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LAAL ROUNDING HARMONY: THE CASE FOR SUBFEATURAL REPRESENTATIONS IN PHONOLOGY

1 Introduction

(1) Phonological teamwork, i.e. several segments gang up in order to trigger a phonological process (here assimilation), which they would not trigger on their own (Lionnet 2014, in preparation a)

(2) Cantonese inter-coronal fronting (Flemming 1997, 2001), No back rounded vowel between two coronal consonants: *TuT > TyT

a.	k^hyt	'decide'	k^hut	'bracket'
b.	t^huk	'bald head'		
c.	t^hyt	'take off'	*t^hut	

(3) Two logically possible ways to model phonological teamwork have been proposed:
- a. Phonetically grounded: ganging up of weak phonetic effects to make a single strong influence (e.g. Flemming 1997, 2002)
- b. Grammatically derived: ganging up of weak grammatical constraints (each of which wants a categorical assimilation),
  - i. Local Constraint Conjunction (Suzuki 1997)
  - ii. Weighted constraint model (Lionnet in preparation b)

(4) My proposal: Enrich phonological representations with subfeatural representations to capture distinctive but non-contrastive categories that are available to the phonological grammar.

(5) Goals of this presentation:
- a. Describe an intriguing case of phonological teamwork: doubly triggered rounding harmony in Laal (isolate, Chad, ca. 750 speakers) (Section 2)
- b. Show, based on acoustic measurements, that subphonemic distinctions (distinctive but non-contrastive, and featurally identical) exist (Section 3)
- c. Propose a phonological representation of such distinctions: subfeatures, (Section 4)
- d. Show the promising implications of a theory of subfeatural representations (Section 5)

2 Laal doubly triggered rounding harmony

2.1 Preliminary remarks on Laal phonology

		V_1 (and $V:_1$)				V_2 (*$V:_2$)				
		[+front]		[-front]		[+front]		[-front]		
		[-rd]	[+rd]	[-rd]	[+rd]			[-rd]	[+rd]	
+hi	-lo	**i**	**ü**	**ɨ**	**u**	**i**	--	**ɨ**	**u**	*High*
-hi	-lo	**e**	**üo**	**ə**	**o**	**e**	--	**ə**	**o**	*Mid*
	+lo	**ia**	**üa**	**a**	**ua**	--	--	**a**	--	*Low*
		Front		*Central*	*Back*	*Front*		*Central*	*Back*	

Table 1: Laal vowels

(6) Additional information (see Appendix 1 for a short phonological sketch):

a. Four diphthongized vowels behaving like monophthongs: /ia, ua, üo, üa/ = /ɛ, ɔ, ø, œ/.

b. Labial consonants: /p, b, ɓ, mb, m, w/

c. Vowel length in the word-initial syllable only

d. No prefixes

e. Maximal word size: two syllables (trisyllables → V2 deletion)

(7) Co-phonologies:

a. "Stem" cophonology

b. "Word cophonology

(8) Pervasive vowel harmony: three (four?) harmony processes:

a. High harmony: perseverative agreement in [high].

b. Low harmony: anticipatory agreement in [low]

c. Rounding harmony:

i. Word-level, Systematic, unconditional rounding harmony

ii. Stem-level, doubly-triggered, parasitic rounding harmony

2.2 The doubly triggered rounding harmony

(9) Stem-level anticipatory rounding harmony: in a disyllabic word $CV_1(C).CV_2(C)$, V_1 harmonizes with V_2

a. Two necessary triggers: phonological teamwork

i. Round V_2

ii. **Lab**: labial consonant in the root, in any position

b. Further conditions on similarity between V_1 and $_{V2}$ (parasitic harmony)

i. **Height**: V_1 and V_2 are of equal height

ii. **-Front**: V_1 and V_2 are [-front][i]

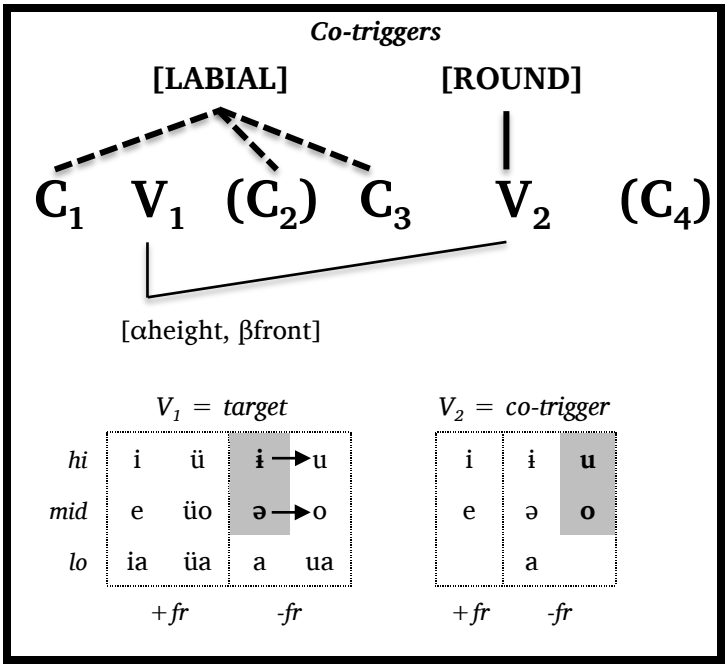

Figure 1. Laal doubly triggered rounding harmony

(10) V2[rd], Lab, Height, -Front → rounding[ii]

a.	/ɓìr-ú/	→ ɓ**ù**r-ú	'hooks'	(C_{lab} = C1)
b.	/tə̀b-ó/	→ t**ò**b-ó	'fishes sp.'	(C_{lab} = C2)
c.	/dìlm-ú/	→ d**ù**lm-ú	'types of houses'	(C_{lab} = C3)
d.	/pə́b-ó/	→ p**ó**b-ó	'cobras'	(C_{lab} = C1,C2)
e.	/mə̂lm-ó/	→ m**ô**lm-ó	'Koranic school teachers'	(C_{lab} = C1,C3)

(11) Only three stem-level suffixes containing a round vowel:

a. *-o*

b. *-u*

c. *-or*∼*-ur*

(12) All four conditions are necessary

				V_2[rd]	Lab	αHeight	βFront
a.	/kə̀ə̀m-ə́/	kə̀ə̀m-ə́	'trees (sp)'	*			
b.	/gín-ù/	gín-ù	'hunting nets'		*		
	/sə̀g-ó/	sə̀g-ó	'bags'				
c.	/mə̀ə̀g-ú/	mə̀ə̀g-ú	'tamarind trees'			*	
	/ɓə̀r-ú/	ɓə̀r-ú	'plants sp.'				
d.	/píl-ù/	píl-ù	'types of mats'				*
	/bìrú/	bìrú	'burn'				
e.	/mèn-ù/	mèn-ù	'hoes'			*	*
	/mèèg-ú/	mèèg-ú	'kaolin (pl.)'				
f.	/dán-ú/	dán-ú	'trees sp.'		*	*	
	/jə̀g-ú/	jə̀g-ù	'throwing knives'				
g.	/jíŋ-ù/	jíŋ-ù	'harpoons'		*		*
	/tíl-ù/	tíl-ù	'sands'				
h.	/nèn-ù/	nèn-ù	'pus (pl.)'		*	*	*
	/tèèr-ú/	tèèr-ú	'grasses sp.'				

Table 3: Non-application of the doubly triggered rounding harmony

(13) Blocking effect of interevening /w/: *UW, general phonotactic constraint (across cophonologies)

	Sg.		*Pl. suffix = -o*
a.	wàár	'genet'	w**òò**r-ó
b.	gâw	'hunter'	gə́w-ó
	gàw	'elephant trap'	gə̄w-ō
	jàw	'cheetah'	jə̀w-ó
	jāgw-ā	'hat'	jə́gw-ó
	māw	'scorpion'	mə́w-ó
	sàw	'fish sp.'	sə̄w-ō
	sáw	'warthog'	sə́w-ò
	táw-ál	'shield'	tə́w-ò

NB: Possible explanation: compensation (vowels preceding /w/ don't sound rounded because the rounding is attributed to the /w/; Mielke & Scarborough 2014)

(14) Limited, but exceptionless

a. 1141 Nouns in the dictionary (out of ca. 2600 lexical entries)

b. 129 nouns combine with plural *-o*, *-u*, *-or*∼*-ur*.

c. 48 of these 120 nouns have an underlying non-round vowel

d. 32 of these 48 nouns meet the conditions of the doubly triggered rd. harm.
→ ALL 32 undergo the harmony, except the 8 cases of intervening /w/ abovein (13) above. (see full list in Appendix 2)

(15) A few nouns have more than one possible plural forms.

a.	sàg	'tree sp.'	→		/sə́g-ú/	sə́gú
				∼	/sə́g-ó/	sə́gó
b.	báág	'ostrich'	→		/bə́ə́g-ú/	bə́ə́gú
				∼	/bə́ə́g-ó/	b**óó**gó ∼ [búúgó] (VGV)

(16) Relation between labial C and vowel rounding is omnipresent in Stem-cophonology

a. Doubly triggered rounding harmony is both an active process and a MSC, where it is only anticipatory:
gōbār 'cloud'
gúmlɨ́l 'round'

b. A frozen suprasegmental alternation (ca. 20 words)

	Sg.		*Pl.*	*Vowel raising*	*Vowel rounding*	*Lab C*
i.	ɗāgān	'be heavy'	ɗɨgìn	lo > hi	--	--
ii.	ɓāgāl	'be hard'	ɓùgùl	lo > hi	✓	C_1
	mān	'be delicious'	mùn	lo > hi	✓	C_1
	tārīm	'fish sp.'	tùrùm	lo > hi	✓	C_3
	pālīm	'tree sp.'	pùlùm	lo > hi	✓	C_1, C_3

(17) A phonological alternation (not just a superficial coarticulatory effect)

a. No sensitivity to speech rate, e.g. /ɓɨ̀r-ú/ with syllable break = [ɓù...rú]

b. Opacity of intervening /w/ (cf. (13) above)

c. Cophonology-dependent: word-level suffixes trigger regular, unconditional rounding harmony, e.g. Verb + *-ò(n)*∼*-ù(n)* 'her' and *-nŭ* 'us (ex.)' object suffixes:

i.	/tír + -ùn/	> *túr-ùn*	'put her across'	*Lab
ii.	/dəg + -òn/	> *dòg-òn*	'drag her'	*Lab
iii.	/dəg + -nŭ/	> *dòg-nŭ*	'drag us (excl.)'	*Lab, *Height
iv.	/léér + -nŭ/	> *lüóór-nŭ*	'wrap us'	*Lab, *Height, *-Front

3 The phonetic underpinnings of the harmony

(18) Acoustic measurements showing that

a. [ɨ, ə] are greatly affected by a neighboring labial consonant

b. much more so than by a following round vowel

c. I will then use this in section 4 as an argument in favor of analyzing labialized [ə^b, ɨ^b] as a separate contrastive but non-distinctive phonological category in Laal.

(19) Recordings:

a. in Gori (Laal speaking village), March 2014 and January 2015

b. Two male speakers, only one of whom is included here (Speaker 2)

i. Speaker 1: in his fifties

ii. Speaker 2: 27 years old (in 2014)

c. Both speak several other neighboring languages and (some) French.

d. mainly wordlists, elicited in French.

e. Equipment: Zoom H4n recorder, set at a sample rate of 44.1 kHz and 16 bit sample size (later downsampled to 11025 Hz), and a mono Røde NTG2 condenser shotgun microphone.

(20) Measurements in Praat (Boersma and Weenink 2014)

a. Stem-initial vowel's F1, F2 and F3

b. Automatically extracted at the midpoint of the total vowel interval (defined manually), i.e. as far as possible from formant transitions.

c. Some recordings were excluded from the sample due to excessive background noise.

3.1 Coarticulatory effects on [ə]

Conditions	Speaker 2 #w	#t	Example	
ə(ə)	**8**	**20**		
ə	*5*	*12*	gə̄rī	'tree sp. (pl)'
əə	*3*	*8*	ndə́ə́r	'skulls'
B	**34**	**98**		
Bə	*18*	*47*	pə́d	'pass'
Bəə	*6*	*27*	pə̄ə̄l	'village'
əB	*5*	*13*	kə́m	'fish sp. (pl)'
əəB	*2*	*5*	tə́ə́mər	'my cheek'
BəB	*1*	*3*	məmlə̀l	'my grandchild'
BəəB	*1*	*2*	mə̀ə̀mər	'my grandmother'
U	**3**	**7**		
ə-U	*2*	*6*	də́nú	'tree sp. (pl)'
əə-U	*1*	*1*	ʔə́ə́rú	'sauces'
BU	**6**	**9**		
Bə-U	*2*	*3*	pə̄nùg	'her nose'
Bəə-U	*3*	*5*	bə̀ə̀gú	'ostriches'
əB-U	*1*	*1*	tə̀bú	'fish sp. (pl)'
W	**14**	**23**		
wə	*1*	*1*	wə̂l	'oath'
əw	*10*	*18*	kə́w	'body'
əəw	*3*	*4*	kə́ə́w	'fingernails'
BW	**6**	**12**		
Bəw	*5*	*9*	pə́wər	'my friend'
WU	**5**	**9**		
əwU	*4*	*7*	gə́wò	'hunters'
ərwU	*1*	*2*	sə́rwò	'turtles'
BWU	**2**	**3**		
Bəw-U	*1*	*2*	pə́wrŭ	'our friend'
BəwU	*1*	*1*	mə́wó	'scorpions'

Table 1: ə-words sample ("#w" number of words; "#t" number of tokens)

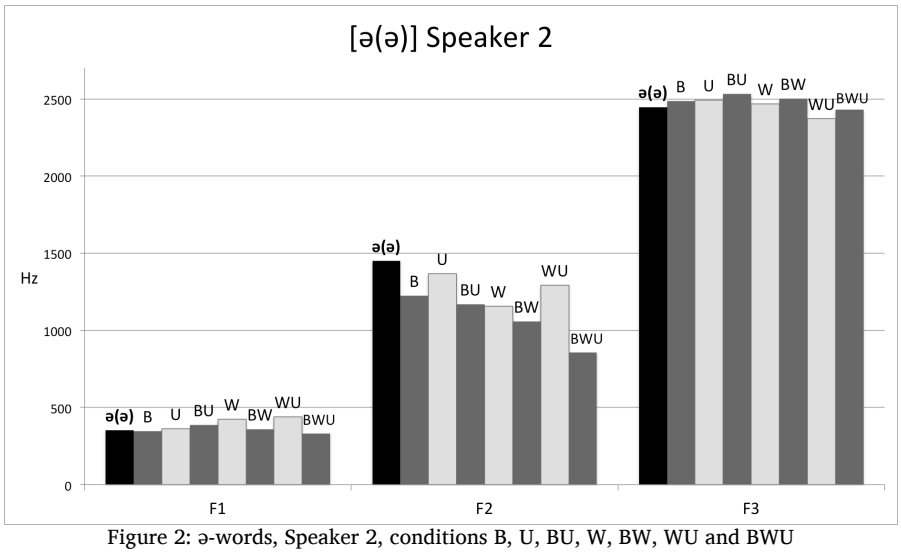

Figure 2: ə-words, Speaker 2, conditions B, U, BU, W, BW, WU and BWU

(21) Observations:

a. Clear lowering effect on F2 of al conditions (albeit not to the same extent)

b. No noticeable effect on F1 or F3

3.1.1 Effect of (near-)adjacent labial consonant (B condition)

(22) A (near-)adjacent labial consonant (B condition) has a very significant lowering effect on F2

a. Average F2 difference: 204 Hz

b. $p < 9.5 \times 10^{-5}$

(23) Effect of vowel length

a. Average F2 difference: 266 Hz

b. $p < 0.00012$

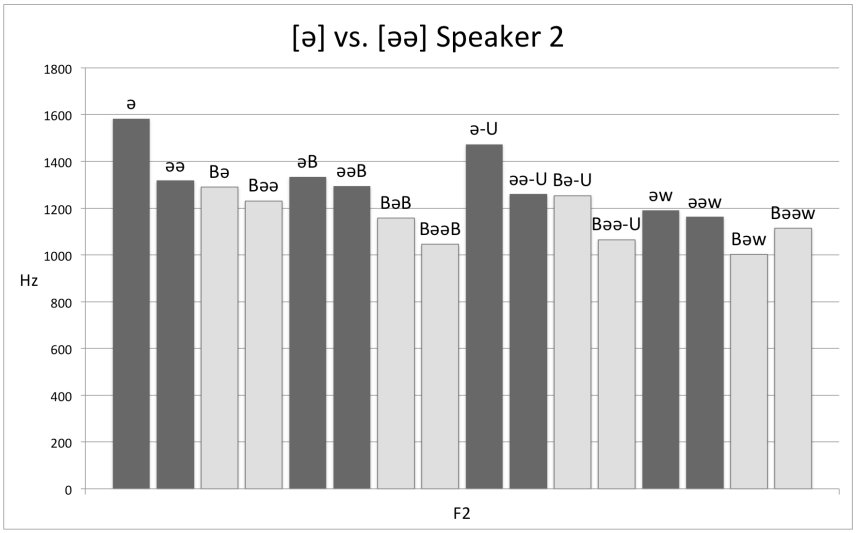

Figure 3: : [ə] vs. [əə], Speaker 2

(24) When short and long vowels are teased apart → same trend in both sets: they don't start with the same F2, but both undergo F2 lowering (cf. Figure 4):

a. Short [ə] and [ə^{b}]: significant F2 difference
   i. Average F2 difference: 286 Hz
   ii. $p = 4.3 \times 10^{-5}$

b. Long [əə] and [əə^{b}] (=Bəə + əəB): significant, but a little less so.
   i. Average F2 difference: 88 Hz
   ii. $p < 0.0034$

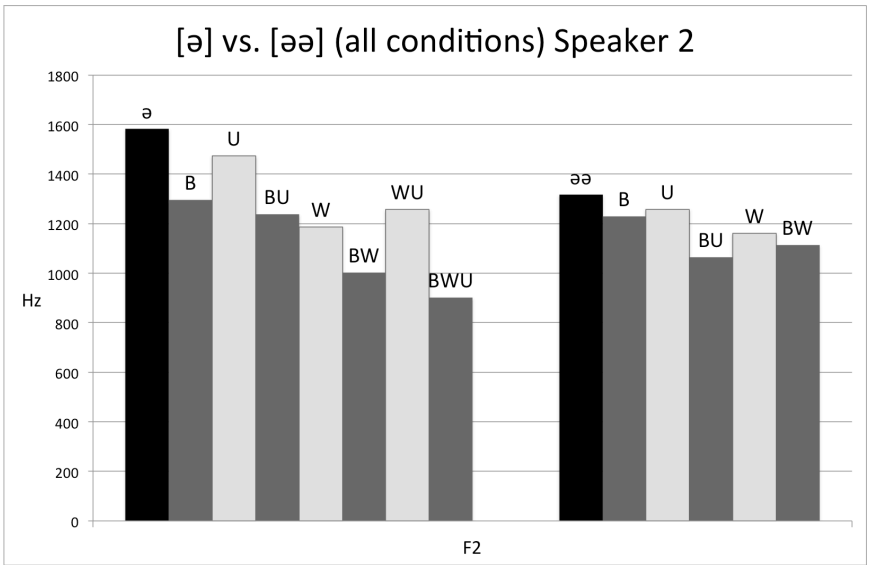

Figure 4: [ə] vs. [əə], Speaker 2

3.1.2 Effect of round V_2 (U condition)

(25) A following round vowel (U condition) has a lesser F2 lowering effect on [ə(ə)] (not or barely significant).

a. Average F2 difference: 110 Hz (quite important)

b. $p = 0.11$, i.e. NOT SIGNIFICANT
   (cf. overlapping distribution of E and U clouds on vowel plot in fig. 8-9 below)

3.1.3 Cumulative effects (BU, BW, WU, BWU conditions)

(26) F2 gets lower as conditions are added: B > BU > BW > BWU (cf. Figure 4 above and vowel plot in Figure 7 below)

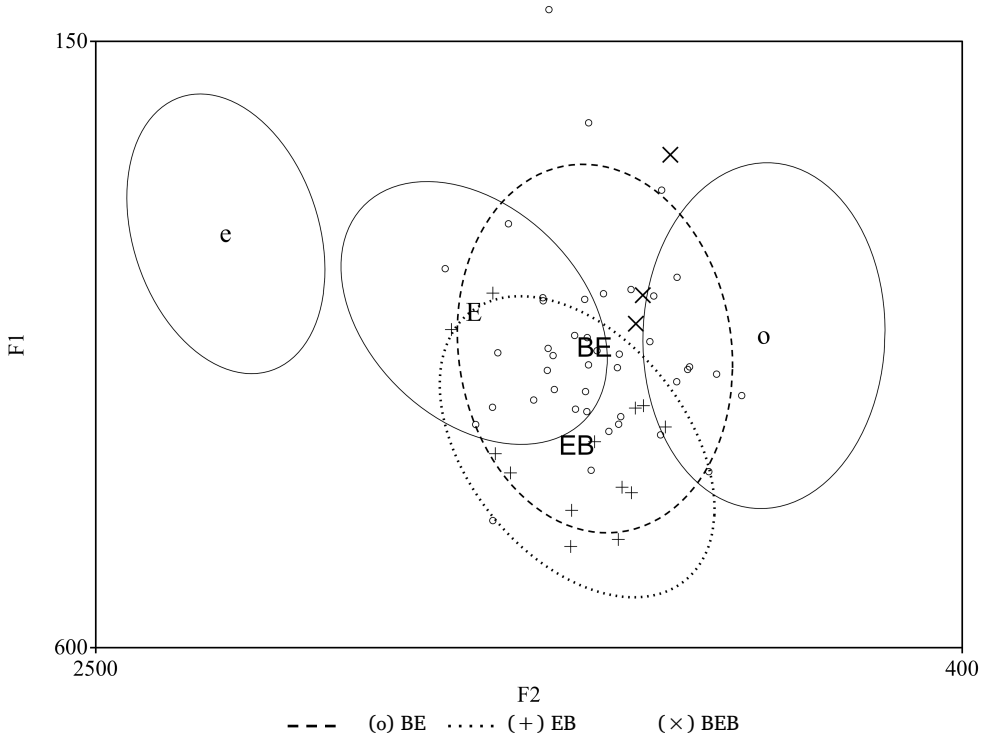

Figure 5: Bə, əB and BəB conditions, Speaker 2

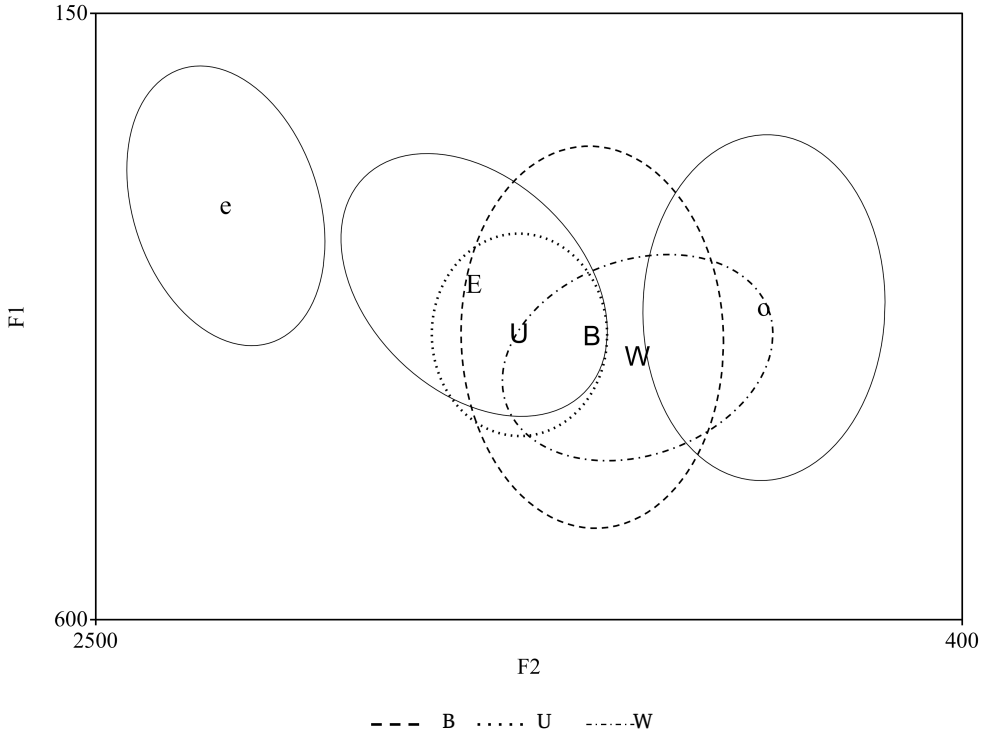

Figure 6: short [ə] in B, U and W conditions, Speaker 2

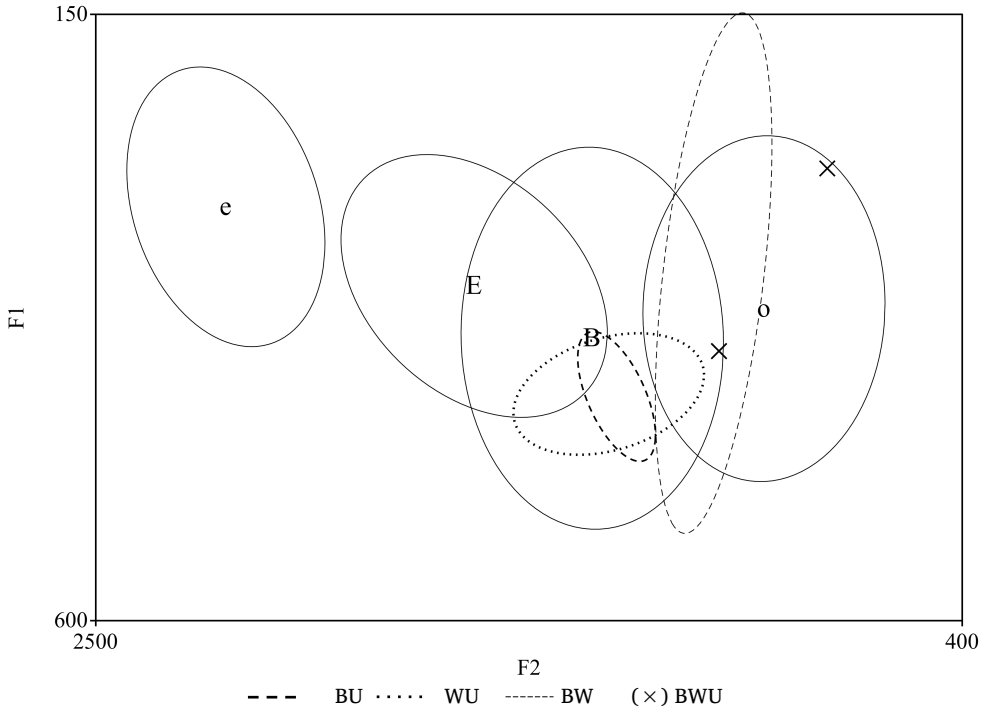

Figure 7: short [ə] in BU, WU, BW, BWU conditions, Speaker 2

Effects on [ɨ]: Similar as effects on [ə] (cf. Appendix 3)

3.2 Summary and interpretation

(27) There is a clear phonetic distinction between [ɨ, ə] and [ɨ^b, ə^b] (= B-condition): non-overlapping distributions
   a. Significant F2 lowering effect of (near-) adjacent labial consonant
   b. No significant effect of round V_2

(28) Phonetic data point to a phonological distinction: F3 is not affected, unexpected for labial coarticulation
   a. not a purely phonetic effect (not pure labial coarticulation),
   b. but phonetic encoding/realization of a phonological distinction.

(29) Conclusion: the distinction between [ɨ, ə] and [ɨ^b, ə^b] is phonological in nature:
   a. Phonology is sensitive to the phonetic distinction (stem-level doubly-triggered rounding harmony only targets [ɨ^b, ə^b], excluding [ɨ, ə])
   b. However, the word-level rounding harmony treats both as [-round]
   c. CLAIM: [ɨ, ə] and [ɨ^b, ə^b] are
      i. distinctive (subphonemically): two distinct perceptual categories
      ii. but NOT contrastive (phonemically, featurally): both [-round]

4 Subfeatural distinctions

(30) Growing body of evidence showing that (distributional) CONTRASTIVENESS and (perceptual) DISTINCTIVENESS are independent notions

	Contrastive	*Non-contrastive*
Distinctive	Phonemes	Quasi-phonemes (Kiparsky 2012 and ref. therein)
Non-distinctive	Near-mergers (Labov 1994)	Allophones

Table 2: Contrastiveness vs. distinctiveness (from Kiparsky 2012)

(31) Proposal: enriching phonology with subfeatural representations, to adequately represent (at least some) phonological relationships and categories that are between contrast and allophony (Currie Hall 2013).

4.1 Subfeatures and subfeatural scales

(32) Features: binary distinctions between <u>contrastive PHONEME</u> or natural classes.

a. E.g. Laal vowels: [+round] /ü, üo, üa, u, o, ua/
[-round] /i, e, ia, ɨ, ə, a/

b. Minimal pairs:
tɨ́m 'hand' vs. *túm* 'poke'
mèèg 'my neck' vs. *müòòg* 'her neck'
etc.

c. Word-level rounding harmony changes [-round] V_1 into [+round] if V_2 is [+round] (cf. (17)c)

(33) Subfeatural level: <u>distinctive</u> but <u>non-contrastive SUBPHONEMES</u>.

a. Capture fine-grained subphonemic distinctions within phonemic categories,

b. Subphonemes are visible to phonology as distinctive categories on the basis of subphonemic differences mostly resulting from phonologized (but not phonemicized) phonetic distinctions (coarticulation, enhancement etc.)

(34) Phonological categorization of [ɨ^b, ə^b]:

a. featurally: [-round] (like [ɨ, ə]) → relevant for word-level RdH
b. subfeaturally: ⟦.5 round⟧ (unlike [ɨ, ə]) → relevant for stem-level RdH

(35) With these subfeatural representations:

a. The doubly triggered rounding harmony can be understood as a case of harmony targeting ⟦.5 round⟧ vowels, and parasitic on height and backness.

b. Any theory of vowel harmony can account for the doubly triggered rounding harmony if it is allowed to manipulate subfeatural representations.

(36) The analysis proposed in Appendix 4 uses Hansson's (2014) modified version of Agreement by Correspondence (ABC)

5 Implications of a theory of subfeatural representations

5.1 Solving the "stabilization problem" of phonetically based phonology

(37) Examples of phonetically based approaches to phonology:
  a. Flemming's (2001, 2002) auditory representations
  b. Steriade's (2009) P-map
  c. All the papers in Hayes et al.'s (2004) *Phonetically based phonology*

(38) "Phonetic knowledge" (Kingston and Diehl 1994) is crucial to phonetically based approaches to phonology
  a. "the speaker's partial understanding of the physical conditions under which speech is produced and perceived." (Hayes and Steriade 2004:1)
  b. Phonetic knowledge = source of markedness constraints

(39) "Stabilization problem" ((Hayes and Steriade 2004:14-15):
  a. "maintaining a (relatively) stable phonology in the face of extensive variation in the phonetic factors that govern the phonological constraints."
  b. "[…] variation in speech rate is seldom associated with phonological neutralization."

(40) However:
  a. Phonetic knowledge is knowledge about phonetics, i.e. abstract representation of phonetics, i.e. PHONOLOGY
  b. Consequently, phonetic grounding is not tantamount to including direct phonetic motivations in phonology

(41) Subfeatural representations are a reification of phonetic knowledge (about coarticulation in this case) → entirely phonological. Compared to Flemming's auditory representations (for example):
  a. Flemming: Evaluation of MinDist requires reference to absolute formant values
  b. Subfeatural representations = relative values (cf. Fe[əə] = F2[ə^{b}]: what counts is not the actual F2 value)

5.2 Subfeatural scales: representing enhancement

(42) Enhancement between rounding, height and backness (Terbeek 1977; Linker 1982): height/backness enhance articulatory and perceptual salience of vowel rounding

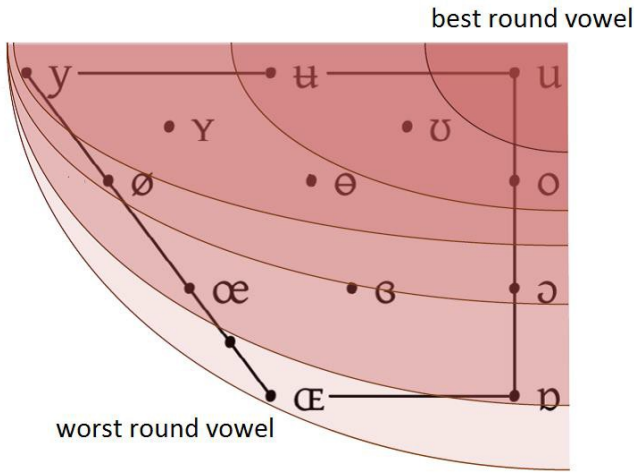

Figure 8: Rounding continuum (sketch)

(43) Sometimes relevant to phonological processes, such as rounding harmony parasitic on height and/or backness (cf. Kaun 1995, 2004): phonology needs to refer to these degrees of rounding.
→ Subfeatural distinctions make this possible:

Rounding continuum	*Subfeatural scale (distinctive)*	*Featural scale (contrastive)*
u	⟦3 round⟧	[+round]
o	⟦2 round⟧	
ua	⟦1 round⟧	
ɨᵇ, əᵇ	⟦.5 round⟧	[-round]
ɨ, ə, a	⟦0 round⟧	

Figure 9: (Sub)featural representation of the rounding continuum in Laal

(44) Other previous scalar representation proposals: De Lacy (2002), Mortensen (2006), Inkelas (2010), Rhodes (2012), or Flemming (2001, 2002).

(45) Novelty: features are defined as both binary and scalar:
a. Binary at the featural/contrastive level
b. Scalar at the subfeatural/non-contrastive level

(46) <u>Phonetically grounded</u>: it is the phonological representation of a phonologized phonetic continuum.
a. But it is <u>purely phonological</u>: phonologization has taken place and given the scale a phonological life of its own, although its phonetic origin is still transparent, and the phonological distinctions it makes still have distinct phonetic correlates
b. but NOT incompatible with Mortensen's (2006) non-substantive logical scales: further phonologization may lead an originally phonetically grounded subfeatural scale to become fully divorced from its phonetic origins (cf. Buckley 2000).

(47) Enabling constraints to refer specifically to, for example, ⟦3 rd⟧ to the exclusion of every other [+rd] vowel may simplify our analysis of parasitic rounding harmony.

5.2.1 Non-distinctive but contrastive: abstract contrast

(48) (Sub)featural scales make mismatches between (contrastive) features and (distinctive) subfeatures possible

a. apt representation of abstract featural distinctions between otherwise identical surface vowels, a very frequent example of loss of phonetic motivation due to phonologization

b. cf. Nupe's three /a/'s (Hyman (1970), Nez Perce two /i/'s (Hall and Hall 1980) etc.

(49) Laal: 2SG.OBJ 'you' (*-án* ~ *-á*) and 3N.PL.OBJ 'them (nt)' (*-àn* ~ *-àr*) suffixes:

a. always realized with [a]

b. but systematically trigger word-level rounding harmony

c. Contrast with 3M.SG.OBJ 'him' (*-án* ~ *-ár*) and 3N.SG.OBJ 'it' (*-àn* ~ *àr*) singular object suffixes, as shown below.

(50)

			-án ~ *-á* 'you (obj.)'	vs.	*-án* ~ *-ár* 'him'
a.	dāg	'drag'	d**uà**g-án		dàg-án
b.	piār	'tear apart'	p**üà**r-án		piàr-án
c.	ɓəj	'fool'	ɓ**uà**j-án		ɓàj-án
d.	léérí	'coil'	l**üáá**r-án		liáár-án
e.	pɨ́r	'catch'	p**ú**r-á		pɨ́r-ár
f.	ɓír	'show'	ɓ**ǘ**r-án		ɓír-án

(51)

			-àn 'them (neut., obj.)'	vs.	*-àn* 'it (obj.)'
a.	dāg	'drag'	d**uà**g-àn		dàg-àn
b.	piār	'tear apart'	p**üà**r-àn		piàr-àn
c.	ɓəj	'fool'	ɓ**uà**j-àn		ɓàj-àn
d.	léérí	'coil'	l**üáá**r-àn		liáár-àn
e.	pɨ́r	'catch'	p**ú**r-àn		pɨ́r-àr
f.	ɓír	'show'	ɓ**ǘ**r-àn		ɓír-àn

(52) Historically: /ia/ < *ɛ and /ua/ < *ɔ, but peripheral low vowels merged with /a/ outside σ1 (*CɛCɛ > CiaCa; *CɔCɔ > CuaCa)

a. Former /ua/ still triggers rounding harmony, despite being realized [a]

b. Subfeatural account of historical merger:

	[+rd]/⟦1 rd⟧	/ua/ (vs. /a/)	triggers RdH	
→	[+rd]/⟦0rd⟧	/a_1/ (vs. /a_2/)	triggers RdH	(mismatch)
→	[-rd]/⟦0rd⟧	/a/	no RdH	(realignment)

(53) Prediction: unless the morphemes in question are very frequent, such mismatches are predicted to be fairly unstable, i.e. mismatch tends to be realigned (no phonetic realization for abstract feature → poor recoverablity).

(54) Case in point: Laal, again!

a. Possessive suffixes on 65 nouns (inalienable): separate paradigm from object suffixes, but historically related (much less frequent)

b. 2SG.POSS 'your' does NOT trigger RdH (but most probably historically did)

c. (3N.PL 'their (nt)' still triggers RdH)

		-*à* 'your'	vs.	-*àr* 'his'	vs.	-*àn* 'their (neut.)
ndáár	'skull'	nd**áá**r-à		ndáár-àr		nduáár-àn
bāg	'shoulder'	b**à**g-à		bàg-àr		buàg-àn
piáár	'shin'	p**iáá**r-à		piáár-àr		püáár-àn

6 Conclusion

(55) The doubly triggered rounding harmony of Laal can be used as evidence in favor of subphonemic distinctions in phonology: labialized [ɨ^{b}, ə^{b}] are phonologically different from non-labialized [ɨ, ə], despite sharing exactly the same phonological features (both are [-rd]).

(56) This is new evidence in favor of a clear distinction between DISTINCTIVENESS and CONTRASTIVENESS

(57) The theory of subfeatural representations proposed here gives shape and substance to this distinction, and makes it possible to represent "intermediate phonological relationships" (Currie Hall 2013).

(58) What subfeatural can do for us:
   a. Solve the "stabilization problem" of phonetically grounded phonology
   b. Allow for a simple representation of phonological enhancement
   c. Allow for a simple representation of cases of abstract contrast, and their historical development

(59) Further possible applications:
   a. Incomplete neutralization (Dinnsen and Garcia-Zamor 1971, Port, Mitleb, O'Dell 1981, among others)
   b. Near-mergers and covert contrast (Labov et al. 1991, Labov 1994)

(60) Other options to explore: non-representational, more grammatical approaches:
   a. Local Constraint Conjunction
   b. Gang-up effect in Harmonic Grammar (Lionnet in preparation b)

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Appendix 1: Laal Phonological sketch

		V_1 (and $V:_1$)				V_2 (*$V:_2$)				
		[+front]		[-front]		[+front]		[-front]		
		[-rd]	[+rd]	[-rd]	[+rd]			[-rd]	[+rd]	
+hi	-lo	**i**	**ü**	**ɨ**	**u**	**i**	--	**ɨ**	**u**	*High*
-hi	-lo	**e**	**üo**	**ə**	**o**	**e**	--	**ə**	**o**	*Mid*
	+lo	**ia**	**üa**	**a**	**ua**	--	--	**a**	--	*Low*
		Front		*Central*	*Back*	*Front*		*Central*	*Back*	

Table 1: Laal vowels

(61) Additional information (see Appendix 1 for a short phonological sketch):

a. Four diphthongized vowels behaving like monophthongs: /ia, ua, üo, üa/ = /ɛ, ɔ, ø, œ/.

b. Labial consonants: /p, b, ɓ, mb, m, w/

c. Vowel length in the word-initial syllable only

d. No prefixes

e. Maximal word size: two syllables (trisyllables → V2 deletion)

i.	*súrám*	'tree sp.'	**súrám-ú* > *súrm-ú*	id.(pl)
ii.	ɓàgál	'head'	*ɓàgál-ál > ɓàgl-ál	'his head'

The vowel inventory includes four diphthongized vowels: /ia, ua, üo, üa/. The low peripheral vowels /ia/ and /ua/ are derived from former *ɛ and *ɔ respectively, and are still occasionally realized [ɛ] and [ɔ]. /üo/ and /üa/, on the other hand, are always realized as diphthongs: [ɥo~ɥø] and [ɥa] respectively. These complex vowels behave exactly like monophthongs from a phonological point of view.

Front rounded vowels are contrastive in the language, as shown by the minimal pairs in [ExFRV1] and [ExFRV2] below. [ExFVR1] = rounding contrast among front vowels [ExFVR2] = front/back contrast among round vowels

[ExFRV1]	ɓírán	'show him'	vs.	ɓűrán	'show you (sg)'
	/ɓír-án/			/ɓír-uán/	
	mèèg	'my neck'	vs.	müòòg	'her neck'
	miààg	'his neck'		müààg	'your neck'

[ExFRV2]	ɓűrùn	'show her'	vs.	ɓúrùn	'tear/pull her out'
	/ɓír -òn/			/ɓɨr-òn/	
	püòòròn	'advise her'		póóròn	'knock her down'
	/piààr -òn/			/páá -òn/	
	püààrán	'advise you (sg)'	vs.	puáárán	'knock you (sg) down'
	/piààr -uán/			/páá -uán/	

However, with very few exceptions, front rounded vowels are only found as the result of a morpho-phonological process, mostly anticipatory rounding harmony (only three roots can be said to have a front rounded vowel underlyingly). This explains why they are never found outside of the stem-initial syllable. These vowels, most probably quite recently phonemicized, can thus be considered relatively marginal in the vowel system of Laal.

The distribution of vowels and consonants defines the stem-initial C_1V_1 sequence as the locus of maximal phonological distinction in Laal: it is the only position where the full inventory of consonants (except /ŋ/) and vowels is attested. Elsewhere, front rounded vowels, the

peripheral low vowels /ia/ and /ua/, and /h/ are prohibited, and the plosives are reduced to an underspecified series /B, D, J, G/, with roughly two complementary realizations: [+voice] word-internally (/b, d, j, g/ both intervocalically and in CC clusters), [-voice] and often unreleased word-finally (/p, t, c, k/). V_1 is also the only position where vowel length is contrastive.[iii]

		C_1					Non-C_1				
		Lab	Dent	Pal	Vel	Gl	Lab	Dent	Pal	Vel	Gl
Plosive	Voiceless	**p**	**t**	**c**	**k**	**(ʔ)**					
	Voiced	**b**	**d**	**j**	**g**		**B**	**D**	**J**	**G**	**--**
	Prenasalized	**mb**	**nd**	**nj**	**ng**						
	Implosive/glottalized	**ɓ**	**ɗ**	**'y**							
Non-plosive	Nasal	**m**	**n**	**ny**	**--**		**m**	**n**	**ny**	**ŋ**	
	Lateral		**l**					**l**			
	Tap		**r**					**r**			
	Glide	**w**		**y**			**w**		**y**		
	Fricative		**s**			**h**		**s**			**--**

Table 2: Laal consonants

The morpho-phonology of Laal is characterized by pervasive vowel harmony. Four harmony processes are attested: two height harmonies (high and low), briefly described in the remainder of this section, and two rounding harmonies, including the doubly triggered one which is the object of this paper.

High harmony is perseverative, and can be characterized as follows: a high vowel in the stem-initial syllable (V_1) causes any following mid vowel to become high. This is illustrated in [ExHiH] below with the first person singular possessive -ə̀r and object -ə́r/ə́n suffixes.

[ExHiH] High harmony

mīīw	'live'	→	mììw-ɨ̀r	'my liver'
mɨ̄lā	'eye'	→	mɨ̀l-ɨ̀l	'my eye'
mbūl	'navel'	→	mbùl-ɨ̀l	'my navel'
ɨ́ɨ́rí	'annoy'	→	à ɨ́ry-ɨ́n	'he annoys me'

Low harmony is anticipatory, and enforces agreement in the feature [low] between a non-high V_1 and the following vowel. As a consequence, two consecutive non-high vowels in a word may only be either both low or both mid (i.e. *mid-lo and *lo-mid), and a high vowel may only be preceded by a non-low vowel (this last rule suffers many exceptions, which shall not preoccupy us here). This is illustrated in [ExLoH]a and [ExLoH]b below with the third person neuter singular object suffix *-àr* ~ *-àn* and the medio-passive suffix *ɨ́ny*~*-í*

[ExLoH1] Low Harmony

a.	léérí	'roll'	→	liáár-àn	'roll it'
	cə̄r	'want'	→	càr-àr	'want it'
	sór	'find'	→	suár-àr	'find it'
b.	iáár	'choose'	→	éér-ɨ́ny	'chosen'
	màŋà	'gather'	→	màŋ-ɨ́ny	'gathered'
	juāŋ	'buy, sell'	→	jòŋ-ɨ́ny	'buy from one another'

Finally the lexical phonology of Laal involves two separate co-phonologies (stem vs. word), characterized by different morpho-phonological processes. While the High- and Low-harmonies briefly described above are general processes applying across cophonologies, other processes apply only within a specific cophonology. Such is the case of the two rounding harmonies that I

will analyze in this paper: the doubly triggered rounding harmony is only active in the stem cophonology, whereas the general rounding harmony is attested in the word cophonology.

Appendix 2: List of nouns where the doubly triggered rounding harmony applies actively

	High Vowel:			
	Sg.		*Pl. suffix* = -u, -ur	
a.	bɨ́nàn	'okra'	bûnn-ú	
b.	bɨ̀g-ál	'bark'	būg-ū	
c.	ɓɨ̀r-à	'fish hook'	ɓùr-ú	
d.	cɨ́rám ~ [círám][iv]	'tree (sp.)	cúrm-ú	
e.	dīlām	'type of house'	dùlm-ú	
f.	màl	'skilled artisan'	mùl-ù	
g.	sɨ́bl-ál	'lie'	súb-ùr	
h.	sɨ̀m-à	'fishing net'	sùm-ú	
	Mid-vowel:			
	Sg.		*Pl. suffix* = -o, -or	
i.	bàg-à	'antelope sp.'	bòg-r-ó	
j.	báág	'ostrich'	bóóg-ó ~ [búúgó]	(VGV)[v]
k.	ɓàg-ál	'head'	ɓòg-ór ~ [ɓùgór]	(VGV)
l.	bǎl	'fish sp.'	bòl-ó	
m.	málìm	'Koranic teacher'	môlm-ó	
n.	màm-ál	'grand-child'	mòm-ór	
o.	mààm-ál wīī	'fish sp.'	mòòm-ór wīyā	
p.	mə́g-ól [mɨ́gə́l]	'mouse'	móg-ór ~ [múgór]	(VGV)
q.	nyàm jàm	'antelope sp.'	nyəm jòm-ó	
r.	sám	'boa'	sóm-ò	
s.	sāām	'skin'	sóóm-ó	
t.	tàb	'fish sp.'	tòb-ó	
u.	wàár	'genet'	wòòr-ó	

Appendix 3: Coarticulatory effects on [ɨ]

Conditions	Speaker 2 #w	#t	Example	
ɨ	**24**	**41**	dīgā	'be bad'
B	**38**	**99**		
Bɨ	*17*	*46*	ɓɨ̀rà	'fish hook'
Bɨɨ	*3*	*3*	mɨ̀ɨ̀r	'curse (pl)'
ɨB	*17*	*49*	lɨ̀bár	'immerse'
ɨCB	--	--	lɨ̀gmà	'horses'
BɨrB	*1*	*1*	pɨ́rmɨ́n	'dust'
U	**1**	**1**	gɨ́nù	'hunting nets'
W	**6**	**10**		
ɨw	*5*	*6*	kɨ̄w	'eat (pl)'
ɨɨw	*1*	*4*	gɨ́ɨ́wí	'turn'

Table 3: ɨ-words sample ("#w" number of words; "#t" number of tokens)

NB: the U condition is attested only in the word gɨ́nù *'nets (sp.)', recorded only once (only one token).*

(62) Various conditions lower F2, but no change to F1 and F3.

a. B-condition: [ɨ] vs. [ɨ^{b}] (= Bɨ + ɨB)

i. Average F2 difference: 399 Hz

ii. $p < 2.2 \times 10^{-16}$

b. U-condition: no effect (but only one token: no solid conclusion can be drawn)

c. Cumulative conditions: no effect

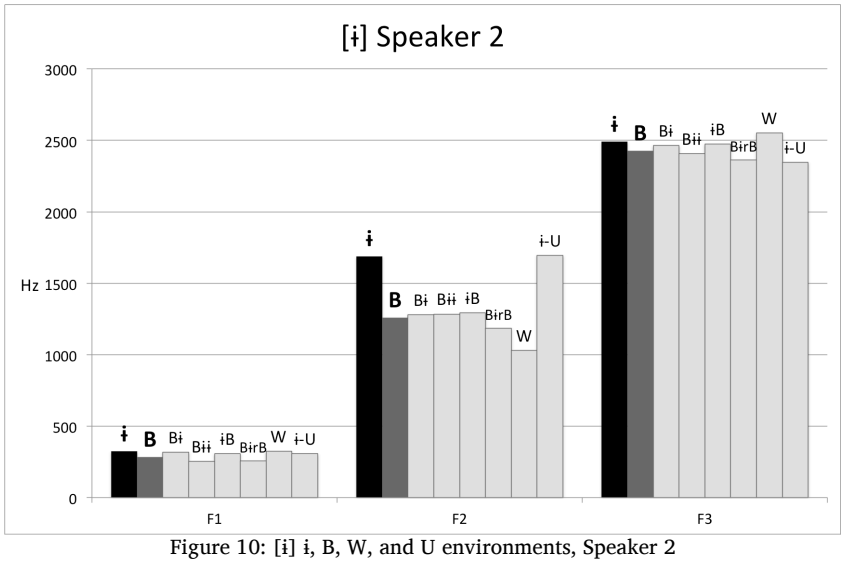

Figure 10: [ɨ] ɨ, B, W, and U environments, Speaker 2

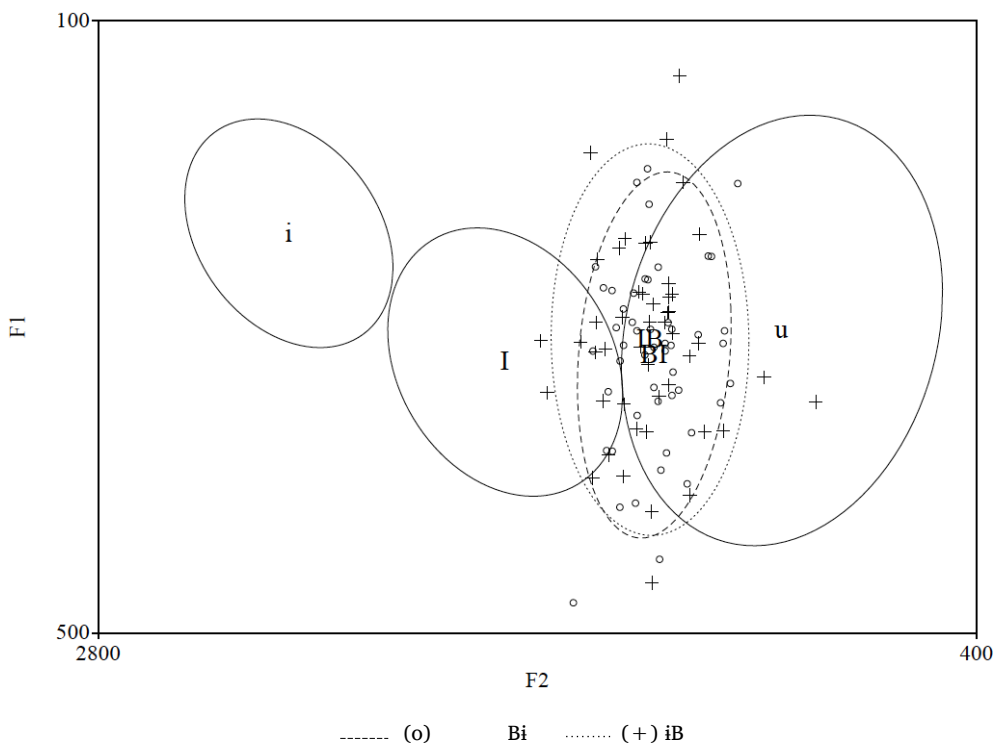

Figure 11: Coarticulatory effect of adjacent labial consonant on /ɨ/ (Speaker 2)

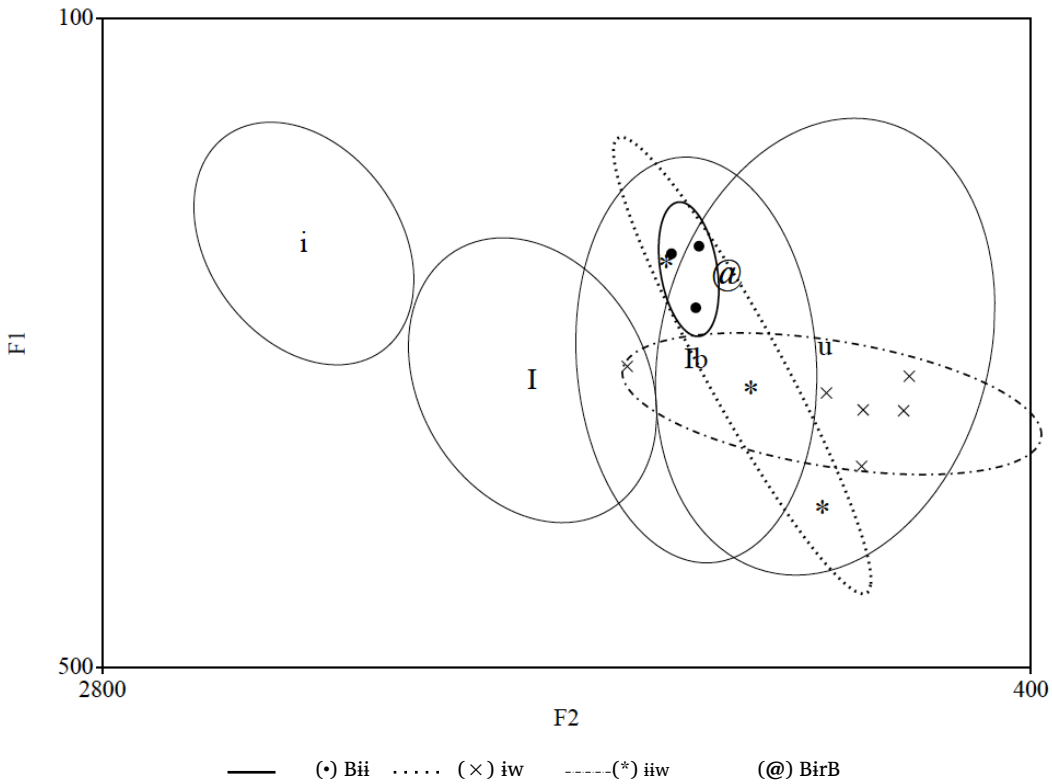

Figure 12: [ɨ] in conditions Bɨɨ, ɨw, ɨɨw and BɨrB, Speaker 2

Appendix 4: One possible analysis of the doubly triggered rounding harmony

(63) With these subfeatural representations:

a. The doubly triggered rounding harmony can be understood as a case of harmony targeting ⟦.5 round⟧ vowels, and parasitic on height and backness.

b. Any theory of vowel harmony can account for the doubly triggered rounding harmony if it is allowed to manipulate subfeatural representations.

(64) Analysis proposed here uses Hansson's (2014) modified version of Agreement by Correspondence (ABC): SIMILARITY-based

a. Generally speaking, assimilation (harmony) has to do with similarity

b. Parasitic harmony involves specific featural similarity constraints between targets and triggers: here [αheight, βfront].

(65) Agreement by Correspondence (ABC):

a. **Long-distance consonant agreement** (original ABC: Walker 2000a,b, 2001; Hansson 2001; Rose & Walker 2004)

b. Extended to **Vowel Harmony** (Sasa 2009; Walker 2009; Rhodes 2012)

c. and **Long-distance Consonant Dissimilation** (Bennett 2013)

d. + recent and ongoing effort to account for **local effects** of assimilation and dissimilation in ABC (Inkelas and Shih 2013a,b; Shih 2013; Sylak-Glassman 2013; Lionnet 2014)

(66) Basic mechanics of Hansson's 2014 revised ABC: targeted markedness constraints *[αF][-αF]/[βG, ɣH] replace output-to-output IDENT and CORR constraints:

*[αF][-αF] / [βG, ɣH]

penalizes any sequence of segments disagreeing in the feature [F]… ≈ IDENT-XX[F]	…within the set/projection of output segments specified as [βG, ɣH] ≈ CORR-XX[βG, ɣH]

(67) ***⟦.5 rd⟧[+ rd]/[αheight, βfront]**: A round vowel may not be preceded by a subphonemically rounded vowel in an output string if both segments agree in height and [-front]. Assign one violation for each pair of neighboring segments that meet the criteria but fail to correspond.

(68) Laal rounding similarity scale (how similar is each [-round] vowel to the [+round] vowels /u, o/?)

	Similarity between trigger and target	*V similar to /u/*	*V similar to /o/*
most similar	⟦.5rd⟧/[αheight, βfront]	ɨ^{b}	ə^{b}
(potentially difficult to rank)	⟦.5rd⟧/[αheight]	i^{b}, ɨ^{b}	e^{b}, ə^{b}
	⟦.5rd⟧/[βfront]	ɨ^{b}, ə^{b}	
	⟦.5rd⟧	i^{b}, ɨ^{b}, e^{b}, ə^{b}	
	[αheight, βfront]	ɨ, (incl. ɨ^{b})	ə (incl. ə^{b})
	[αheight]	i, ɨ, (incl. i^{b}, ɨ^{b})	e, ə (incl. e^{b}, ə^{b})
	[βfront]	ɨ, ə (incl. ɨ^{o}, ə^{o})	
least similar	V (any vowel)	i, ɨ, e, ə, ia, a (incl. i^{o}, ɨ^{o}, e^{o}, ə^{o}, ia^{o}, a^{o})	

(69) Markedness constraint hierarchy:

Similarity scale	**Markedness hierarchy**
⟦.5rd⟧/[αheight, βfront]	*⟦.5rd⟧[+rd]/[αheight, βfront]
> ⟦.5rd⟧/[αheight] ⟦.5rd⟧/[βfront] ⟦.5rd⟧ [αheight, βfront] [αheight] [βfront]	≫ *⟦.5rd⟧[+rd]/[αheight] *⟦.5rd⟧[+rd]/[βfront] *⟦.5rd⟧[+rd] *[-rd][+rd]/[αheight, βfront] *[-rd][+rd]/[αheight] *[-rd][+rd]/[βfront]
> V (any vowel)	≫ *[-rd][+rd]

(70) Activity of Markedness constraints in hierarchy depends on relative ranking of Faithfulness to [round]:

Stem cophonology	*Word cophonology*
*⟦.5rd⟧[+rd]/[αheight, βfront]	*⟦.5rd⟧[+rd]/[αheight, βfront]
|	|
IDENT [rd]	*[-rd][+rd]
|	|
*[-rd][+rd]	**IDENT [rd]**

(71) Other constraints needed:

a. *U(C)W — Assign a violation for each round vowel followed (with or without an intervening consonant) by /w/

b. IDENT$_{\sigma 2}$[RD] — For every [round] feature in the second syllable of an output form, a corresponding [round] feature must exist in its input form, and for every [round] feature in the second syllable of an input form, a corresponding [round] feature must exist in its output form.
(Accounts for right-to-left directionality)

(72) /ɓɨ̀r-ú/ → [ɓùrú] (all conditions met: harmony)

/ɓɨ̀r-ú/	*U(C)W	IDENT$_{\sigma 2}$[RD]	*⟦.5RD⟧[+RD]/[αHT, βFR]	IDENT [RD]
a. ɓɨ̀^{b}r-ú			*!	
☞b. ɓùr-ú				*
c. ɓɨ̀^{b}r-ɨ́		*!		*

(73) /mèn-ú/ → [mènú] (not all conditions met: no harmony)

/mèn-ú/	*U(C)W	IDENT$_{\sigma 2}$[RD]	*⟦.5RD⟧[+RD]/[αHT, βFR]	IDENT [RD]
☞a. mè^{b}n-ú				
b. müòn-ú				*!
c. mùn-ú				*!
d. mè^{b}n-ɨ́		*!		*

(74) /sə̀g-ó/ → [sə̀gó] (not all conditions met: no harmony)

/sə̀g-ó/	*U(C)W	IDENT$_{\sigma 2}$[RD]	*⟦.5RD⟧[+RD]/[αHT, βFR]	IDENT [RD]
☞a. sə̀g-ó				
b. sòg-ó				*!
c. sə̀g-ə́		*!		*

(75) /mə́w-ó/ → [mə́w-ó] (opacity of intervening /w/: no harmony)

/mə́w-ó/	*U(C)W	IDENT$_{\sigma 2}$[RD]	*⟦.5RD⟧[+RD]/[αHT, βFR]	IDENT [RD]
☞a. mə́^{b}w-ó			*	
b. mów-ó	*!			*
c. mə́^{b}w-ə́^{b}		*!		*

(76) /gōbər/ → [gōbər] (strictly anticipatory, never perseverative)

	/gōbə̄ᵇr/	*U(C)W	IDENT$_{\sigma 2}$[RD]	*⟦.5RD⟧[+RD]/[αHT, βFR]	IDENT [RD]
☞a.	gōbə̄ᵇr				
b.	gōbōᵇr				*!
c.	gə̄ᵇbə̄ᵇr		*!		*

[i] There is only one exception of a [+front] /i/ rounding to /ü/, cf. Appendix 3.

[ii] Throughout this paper, underlying forms are given after application of all other phonological processes, e.g. V_2 deletion (e.g. /dīlām + -ú/ → dùlm-ú), other vowel harmonies (e.g. Low harmony triggering raising of low /a/ to mid /ə/ in /páb + -ó/ → pə́b-ó → pób-ó), etc.

[iii] Since the two realizations of non-C1 plosives are in complementary distribution, they are not distinguished in the orthography: all non-C1 plosives are written as *b, d, j* and *g* respectively. Vowel length is orthographically represented by doubling the (last) vowel, e.g. *gàl* 'hang' vs. *gààl* 'jar', *biàr* 'plant sp.' vs. *biàár* 'fish sp.'

[iv] The singular form of [ExListU]d is often realized with a front V_1 [círám], due to the tendency of non-low central vowels to be fronted when adjacent to a palatal consonant: /Jɨ, Jə/ → [Jɨ~Ji, Jə~Je] (but /Ji, Je/ → [Ji, Je]). The [+front] vs. [-front] realization seems to depend largely on the segmental environment: acoustically grave segments such as velar and labial consonants or back rounded vowels tend to favor the [-front] allophone, while the [+front] realization is more frequent in other contexts.

[v] The [+high] realization of V_1 in 0j-k-p and (15)b is due to a stem-level dissimilation process ("VGV" dissimilation) whereby a word-internal velar consonant wedged between two identical [-front] mid vowels causes the first vowel to raise to high: /oGo, əGə/ → [uGo, ɨGə]. This process is sometimes optional, and subject to idiolectal variation.