial2]. But positing such a general constraint in Karata makes the prediction that labialized consonants should only be the result of the morpho-

(44) IDENT-OI[labial*x*]: Assign a violation mark for every link between a [labial*x*] feature and a segment in the output that is not present in the input.

Assimilation of a vowel to its preceding glide is obligatory, even if it involves spreading a [labial*x*] feature.

(45) $*O_{\alpha}N_{\neg\alpha_{PLACE}}$ >> IDENT-OI[labial*x*]

/w i ʧ/ (w linked to [lab3])	$*O_{\alpha}N_{\neg\alpha_{PLACE}}$	IDENT-OI[labial*x*]
a. ☞ w u ʧ (w and u linked to [lab3])		*
b. w i ʧ (w linked to [lab3])	*W	L

The prefixation of a plural class marker containing a vocalic floating node specified for aperture 1 docks on the following vowel, turning it into the only aperture 1 vowel that the language has (Figure 7).

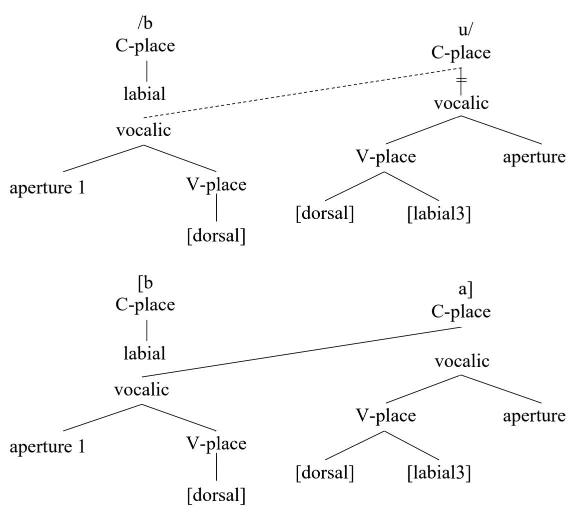


FIGURE 7. Docking of the human plural class marker's floating vocalic node onto the stem-initial vowel.

More generally, it is the case that floating features in Karata have to be realized phonetically.[26] I use the constraint in 46, which is undominated.

(46) MAXFLOAT (Wolf 2007): Assign a violation mark to each feature that is floating in the input and not present in the output.

phonological process this article is giving an account of, but this is not the case since Karata has labialized phonemes. Another solution would be to have a more specific markedness constraint: one that penalizes labialized consonants whose labial feature has value 2, *C[labial2]. I discuss this possibility in §6.1.

[26] As noted previously, a few Karata verbs and adjectives have a nasal floating feature that docks preferably on heteromorphic /b, l, r/ or on the closest heteromorphic vowel.

(47) MaxFloat >> Ident-OI[labial*x*]

/b u ʧ/ [ap1] [lab3]	MaxFloat	Ident-OI[labial*x*]
a. ☞ /b a ʧʷ/ [ap1] [lab3]		*
b. /b u ʧ/ ~~[ap1]~~ [lab3]	*W	L

Only a certain type of [labial*x*] feature reassociates. The round vowels /u/ and /o/ (48–49, repeated from 31–32 above) become unrounded as a result of their assimilation in place of articulation with the preceding palatal glide /j/. A delinked labial feature reassociates to the following consonant only if it comes from a high vowel, as in 48.

(48) The adjacent consonant is labialized

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	j-uʧ˜-aʟ̝̊a	jiʧʷãŋʟ̝̊a	'bathe'
b.	j-uʧ'ã-aʟ̝̊a	jiʧ'ʷãːŋʟ̝̊a	'open'
c.	j-ut-aʟ̝̊a	jitʷaʟ̝̊a	'untie'
d.	j-uʟ̥̄'˜-aʟ̝̊a	jiʟ̥̄'ʷãŋʟ̝̊a	'share'

(49) The adjacent consonant remains unlabialized

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	j-oχ̄a-aʟ̝̊a	jeχ̄aːʟ̝̊a	'thrust'
b.	j-oq̄-aʟ̝̊a	jeq̄aʟ̝̊a	'remove'
c.	j-oχ̄-aʟ̝̊a	jeχ̄aʟ̝̊a	'appear'
d.	j-oʟ̥̄'-aʟ̝̊a	jeʟ̥̄'aʟ̝̊a	'warm up'

As shown in 48d and 49d and discussed above, the difference in labialization pattern is not due to the consonant. In fact, this would have been surprising since, as shown above in §3.1, any nonlabial consonant can be labialized. The only correlate of labialization is the height of the vowel. The pattern can be summarized as in 50.

(50) a. /j-uC/ → [jiCʷ] ≻ *[jiC]
     b. /j-oC/ → [jeC] ≻ *[jeCʷ]

As we have seen, when preceded by the palatal glide, the round feature of the round vowels /u/ and /o/ is detached, but only that of the high vowel /u/ reassociates to the adjacent consonant. In the proposed framework, this means that only [labial3] reassociates to the following consonant, whereas [labial2] deletes; see Figure 8.

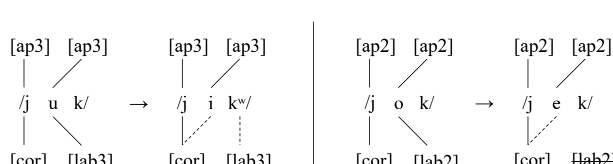


Figure 8. [labial3] reassociates while [labial2] deletes.

We want the constraints enforcing relinking of [labial3] to be ranked above the constraints prohibiting relinking, and the constraints enforcing relinking of [labial2] to be ranked below. The conservation of [labial3] over [labial2] is ensured by a faithfulness constraint that assigns a violation mark specifically if [labial3] is deleted (51). In fact, I argue that there is a universal hierarchy Max[labial3] >> Max[labial2] >> Max[labial1] (see §5.4).

(51) Max[labial3]: Assign a violation mark for every [labial3] feature that is not present in the output.

Tableau 52 shows that it is better to preserve [labial3] and create a new association line than to delete it.

(52) Max[labial3] >> Ident-OI[labial*x*]

/j u ʧ/ (ʧ linked to [lab3])	Max[labial3]	Ident-OI[labial*x*]
a. ☞ j i ʧʷ (ʧʷ linked to [lab3])		*
b. j i ʧ ~~[lab3]~~	*W	L

It is better to delete a labial feature that is not specified for degree 3 than allow it to dock. A [labial2] feature will delete, as in 53.

(53) /j-oχ̄ai̥̯a/ 'appear'
[jeχ̄ai̥̯a] ≻ *[jeχ̄ʷai̥̯a]

In tableau 54, it is better to delete [labial2] than to create an association line.

(54) Ident-OI[labial*x*] >> Max[labial2]

/j o ʧ/ (o linked to [lab2])	Ident-OI[labial*x*]	Max[labial2]
a. j e ʧʷ (ʧʷ linked to [lab2])	*W	L
b. ☞ j e ʧ ~~[lab2]~~		*

It is never the case that a floating feature in Karata remains floating in the output. Therefore, I use a constraint to penalize the existence of a floating feature/node in the output: *Float (Wolf 2007).

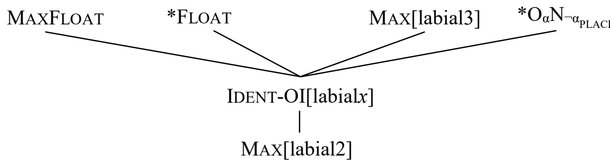
(55) *Float: Assign a violation mark to each feature that is floating in the output.

(56) *Float >> Ident-OI[labial*x*]

/j u ʧ/ (u linked to [lab3])	*Float	Ident-OI[labial*x*]
a. ☞ j i ʧʷ (ʧʷ linked to [lab3])		*
b. j i ʧ [lab3]	*W	L

I recapitulate the ranking arguments obtained so far with the Hasse diagram in 57.

(57) Hasse diagram



The following tableaux summarize the analysis so far.

(58) /j-uʧ/ → [jiʧʷ] summary

/j u ʧ/ [lab3]	MaxFl	*$O_\alpha N_{\neg\alpha_{\text{PLACE}}}$	Max[lab3]	*Float	Id-OI[lab*x*]	Max[lab2]
a. ☞ j i ʧʷ [lab3]					*	
b. j i ʧ [lab3]				*W	L	
c. j i ʧ ~~[lab3]~~			*W		L	
d. j u ʧ [lab3]		*W			L	

(59) /j-oʧ/ → [jeʧ] summary

/j o ʧ/ [lab2]	MaxFl	*$O_\alpha N_{\neg\alpha_{\text{PLACE}}}$	Max[lab3]	*Float	Id-OI[lab*x*]	Max[lab2]
a. j e ʧʷ [lab2]					*	L
b. j e ʧ [lab2]				*W		L
c. ☞ j e ʧ ~~[lab2]~~						*
d. j o ʧ [lab2]		*W				L

(60) /b-uʧ/ → [baʧʷ] summary

/b u ʧ/ [ap1] [lab3]	MaxFl	*$O_\alpha N_{\neg\alpha_{\text{PLACE}}}$	Max[lab3]	*Float	Id-OI[lab*x*]	Max[lab2]
a. b u ʧ [ap1] [lab3]				*W	L	
b. b u ʧ ~~[ap1]~~ [lab3]	*W				L	

(*tableau continues*)

/b u ʧ/ [ap1] [lab3]	MaxFl	$*O_\alpha N_{\neg\alpha_{PLACE}}$	Max[lab3]	*Float	Id-OI[lab*x*]	Max[lab2]
c. ☞ b a ʧʷ [ap1] [lab3]					*	
d. b a ʧ [ap1] ~~[lab3]~~			*W		L	

(61) /w-eʧ/ → [woʧ] summary

[ap2] /w e ʧ/ [lab3]	MaxFl	$*O_\alpha N_{\neg\alpha_{PLACE}}$	Max[lab3]	*Float	Id-OI[lab*x*]	Max[lab2]
a. ☞ [ap2] w o ʧ [lab3]					*	
b. [ap2] w e ʧ [lab3]		*W			L	

(62) /j-iʧʷ/ → [jiʧʷ] summary

/j i ʧʷ/ [lab3]	MaxFl	$*O_\alpha N_{\neg\alpha_{PLACE}}$	Max[lab3]	*Float	Id-OI[lab*x*]	Max[lab2]
a. ☞ j i ʧʷ [lab3]						
b. j i ʧ [lab3]				*W		
c. j i ʧ ~~[lab3]~~			*W			

Analysis of labial dissimilation. In §3.3, we saw that Karata has a phonotactic restriction against two subsequent labialized onsets (63).

(63) Two labial onsets in a row are forbidden: the second dissimilates

	UNDERLYING FORM	SURFACE FORM	MEANING
a.	w-it'ʷ-aɬ̥a	wut'aɬ̥a	'collapse'
b.	w-eʒʷ-aɬ̥a	woʒaɬ̥a	'believe'
c.	w-aʧʷ-aɬ̥a	waʧaɬ̥a	'destroy'

The constraint in 64 will penalize such sequences.

(64) $*(OO)_{labialx}$: Assign a violation mark to each output sequence of two onsets whose V-place contains a [labial*x*] feature.

$*O_{\sigma_n}$ $O_{\sigma_{n+1}}$

[labial*x*] [labial*x*]

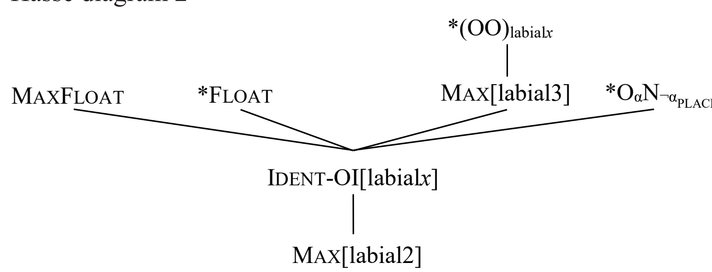
Tableau 65 shows that this constraint dominates all MAX[labial*x*] constraints.

(65) *(OO)$_{labialx}$ >> MAX[labial3]

/w a ʧʷ/ | | [lab3] [lab3]	*(OO)$_{labialx}$	MAX[labial3]
a. ☞ w a ʧ | [lab3] ~~[lab3]~~		*
b. w a ʧʷ | | [lab3] [lab3]	*W	L

MAXFLOAT, *FLOAT, and *O$_α$N$_{¬α_{PLACE}}$ never conflict with MAX[labial3] over the choice of the winner. Since [labial3] is never floating in the input, these constraints never interact.

(66) Hasse diagram 2



LABIALIZATION AND RICHNESS OF THE BASE. I have presented and argued for a particular analysis of the labialization facts of Karata: consonant labialization occurs only as a result of vowel delabialization. Karata has contrastive [labial*x*] features, and there is more faithfulness to more extreme degrees of labialization. Thus it is never the case that [labial2] docks on a consonant; this is why delabialization of /o/ never triggers labialization of the following consonant, contrary to delabialization of /u/. Crucially, this account assumes that there are no underlying vowel-initial verb stems whose initial vowel is round and followed by a labialized consonant (i.e. *uCʷ, *oCʷ).[27] However, in an optimality-theoretic framework where no restriction can be posited on the set of inputs to the grammar, language-specific patterns have to fall out from the constraints used.

In what follows I show that if we assume a cyclic version of OT, whereby the grammar applies cyclically 'as the word is built', then we can naturally (i.e. using only independently needed constraints) derive that Karata does not have verb stems of the form /uCʷ/, /oCʷ/ without restricting the set of possible inputs. Furthermore, I show that cyclic OT must be used, because keeping to a noncyclic grammar overgenerates.

Cycle 1. This section aims to show how the grammar presented earlier in §4.2 handles RICHNESS OF THE BASE (i.e. how we derive the fact that Karata has no underlying verb stems of the form /uCʷ/, /oCʷ/ without actually restricting the set of inputs to the grammar). The set of verb stems input to cycle 2 (Table 12 above) falls out from the phonotactic restrictions if we assume a cyclic version of OT, in which the grammar applies cyclically to successively larger constituents. In other words, every time a mor-

[27] As noted previously, Karata provides no positive evidence that there are sequences like /uCʷ/ and /oCʷ/, and negative evidence confirms that they are not allowed in the language.

pheme has been added, Eval generates output candidates from that new form. As far as verbs are concerned, I assume that, at cycle 1, the grammar applies to bare stems; at cycle 2 (presented above), it applies to the prefixed stems.

In Karata, a labial vowel can never be followed by a labialized consonant. This restriction is formalized in 67.

(67) $*V_{[labialx]}C_{[labialx]}$: Assign a violation mark to a sequence of adjacent labial vowel and consonant.

*[+vocoid] [–vocoid]
| |
[labial*x*] [labial*x*]

This constraint could be satisfied by any of the following changes: (i) delabialization of the vowel, (ii) delabialization of the consonant, or (iii) both. In fact, there is good evidence that change (ii) is chosen to satisfy the undominated $*V_{[labialx]}C_{[labialx]}$ constraint (see the tableau in 65).

We have seen evidence that Karata applies greater faithfulness to the initial segment of an input. For instance, $*O_{\alpha}N_{\neg\alpha_{PLACE}}$ is satisfied by changing the V-place specification of the vowel following the initial phoneme and never by changing the V-place of the class marker. In the input /juC/, $*O_{\alpha}N_{\neg\alpha_{PLACE}}$ is satisfied by remaining faithful to the feminine class marker /j/ (68).

(68) /j-uC/ → [jiC^w] ≻ *[wuC]

I posit the undominated constraints in 69 and 70 to enforce faithfulness to the initial segment of an input.

(69) Max#V-place: Assign a violation mark to an input-initial V-place node if the same V-place node is not present in the output.

(70) Ident#V-place: Assign a violation mark to an input-initial root node linked to a V-place node if its corresponding output rootnode is linked to a different V-place node.

Given these constraints, when the grammar applies to stems containing a round V followed by C^w, the winning candidate is one in which the C has been delabialized.

(71) Ident#V-place, Max#V-place, $*V_{[labialx]}C_{[labialx]}$ are undominated

/u k^w/ | | [lab3] [lab3]	Id#V-pl	Max#V-pl	$*V_{[labx]}C_{[labx]}$	Max[lab3]
a. ☞ u k | [lab3] ~~[lab3]~~				*
b. u k^w | | [lab3] [lab3]			*W	L
c. i k^w | ~~[lab3]~~ [lab3]		*W		*
d. i k^w | [lab3] [lab3]	*W			L

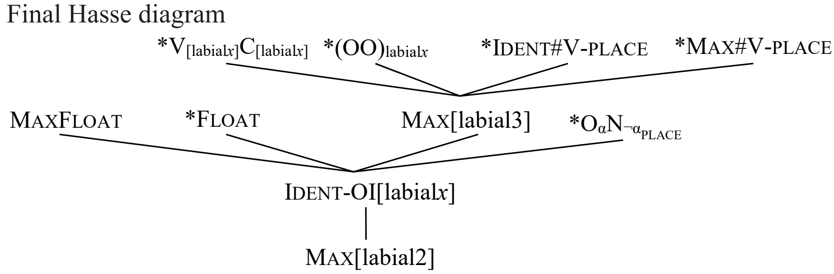
(*tableau continues*)

/o kʷ/ [lab2] [lab3]	ID#V-PL	MAX#V-PL	$*V_{[labx]}C_{[labx]}$	Max[lab3]
a. ☞ o k [lab2] ~~[lab3]~~				*
b. o kʷ [lab2] [lab3]			*W	L
c. e kʷ ~~[lab2]~~ [lab3]		*W		L
d. e kʷ [lab2] [lab3]	*W			L

Given richness of the base, I do not make the claim that labialized consonants are always [labial3]. Though it would make the analysis much simpler, my analysis does not restrict labialized consonants to being specified for only [labial3] (the impossibility of linking [labial2] to a consonant results from more general restrictions (i.e. undominated constraints) on the consonantal inventory of Karata). First, this assumption would go counter to Clements and Hume's (1995) claim that the degree/aperture of secondary articulations is specified in the phonetics. Second, I discuss this possibility in §6.1 and show that this analysis is not well motivated in light of the array of segments that can be labialized, and it lacks explanatory power.

My analysis thus does not make a claim about the compatibility of certain features, but it does make a claim about the preference for one type of labialization process over another.

(72) Final Hasse diagram



I have shown that cyclic OT may be resorted to in order to account for why verb stems are never of the form /uCʷ/, /oCʷ/. In the following section, I show that, in fact, we MUST resort to cyclic OT.

The need for cyclic OT. Given richness of the base, a fair assumption would be that 'consonant labialization' is not the result of a phonological process; rather, it reflects the feature specification of the input. In other words, one could assume that what seems to be a process of consonant labialization is in fact not a process at all but the mere consequence of the fact that the underlying consonant is already labialized in the input. Under such an account, paradigm alternations of the type *wuC/jiCʷ* would be derived from a verb stem of the type /uCʷ/. When this verb stem is prefixed with a class marker (CM), EVAL eliminates candidates that violate phonotactic constraints. The phonotactic constraints in 73 are enough to deal with inputs of the /uCʷ/ type: the consonant can be delabialized, or the stem-initial vowel can be delabialized via assimilation to the preceding glide.

(73) Two ways of satisfying the phonotactic constraint $*(OO)_{labialx}$ in CM-*uC^w*

	$*(OO)_{labialx}$	$*O_\alpha N_{\neg\alpha_{PLACE}}$
/wuC^w/		
a. wuC^w	*W	
b. ☞ wuC		
/juC^w/		
a juC^w		*W
b. ☞ jiC^w		

A problem arises if we assume verb stems of the type /oC^w/, whose initial vowel is round and not high. When the feminine singular marker *j-* is prefixed to it and assimilation of /o/ occurs, we would wrongly predict two possible outputs: **jeC^w* and *jeC*, but only the latter is attested. The $*(OO)_{labialx}$ phonotactic constraint will not be enough to bar the wrong output **jeC^w* in 74b.

(74) Failure of $*(OO)_{labialx}$ to yield the right output for CM-*oC^w*

	$*(OO)_{labialx}$	$*O_\alpha N_{\neg\alpha_{PLACE}}$
/woC^w/		
a. woC^w	*W	
b. ☞ woC		
/joC^w/		
a. joC^w		*
b. X jeC^w		
c. ☞ jeC		

Parallel OT cannot handle richness of the base to yield the Karata facts. As tableau 74 shows, given an input /j-oC^w/, parallel OT predicts both *[jeC^w] and [jeC] to be winners, when in fact only [jeC] is. Descriptively, this asymmetry could be captured by saying that Karata has the verb stems in Table 13: there are underlying /uC^w/ stems but no underlying /oC^w/ stems. Such a description posits an asymmetry that does not seem to be motivated (indeed, we know that the language prohibits sequences of a round vowel and a labialized consonant). Moreover, in an optimality-theoretic framework where no restriction can be posited on the set of inputs to the grammar, language-specific patterns have to fall out from the constraints used. A constraint specifically targeting /oC^w/ sequences would do the job but would be less motivated than the more general $*V_{[labialx]}C_{[labialx]}$.[28]

INITIAL FRONT VOWEL			INITIAL BACK ROUNDED VOWEL	
iC	iC^w		uC	uC^w
eC	eC^w		oC	—
		aC aC^w		

TABLE 13. Alternate possible description of underlying forms in Karata.

[28] An anonymous referee notes that a *oC^w constraint would be consistent with the ANTI-MISMATCH constraint. That is indeed the case, since ANTI-MISMATCH does not apply to sequences of segments but only to individual segments.

To conclude, an OT analysis where inputs are evaluated at each 'morphological layer' accounts for the Karata data in a uniform and independently motivated way.

5. The indexed [labial*x*] feature. I have presented an analysis according to which, upon the delinking of [labial3] and [labial2], only [labial3] relinks to a consonant, because faithfulness to [labial3] is universally higher ranked than faithfulness to [labial2]. Crucially, this account assumes the existence of different degrees of labiality. In this section I examine the evidence for their existence.

5.1. Phonetic differences.

Articulatory evidence. Linker (1982) studied labial activity in vowels for five different languages: English, Cantonese, Finnish, French, and Swedish. Her data involved measurements of twenty-four distinct dimensions taken from still photographs of the side and front view of the mouth. She identified three articulatory dimensions of lip position that are typically involved for distinguishing vowels within each of the languages studied: horizontal opening, vertical opening, and lip protrusion. With the help of a computer program (CANON), she isolated a set of canonical factors of lip position relevant to the five languages studied. Canonical factor 1 involves horizontal opening, and canonical factor 2 involves vertical opening and protrusion.

She observed that across all five languages high rounded vowels display narrower horizontal and vertical opening than do the nonhigh rounded vowels; in other words, high vowels involve more extreme lip-rounding gestures than nonhigh vowels. Moreover, according to the same criteria, back rounded vowels are more rounded than their front counterparts.

We know that, crosslinguistically, /u/ is higher than /o/, and /u/ is articulated further back than /o/ (Lindau 1978, Ladefoged & Maddieson 1996, among others). Furthermore, we know from Linker 1982 that, crosslinguistically, the higher the round vowel, the more extreme the rounding gesture of the lips is, and the further back the vowel, the more rounded it is. Although no phonetic measurements have been performed on Karata vowels so far, I assume the null hypothesis that Karata /u/ and /o/ behave like other /u/ and /o/, and therefore it is reasonable to assume that /u/ is higher and further back than /o/ in Karata. From crosslinguistic tendencies seen in Ladefoged & Maddieson 1996 and Linker 1982, it is also reasonable to assume that /u/ is more rounded than /o/ in Karata (although measurements would have to be performed to be sure). As is well known (see Lindau 1978 for instance), vowels that are characterized as being phonologically high and back are in fact articulated a little further to the back than vowels characterized as being phonologically nonhigh and back.

Perceptual evidence. Terbeek (1977) investigated the factors that contribute to perceptual distance in the vowel space of twelve monophthongs [i, e, æ, ɑ, o, u, ɚ, y, ø, ɨ, ɑ˞, ʌ].[29] Subjects (about thirty-five) were speakers of five languages: English, German, Thai, Turkish, and Swedish. Some but not all monophthongs were similar to vowels occurring in each listener's native language. The data consisted of triadic comparisons of the test vowels in the context [bəb _]. The task was to determine which of the three stimuli sounded the most distinct from the others. Dissimilarity matrices were constructed from the responses collected, and the analysis yielded five factors relevant to the identification of vowels.[30]

[29] Swedish speakers were tested on [ʉ, œ] instead of [ɑ˞, ʌ].

[30] The analysis actually yielded six factors, but the additional factor is the result of the Swedish vowels patterning in a separate back vs. nonback dimension.

(75) Factors relevant to the identification of vowels (from Terbeek 1977)
  a. back vs. nonback
  b. low vs. nonlow
  c. high vs. nonhigh
  d. round vs. nonround
  e. peripheral vs. central

The results of Terbeek's study indicate that along the round vs. nonround continuum, the round vowels are arranged as shown schematically in Figure 9 (relative distance is approximated).

FIGURE 9. The round vs. nonround continuum (based on Kaun 1995:88, ex. 12, who adapted it from Terbeek 1977:140 (figures 5.13 and 5.14)).

These results clearly show that the back vowels [u] and [o] are perceived as more rounded than their front counterparts [y] and [ø], and that the high vowels [u] and [y] are perceived as more rounded than their nonhigh counterparts [o] and [ø]. These results are consistent with Linker's: the greater the magnitude of the rounding gesture, the greater its salience.

5.2. PHONOLOGIZED DIFFERENCES.

DIFFERENT LIP-ROUNDING GESTURES FOR THE SAME HEIGHT. If indeed some languages make use of contrastive labial features as opposed to always deriving degree of rounding from vowel height, we would expect some of those languages to have round vowels that are the same with respect to height and backness, but contrast in terms of how rounding is realized. The independence of labiality degree or gesture with regard to aperture is evinced by the fact that, in certain languages, round vowels of the same height have distinct contrastive labial gestures, as in the following examples.

- Assamese has two low back round vowels, 'one of which sounds like British English [ɑ] as in "father" ', and the low back vowel [ɒ̜], which 'has a slightly different tongue position—more like that of British English [ɔ] as in "caught"—but is accompanied by close lip rounding like that in [u]' (Ladefoged & Maddieson 1996:293).
- Swedish has two high front round vowels [yː, ʉ], where [ʉ] is used to specify a high front vowel, rather than a high central one. It has a similar tongue position to [yː], but [yː] has a more open and protruded lip position; [ʉ] has a fairly close approximation of the upper and lower lip, but without protrusion (Linker 1982).

Languages like Assamese and Swedish provide evidence that, given a constant vowel height or aperture, lip gestures can vary independently.

PARASITIC ROUNDING HARMONY. The existence of the ANTI-MISMATCH constraint (34) predicts the existence of [labial*x*] features (see §4.1). Languages with parasitic rounding harmony provide independent evidence for this constraint and therefore for the existence of [labial*x*] features.

In Yawelmani Yokuts and Kachin Khakass,[31] vowels harmonize for rounding only if they agree in height or aperture. This can be modeled by positing that in the phonology

[31] Data from Kaun 1995.

of these languages, the ANTI-MISMATCH constraint outranks the constraint enforcing rounding harmony, for example, EXTEND[labial*x*] (Kaun 1995) defined in 76.

(76) EXTEND[labial*x*]: Assign a violation mark to each output vowel that is not linked to a [labial*x*] feature.

The phonology of Yawelmani Yokuts distinguishes two apertures of vowels.

(77) Yawelmani underlying vowel inventory

aperture 2	i	u
aperture 1	a	o

In Yawelmani Yokuts, suffixal vowels are rounded following a rounded root vowel only if both vowels have the same aperture: in tableau 78a, the faithful candidate (b) loses because harmony has not occurred and EXTEND[labial*x*] is violated. The same occurs in tableau 78b: the feature [labial1] can spread without violating the ANTI-MISMATCH constraint since the target vowel in the suffix has aperture 1. In tableau 78c, however, satisfying EXTEND[labial*x*] by spreading [labial2] to the suffixal vowel violates the ANTI-MISMATCH constraint since the suffixal vowel has aperture 1. It is therefore better not to spread and incur a violation of EXTEND[labial*x*] than to spread and violate the ANTI-MISMATCH constraint.

(78) Parasitic rounding harmony in Yawelmani Yokuts

a. high-high harmony

/muʈ + hin/: [muʈhun] ≻ *[muʈhin]

[ap2] [ap2] /m u ʈ/ + /h i n/ [lab2]	$*aperture_{\alpha}/labial_{\neg\alpha}$	EXTEND[labial*x*]
a. ☞ [ap2][ap2] m u ʈ h u n [lab2]		
b. [ap2][ap2] m u ʈ h i n [lab2]		*W

b. low-low harmony

/gop + taw/: [goptow] ≻ *[goptaw]

[ap1] [ap1] /g o p/ + / t a w/ [lab2]	$*aperture_{\alpha}/labial_{\neg\alpha}$	EXTEND[labial*x*]
a. ☞ [ap1][ap1] g o p t o w [lab1]		
b. [ap1][ap1] g o p t a w [lab1]		*W

c. no harmony
/muʈ + taw/: [muʈtaw] ≻ *[muʈtow]

[ap2] [ap1] /m u ʈ/ + /t a w/ [lab2]	*aperture$_{\alpha}$/labial$_{\neg\alpha}$	Extend[labial*x*]
a. [ap2][ap1] m u ʈ t o w [lab2]	*W	L
b. ☞ [ap2][ap1] m u ʈ t a w [lab2]		*

Kachin Khakass phonology also distinguishes two aperture degrees for vowels (79).

(79) Kachin Khakass underlying vowel inventory
aperture 2   i y   ɯ u
aperture 1   e ø   a o

In this language, too, suffixal vowels become rounded following a rounded root vowel if they have the same aperture. However, there is a further requirement: the root vowel must have aperture 2; see the constraint in 80 below. In tableau 81a, the faithful candidate (a) loses because it violates Extend[labial*x*]; the winner is candidate (b), which satisfies all of the constraints. In 81b, however, the suffixal vowel has aperture 1, so satisfying Extend[labial*x*] by spreading [labial2] leads to a violation of the anti-mismatch constraint. It is therefore better to violate Extend[labial*x*] by not spreading the labial feature. The same occurs in tableau 81c where spreading the root [labial1] to the suffixal vowel, specified aperture 2, leads to a violation of the anti-mismatch constraint. Finally, rounding harmony does not occur in tableau 81d because spreading [labial1] to the suffixal vowel yields a further violation of the markedness constraint against vowels that are both aperture 1 and labial (80). Here again, it is better not to spread and violate Extend[labial*x*].

(80) *ap(erture) 1/lab(ial)*x*: Assign a violation mark to each output rootnode that is linked to an aperture node with degree 1 and a labial feature.
*aperture 1
|
x
|
labial*x*

(81) Parasitic rounding harmony in Kachin Khakass only if trigger is high
a. high-high harmony
/kuʃ + tɯŋ/: [kuʃtuŋ] ≻ *[kuʃtɯŋ]

[ap2] [ap2] /k u ʃ/ + /t ɯ ŋ/ [lab2]	*aperture$_{\alpha}$/labial$_{\neg\alpha}$	*ap 1/labial*x*	Extend[labial*x*]
a. [ap2][ap2] k u ʃ t ɯ ŋ [lab2]			*W

(*tableau continues*)

[ap2] [ap2] /k u ʃ/ + /t ɯ ŋ/ [lab2]	*aperture$_{\alpha}$/labial$_{\neg\alpha}$	*ap 1/labial*x*	EXTEND[labial*x*]
b. ☞ [ap2][ap2] k u ʃ t u ŋ [lab2]			

b. high-low harmony failure
/kuzuk + ta/: [kuzukta] ≻ *[kuzukto]

[ap2][ap2] [ap1] /k u z u k / + /ta/ [lab2]	*aperture$_{\alpha}$/labial$_{\neg\alpha}$	*ap 1/labial*x*	EXTEND[labial*x*]
a. ☞ [ap2][ap2][ap1] k u z u k t a [lab2]			*
b. [ap2][ap2][ap1] k u z u k t o [lab2]	*W	*W	L

c. low-high harmony failure
/ok + tɯŋ/: [oktɯŋ] ≻ *[oktuŋ]

[ap1] [ap2] /o k/ + /t ɯ ŋ/ [lab1]	*aperture$_{\alpha}$/labial$_{\neg\alpha}$	*ap 1/labial*x*	EXTEND[labial*x*]
a. ☞ [ap1][ap2] o k t ɯ ŋ [lab1]		*	*
b. [ap1][ap2] o k t u ŋ [lab1]	*W	*	L

d. low-low harmony failure
/pol + za/: [polza] ≻ *[polzo]

[ap1] [ap1] /p o l/ + /z a/ [lab1]	*aperture$_{\alpha}$/labial$_{\neg\alpha}$	*ap 1/labial*x*	EXTEND[labial*x*]
a. ☞ [ap1][ap1] p o l z a [lab1]		*	*

(*tableau continues*)

[ap1] [ap1] /p o l/ + /z a/ [lab1]	*aperture$_{\alpha}$/labial$_{\neg\alpha}$	*ap 1/labial$x$	EXTEND[labial$x$]
b. [ap1][ap1] p o l z o [lab1]		**W	L

Parasitic rounding harmony is directly predicted by the ANTI-MISMATCH constraint being ranked above the constraint that triggers harmony: harmony will occur so long as the ANTI-MISMATCH constraint is not violated. Additionally, in Kachin Khakass, nonhigh round vowels are penalized by a markedness constraint ranked above the constraint triggering harmony.

One may wonder how my proposal then handles cases of cross-height rounding harmony. But my proposal is not that all languages have phonologized degrees of rounding. Languages with cross-height rounding harmony can therefore be viewed as languages in which either different [labial] features are not contrastive or, if phonological degrees of rounding are emergent, have not emerged. In any case, any theory of rounding harmony (e.g. Kaun 2004) will handle this state of affairs and make the right predictions.

5.3. DISCUSSION: WHAT GESTURE(S) DOES [LABIALx] CORRESPOND TO? We have seen evidence that the rounding gesture involves a number of subgestures. Linker's (1982) study showed that lip rounding involves three such subgestures: vertical opening, protrusion, and to a lesser extent horizontal opening. From their wide-ranging typological study, Ladefoged and Maddieson (1996) concluded that [labial] corresponds to two lip-position parameters for vowels: vertical lip compression and protrusion (Table 14).

ROUNDING	
VERTICAL COMPRESSION	PROTRUSION
[compressed]	[protruded]
[separated]	[retracted]

TABLE 14. The features of vowel rounding (Ladefoged & Maddieson 1996).

Linker (1982), on the one hand, and Ladefoged and Maddieson (1996), on the other, note that, in the great majority of languages, those subgestures are realized together. Only a few languages do rounding with either one or two of the subgestures (e.g. Japanese, Swedish). In this context, one might wonder what subgestures [labial3] and [labial2] in Karata correspond to.

It is conceivable that Karata could be a language in which /u/ is realized with both compression and protrusion and /o/ is realized with compression only. If this were the case, we could analyze consonant labialization in Karata as the result of the transmission of protrusion onto the consonant. This would then account nicely for the consonant-labialization asymmetry between /u/ and /o/. Further research on the articulatory phonetics of Karata will have to answer this question. The prediction of my account is clear though: the rounding gesture made when Karatas pronounce /u/ is more extreme than that made when they pronounce /o/. In this sense, [compressed] refers to a more extreme gesture than [separated], and [protruded] to a more extreme gesture than [retracted].

The fact that [labial$x$] glosses over the distinctions made by Ladefoged and Maddieson (1996) is therefore a way to capture the fact that high vowels are more rounded than nonhigh vowels, without committing to what the exact nature of the lip gestures is in Karata since no measurement is available.

5.4. Motivation for the [labial*x*] fixed ranking.

The p-map: motivation for docking of [labial*x*]. The central claim of the p-map theory (Steriade 2001) is that the degree to which a change is unfaithful is related to the perceptual distance involved in that change: a highly perceptible change is more unfaithful than a less perceptible change. Under that assumption, the change from [u] to [i] is more unfaithful than the change from [o] to [e] (as in 82), since 'contrastive rounding among non-high vowels is perceptually more subtle than contrastive rounding among high vowels' (Kaun 1995:88). In other words, delinking [labial3] is more unfaithful than delinking [labial2].[32]

(82) Faith(u) >> Faith(o)

Figure 10 is a representation of the process known as rounding harmony: a feature [labial*x*] associated to a trigger spreads to other vowels (targets) in the word by creating new association lines. The result is a single feature associated to several targets' root nodes.[33]

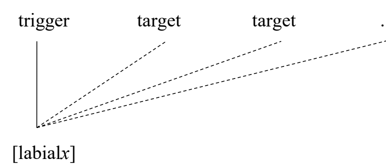


Figure 10. Rounding harmony.

Following Suomi 1983 and Kaun 2004, I take rounding harmony to be perceptually motivated. Harmony gives rise to an extension of the temporal span associated with some perceptually vulnerable quality, represented above as [labial*x*]. By increasing the listener's exposure to the quality in question, harmony increases the probability that the lis-

[32] The reader may object that similarly linking [labial3] to an initially nonlabial segment is more unfaithful than linking [labial2] (i.e. labializing a consonant by docking [labial3] is more unfaithful than labializing with [labial2]). This is indeed a prediction that a theory like the P-map makes. Under the view that [labial*x*] features are privative, delinking a feature [labial*x*] violates Ident[labial*x*] to the input only, whereas linking a [labial*x*] feature violates Ident[labial*x*] to the output (see discussion in n. 25 for more detail). Here I just consider faithfulness to the input, as I am considering only the delinking part that is induced as a result of assimilation of the vowel to the class marker.

More generally, as pointed out by Adam Albright (p.c.), my analysis proposes to solve a markedness effect (i.e. the impossibility of the sequences *[ju]/*[jo]) by creating another markedness effect (i.e. the creation of a labialized consonant). While I share this concern, I also deem plausible that OI-faithfulness to (non)labialized consonants is ranked lower than IO-faithfulness to the existence of the feature [labial3]. This is in fact the claim of the analysis presented in this article.

[33] Kaun (1995) reports that Boyce (1988) studied vowel-to-vowel coarticulation in English and Turkish *uCu* utterances. These two languages were chosen because there is good reason to believe that segmentally identical sequences may be assigned distinct phonological representations. Turkish, as a rounding-harmony language, arguably represents *uCu* sequences as containing a single [+round] autosegment, whereas English, which lacks rounding harmony, would plausibly be expected to represent the same sequence with two independent [+round] specifications. Boyce showed that the two representations corresponded to two articulatorily distinct patterns. English has a 'trough' pattern: the lips attained a position of protrusion in the articulation of the first rounded vowel, then receded during the articulation of the consonantal sequence, then once again attained a position of protrusion for the second vowel. By contrast, Turkish has a 'plateau' pattern: the lips attained a position of protrusion during the articulation of the first rounded vowel and remained protruded throughout the utterance. One plausible interpretation of these results is that whereas English speakers execute two lip-rounding gestures, Turkish speakers execute one.

tener will accurately identify that quality. In Table 15 I give a summary of the typological tendencies (related to vowel height) in rounding harmony, as given in Kaun 2004.

	TENDENCY	PERCEPTUAL EXPLANATION
1.	A good trigger is [−high].	The round gesture 'wants' to be realized more saliently (Kaun 1995, Kimper 2011).
2.	A good target is [+high].	A high vowel realizes the lip-rounding gesture best (Terbeek 1977).
3.	Same-height rounding harmony	A single [labial] should have a uniform phonetic realization across the word (Boyce 1988).

TABLE 15. Typological tendencies in rounding harmony, along with a summary of their corresponding perceptual explanations.

In Karata, just as in languages with rounding harmony, [labial3] associates to another segment. Unlike rounding harmony, however, [labial3] does not spread to a vowel; it delinks from the vowel it is originally attached to and attaches to the following consonant.

The behavior of [labial3] in Karata vs. vowel-harmony languages (i.e. [labial3] relinking vs. spreading) falls out from the same faithfulness preference:

- If [labial3] is linked to a vowel, its articulatory magnitude gives it very salient perceptual correlates, so [labial3] does not 'need' to spread.
- If [labial3] is delinked, it has no perceptual correlates, but its articulatory magnitude renders it more 'persistent', so more pressure applies for it to stay in the output (by relinking to another segment in Karata).

In Karata, markedness is sufficiently high ranked to make both [labial3] and [labial2] delink from the vowel they were linked to. Because [labial3] has greater magnitude than [labial2], there is more faithfulness pressure (to the input) to make [labial3] stay in the output (via relinking) (83). Relinking [labial3] is a better solution than deleting it (while deleting [labial2] is the more optimal strategy).[34]

(83) MAX[labial3] >> MAX[labial2] (>> MAX[labial1])

VOWEL ELISION IN HIATUS. In this section, I show that having scalar features of labiality ranked on a scale of faithfulness solves a false prediction of Casali's (1996) theory of hiatus resolution in Yoruba.

Using the two families of constraints in 84 and 85, Casali (1996) compiles a typology of vowel elision in hiatus and shows how different patterns can be accounted for.

(84) PARSE(F): Preserve an input feature F in the output.

(85) SEGMENT INTEGRITY (SEG-INT): If one feature of a segment is preserved, all of its features are preserved.

One predicted pattern is given in Table 16 (Casali 1996:8, examples 138 and 139). When SEG-INT is undominated, elision of one vowel is predicted (rather than coalescence). Furthermore, because of the particular ranking of PARSE(F) in Casali's typology, a combination of ordinary elision and feature-sensitive elision is predicted. Consider, for example, a five-vowel language with the single ranking PARSE(−high) >> PARSE(+high)$[_W$ and undominated SEG-INT. These rankings would ensure that in combinations involving a word-final nonhigh vowel and a word-initial high vowel, the nonhigh vowel would be preserved in its entirety—that is, we would have the realizations in Table 16a; note that these appear to manifest V2 elision. With all other input sequences, however, the result will be V1 elision, as in Table 16b.

[34] For this reason, IDENT constraints to [labial*x*] are not enough because they can be satisfied by deleting [labial*x*].

a. V2 ELISION

a + i > a	a + u > a
e + i > e	e + u > e
o + i > o	o + u > o[a]

b. V1 ELISION

	e + a > a	o + a > a	i + a > a	u + a > a
a + e > e		o + e > e	i + e > e	u + e > e
a + o > o	e + o > o		i + o > o	u + o > o
				u + i > i
			i + u > u	

TABLE 16. Predicted pattern from Casali 1996:68.

[a] In the original dissertation, 'o + i > o' is repeated here. I take this to be a typographical error.

Casali notes that this predicted pattern is, to his knowledge, not attested, although Yoruba comes really close. In fact, Yoruba differs from the predicted pattern in just one interesting instance: /u/ + /i/ coalesce into [u], not [i] as predicted (see 86). Here is a tableau illustrating how Casali's analysis predicts the wrong outcome for Yoruba /u/ + /i/ coalescence, although it correctly predicts the outcome of Yoruba /o/ + /e/ coalescence.

(86) Casali's analysis 1

	SEG-INT	PARSE(−high)	PARSE(+high)[$_w$	PARSE(−high)[$_w$
I. /u + i/				
a. X☞ ~~u~~ i				
b. u ~~i~~			*(W)	
II. /o + e/				
a. ☞ ~~o~~ e				
b. o ~~e~~				*W

Candidate (b) of input I violates PARSE(+high)[$_w$ because the vowel in the output is +high and is not at the beginning of a word. Candidate (b) of input II violates PARSE(−high)[$_w$ because the vowel in the output is −high and not at the beginning of a word.

As Casali (1996:69, n. 42) points out in a footnote, while /o/ + /e/ does result in [e], /u/ + /i/ actually results in [u] in Yoruba. Casali notes that adopting an additional interleaved ranking PARSE(labial) >> PARSE(+high)[$_w$,[35] as illustrated in tableau 87, would correctly yield the realization of /u/ + /i/ as [u], but would generate a pattern that differs from that of Yoruba in other respects. In particular, such a ranking would cause /o/ + /e/ to be realized as [o] (assuming, as we have been, that SEG-INT is undominated), vs. the attested realization of [e] in Yoruba.

(87) Casali's analysis 2

	SEG-INT	PARSE(−hi)	PARSE(lab)	PARSE(+hi)[$_w$	PARSE(−hi)[$_w$
I. /u + i/					
a. ~~u~~ i			*W	L	
b. ☞ u ~~i~~				*	
II. /o + e/					
a. ~~o~~ e			*(W)		(L)
b. X☞ o ~~e~~					*

[35] Actually, in the footnote Casali (1996:69, n. 42) writes 'PARSE(round) >> PARSE(front)-[$_w$'. It is not clear to me why he wrote PARSE(front)-[$_w$, and I consider this to have just been an oversight.

This unexpected pattern can be accounted for in Casali's analysis if different [labial] features are recognized, and if the faithfulness constraint to labial3 is ranked over the faithfulness constraint to labial2, as in 88.[36]

(88) Casali's analysis (modified)

			Seg-Int	Parse(−hi)	Parse(lab3)	Parse(+hi)[$_w$	Parse(−hi)[$_w$	Parse(lab2)
I		/u + i/						
a.		ʉ i			*W	L		
b.	☞	u ɨ				*		
II		/o + e/						
a.	☞	ɵ e						*
b.		o ɐ					*W	L

We have seen that if Yoruba has contrastive labial features and applies more faithfulness to [labial3] than to [labial2], we can account for its hiatus pattern and solve an incorrect prediction of Casali's theory.

6. About potential alternative solutions to the labialization asymmetry in karata. In this section, I explore several potential alternative ways of analyzing consonant labialization with both indexed and unindexed labial features. I show in the former case that the alternative analyses make wrong predictions, and with respect to the latter analyses, that they are not explanatory and require an unmotivated constraint.

6.1. Potential alternative solutions with [labial*x*].

Parasitic docking. In this section I tentatively explore an account inspired by parasitic vowel harmony, in which consonants have a degree of aperture and the docking of [labial*x*] is contingent on the consonant having the same degree of aperture *x*. This account assumes a slight modification of our representational assumptions: all segments, vowels and consonants alike, are specified for aperture in the same way. The idea that consonantal stricture can be captured in terms of different degrees of aperture has already been proposed by a few linguists (Ladefoged 1971, Browman & Goldstein 1989, Steriade 1993). I present a summary of two existing proposals which posit that all sounds are specified phonologically for a degree of aperture or constriction, and then I sketch a tentative analysis of consonant labialization as 'parasitic docking'. In the end, I discuss why this analysis, though attractive, cannot be right.

Degrees of aperture or degrees of constriction: theoretical background. Steriade (1993) posits three types of aperture position. An aperture position is rather similar to the feature-geometric notion of root node: it anchors segmental features and connects segments to prosodic structures. Each aperture position is specified for a degree of opening of the oral cavity.

(89) Types of aperture positions

Closure (A_0):	total absence of airflow
Fricative (A_f):	degree of oral aperture sufficient to produce a turbulent airstream
Approximant (A_{max}):	maximal degree of oral aperture in consonants

The idea Steriade explores is that plosives (stops and affricates) are phonologically represented as a sequence of two aperture positions, closure and release. In contrast, con-

[36] Yoruba has a three-height system.

tinuants (vowels, approximants, and fricatives) are assumed to carry a single aperture position in phonological representations.

(90) Representation of a few classes of segments

Plain, released stop:	A_0A_{max}
Affricate:	A_0A_f
Unreleased stop:	A_0
Approximant:	A_{max}
Fricative:	A_f

In articulatory phonology, there are five distinctive constriction degrees (Figure 11) arranged on a continuum, and each articulator (of which one or several make a gesture) is specified for a constriction degree. The two most closed categories correspond to stops and fricatives. The other descriptors distinguish among vowels.

FIGURE 11. Constriction degree descriptors.

While the intuition that all segments are specified for aperture or constriction seems very plausible, it appears that with nonlingual consonants, these two notions need to be teased apart. Indeed, pharyngeal consonants have a constriction degree equivalent to that of other (lingual) consonants, but their aperture degree (i.e. jaw position) is similar to that of low vowels. In the following subsection, I present a tentative analysis in which docking of [labial*x*] on a consonant is allowed only if it does not create a mismatch with the aperture specification of the consonant.

Formalization of generalized constriction degrees. In this section I make different assumptions, as represented in Figure 12 for /u/, /k/, and /kʷ/. I assume that constriction degree for both vowels and consonants is specified under the same aperture node. In the absence of a place feature linked to the C-place node, the aperture specification is interpreted with respect to the V-place node. When both C-place and V-place have featural specification(s), the aperture node is interpreted as referring to the primary articulator.

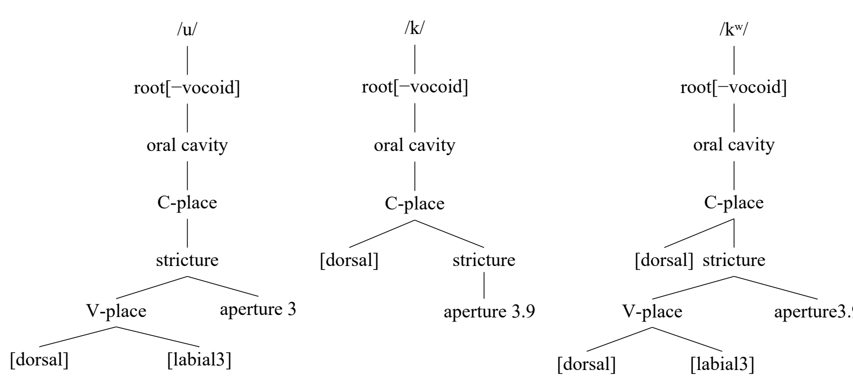


FIGURE 12. Feature-geometric representations of /u/, /k/, and /kʷ/.

There is a body of evidence to show that in many languages high vowels pattern with consonants. Phonetically speaking, there is a general consensus that there is no strict difference between the traditional labels of vowels and consonants; rather, they describe the ends of a continuum, the center of which is occupied by the glides [j] and [w]. Articulatorily speaking, the high vowels are the least open of the category traditionally labeled ‘vowels’. In Figure 13, I illustrate this continuum of aperture with low vowels on one end and stops on the other. I also assign to each type of phone a (somewhat arbitrary) degree of aperture in order to capture the intuition formulated just above.

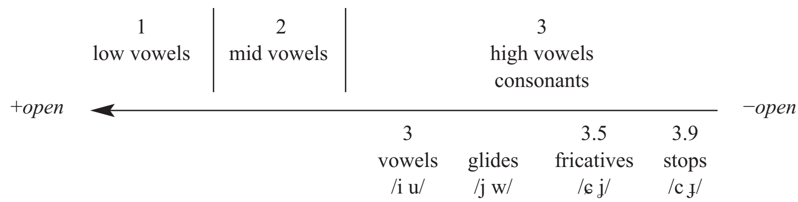


Figure 13. Aperture in vowels and consonants.

I now present an account using the same constraints that were defined previously. This account crucially makes use of *aperture$_\alpha$/labial$_{\neg\alpha}$. Because consonants (at least in Karata) have aperture 3, docking a [labial*x*] feature on a consonant does not violate *aperture$_\alpha$/labial$_{\neg\alpha}$ only if it is [labial3]; all other [labial] features will fatally violate it.

Analysis. We know that it is better to create a new association line between a [labial*x*] feature and a segment so that both segments have the same V-place even though the segment’s [labial*x*] feature and aperture node mismatch (91–92).

(91) /w-ek̄ai̯̊a/ ‘give’
[wok̄ai̯̊a] ≻ *[wek̄ai̯̊a]

(92) *$O_\alpha N_{\neg\alpha_{PLACE}}$ ≻ *aperture$_\alpha$/labial$_{\neg\alpha}$

[ap2] | /w e k/ | [lab3]	*$O_\alpha N_{\neg\alpha_{PLACE}}$	*aperture$_\alpha$/labial$_{\neg\alpha}$
a. ☞ [ap2] | w o k (w and o linked to) [lab3]		*
b. [ap2] | w e k | [lab3]	*W	L

The winner in 93 violates Max[labial*x*].[37] The loser violates both *aperture$_\alpha$/labial$_{\neg\alpha}$ and Ident-OI[labial*x*]. I show this ranking disjunction in 94.

(93) /j-oχ̄aːi̯̊a/ ‘thrust’
[jeχ̄aːi̯̊a] ≻ *[jeχ̄ʷaːi̯̊a]

[37] Max[labial*x*] here is a cover constraint for [labial3], [labial2], and [labial1].

(94) Ranking disjunction

a. *aperture$_{\alpha}$/labial$_{\neg\alpha}$ >> MAX[labial*x*]

<table>
<tr><th>[ap3.9]
|
/j o k/
|
[lab2]</th><th>*aperture$_{\alpha}$/labial$_{\neg\alpha}$</th><th>MAX[labialx]</th></tr>
<tr><td>a. ☞ [ap3.9]
|
j e k

~~[lab2]~~</td><td></td><td>*</td></tr>
<tr><td>b. [ap3.9]
|
j e kʷ
|
[lab2]</td><td>*W</td><td>L</td></tr>
</table>

or

b. IDENT-OI[labial*x*] >> MAX[labial*x*]

<table>
<tr><th>[ap3]
|
/j o k/
|
[lab2]</th><th>IDENT-OI[labialx]</th><th>MAX[labialx]</th></tr>
<tr><td>a. ☞ [ap3]
|
j e k

~~[lab2]~~</td><td></td><td>*</td></tr>
<tr><td>b. [ap3]
|
j e kʷ
|
[lab2]</td><td>*W</td><td>L</td></tr>
</table>

The argument in 95–96 helps us solve this ranking disjunction.

(95) /j-uʧãi̥a/ 'bathe'
[jiʧʷãŋi̥a] ≻ *[jiʧãŋi̥a]

(96) MAX[labial*x*] >> IDENT-OI[labial*x*]

<table>
<tr><th>[ap3]
|
/j u k/
|
[lab3]</th><th>MAX[labialx]</th><th>IDENT-OI[labialx]</th></tr>
<tr><td>a. ☞ [ap3]
|
j i kʷ
|
[lab3]</td><td></td><td>*</td></tr>
<tr><td>b. [ap3]
|
j i k

~~[lab3]~~</td><td>*W</td><td>L</td></tr>
</table>

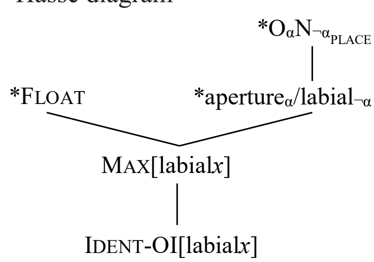
So we have *aperture$_{\alpha}$/labial$_{\neg\alpha}$ >> MAX[labial*x*] >> IDENT-OI[labial*x*]. Furthermore, it is better to delete a floating feature than to leave it floating (97–99).

(97) /j-oχ̄aːḭ̊a/ 'thrust'
[jeχ̄aːḭ̊a] ≻ * [jeχ̄aːḭ̊a] #[labial2]#

(98) *FLOAT >> MAX[labial*x*]

/j o k/ (linked to [lab2])	*FLOAT	MAX[labial*x*]
a. ☞ j e k ~~[lab2]~~		*
b. j e k [lab2]	*W	L

(99) Hasse diagram



The following tableaux summarize the analysis.

(100) /j-uʧ/ → [jiʧʷ] summary

/j u ʧ/ (linked to [lab3])	*FLOAT	*O$_{\alpha}$N$_{\neg\alpha_{PLACE}}$	*ap$_{\alpha}$/lab$_{\neg\alpha}$	MAX[labial*x*]	IDENT-OI[labial*x*]
a. ☞ j i ʧʷ (linked to [lab3])					*
b. j i ʧ [lab3]	*W				L
c. j i ʧ ~~[lab3]~~				*W	L
d. j u ʧ (linked to [lab3])		*W			L

(101) /j-oʧ/ → [jeʧ] summary

/j o ʧ/ (linked to [lab2])	*FLOAT	*O$_{\alpha}$N$_{\neg\alpha_{PLACE}}$	*ap$_{\alpha}$/lab$_{\neg\alpha}$	MAX[lab*x*]	IDENT-OI[lab*x*]
a. j e ʧʷ (linked to [lab2])			*W	L	*W

(*tableau continues*)

/j o ʧ/ [lab2]	*FLOAT	$*O_{\alpha}N_{\neg\alpha_{PLACE}}$	$*ap_{\alpha}/lab_{\neg\alpha}$	MAX[lab*x*]	IDENT-OI[lab*x*]
b. j e ʧ [lab2]	*W			L	
c. ☞ j e ʧ ~~[lab2]~~				*	
d. j o ʧ | [lab2]		*W		L	

This solution is interesting in that it generalizes parasitic assimilation to vowel-consonant interactions. While it demands one more representational assumption (than the previous analysis)—it makes the claim that the aperture of all consonants is closest to the aperture of high vowels—it also dispenses with the universal ranking of faithfulness constraints to [labial*x*].

Under the assumption that segments are specified for 'aperture', the degree of aperture of laryngeal consonants is closest to the degree of aperture of low vowels, yet the pharyngeal consonants /ħ/ and /ʕ/ may be labialized only when the preceding vowel is underlyingly high, just like other consonants.

Under the assumption that segments are specified for 'constriction' (as opposed to jaw aperture) and that constriction is specified for each articulator, pharyngeal consonants are not a problem since the constriction in the larynx is of the same phonological degree as the constriction for, say, a velar fricative. But my analysis would then make a claim about the compatibility of constrictions in two locations (the constriction of the primary articulator and that of the lip), and it is not clear that constriction at the lips is dependent on constriction in the pharynx in the same way that it is dependent on aperture.

RESTRICTION ON THE SEGMENT INVENTORY: *C[LABIAL2]. This analysis would crucially rely on the ranking of a markedness constraint against consonants being associated with a [labial2] feature being ranked above faithfulness to [labial*x*] features.

(102) *C[labial2] >> MAX[labial*x*]

The only motivation (phonetically speaking) for this constraint would be in the same vein as the motivation for the parasitic docking solution, which we saw was not well motivated because it is not clear why pharyngeal and glottal consonants, which aperture-wise are closer to low vowels, could not associate to lower [labial*x*] features.

6.2. POTENTIAL ALTERNATIVE SOLUTION WITH UNINDEXED [LABIAL]: OPAQUE SPREADING OF [LABIAL] TO A C FROM A HIGH V. An anonymous conference abstract reviewer (Pasquereau 2014) wondered why I could not 'just assume that only round high vowels spread'. In parallel cyclic OT, the problem is that it predicts that every (high) round vowel should labialize the consonant that follows it. This makes the right prediction for verb stems whose first vowel is round and that take a class marker (103–104).

(103) a. Cycle 1

/u ʧ/ [+lab]	Ident-IO [leftmost]	Ident-IO [labial]	*(+high, +lab) (−lab)	*+lab+lab	Ident-OI [labial]
a. ☞ u ʧʷ [+lab]				*	*
b. u ʧ [+lab]			*W	L	L
c. i ʧʷ [+lab]	*W	*W		L	*
d. i ʧ ~~[+lab]~~	*W	*W		L	L

b. Cycle 2

/j u ʧʷ/ [+lab]	*Ident-IO [leftmost]	Ident-IO [labial]	*(+high, +lab) (−lab)	*+lab+lab	Ident-OI [labial]
a. ☞ j i ʧʷ [+lab]		*			
b. j i ʧ ~~[+lab]~~		**W			
c. w u ʧʷ [+lab]	*W	L		*W	*W
d. w u ʧ [+lab]	*W	*	*W		*W

(104) a. Cycle 1

/o ʧ/ [+lab]	Ident-IO [leftmost]	Ident-IO [labial]	*(+high, +lab) (−lab)	*+lab+lab	Ident-OI [labial]
a. o ʧʷ [+lab]				*W	*W
b. ☞ o ʧ [+lab]					
c. e ʧʷ [+lab]	*W	*W			*W
d. e ʧ ~~[+lab]~~	*W	*W			

b. Cycle 2

/j o ʧ/ [+lab]	*IDENT-IO [leftmost]	IDENT-IO [labial]	*(+high, +lab)(−lab)	*+lab+lab	IDENT-OI [labial]
a. j e ʧʷ [+lab]		*			*W
b. ☞ j e ʧ ~~[+lab]~~		*			
c. w o ʧʷ [+lab]	*W	L		*W	**W
d. w o ʧ [+lab]	*W	L			*W

However, it wrongly predicts that verb stems whose first vowel is /u/ but which do not take a class marker should also undergo labialization (105).

(105) a. Cycle 1

/u ʧ/ [+lab]	IDENT-IO [leftmost]	IDENT-IO [labial]	*(+high, +lab)(−lab)	*+lab+lab	IDENT-OI [labial]
a. ☞ u ʧʷ [+lab]				*	*
b. u ʧ [+lab]			*W	L	L
c. i ʧʷ [+lab]	*W	*W		L	*
d. i ʧ ~~[+lab]~~	*W	*W		L	L

b. Cycle 2

/u ʧʷ/ [+lab]	IDENT-IO [leftmost]	IDENT-IO [labial]	*(+high, +lab)(−lab)	*+lab+lab	IDENT-OI [labial]
a. X☞ u ʧʷ [+lab]				*	
b. u ʧ [+lab]		*W	*W	L	
c. i ʧʷ [+lab]	*W	*W		L	
d. i ʧ ~~[+lab]~~	*W	**W		L	

In order to get rid of the wrong prediction illustrated in 105, we need stratal OT (with constraint reordering). At stratum 1: Ident-IO[lab] >> *+lab+lab, so that labialization occurs. At stratum 2: *+lab+lab >> Ident-IO[lab], so that labialization is eliminated if the C is preceded by a rounded vowel.

(106) a. Stratum 1

/u ʧ/ (u linked to [+lab])	Ident-IO [leftmost]	Ident-IO [labial]	*(+high, +lab)(−lab)	*+lab+lab	Ident-OI [labial]
a. ☞ u ʧʷ ([+lab] linked to u and ʧʷ)				*	*
b. u ʧ (u linked to [+lab])			*W	L	L
c. i ʧʷ (ʧʷ linked to [+lab])	*W	*W		L	*
d. i ʧ ~~[+lab]~~	*W	*W		L	L

b. Stratum 2

/u ʧʷ/ ([+lab] linked to u and ʧʷ)	Ident-IO [leftmost]	*+lab+lab	Ident-IO [labial]	*(+high, +lab)(−lab)	Ident-OI [labial]
a. u ʧʷ ([+lab] linked to u and ʧʷ)		*W	L	L	
b. ☞ u ʧ (u linked to [+lab])			*	*	
c. i ʧʷ (ʧʷ linked to [+lab])	*W		*	L	
d. i ʧ ~~[+lab]~~	*W		**W	L	

To summarize, this solution requires two specific assumptions, which are not necessarily explanatory:

- constraint reordering from one stratum to the other
- a constraint triggering the spread of rounding from a high V only

Constraint reordering has been assumed to account for a number of opaque processes (Kiparsky 2000), but the second assumption (i.e. the existence of the constraint triggering [labial] spreading from /u/ only) is ad hoc and not motivated. The goal of my account is precisely to motivate this phenomenon.

7. Conclusion. I have argued that the Karata labialization patterns are analyzed best if we recognize that the magnitude of a rounding gesture can be phonologized, and that there is greater faithfulness to more extreme rounding gestures. This in fact falls out of slightly modifying Kaun's (2004) Uniform[rd] constraint to the anti-mismatch constraint. By doing so, not only do we still capture the rounding-harmony facts that Kaun captures, but we also account for the Karata facts and solve a false prediction of Casali's account of hiatus in Yoruba.

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