Phonological Teamwork as Quantal Markedness

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1. Introduction

The goal of this paper is to propose an analysis of phonological teamwork, a process which obtains when two segments aspiring to trigger the same phonological process (here assimilation), but too weak to trigger it on their own, main "join forces" and together pass the threshold necessary for that process to occur. A well-known example of teamwork is Cantonese inter-coronal fronting, a morpheme structure constraint that bans back vowels between two coronal consonants, illustrated in ex. 1 below.

1) Cantonese inter-coronal fronting (Flemming 1997, 2001): *TuT > TyT

a. kʰyt	'decide'	kʰut	'bracket'
b. tʰuk	'bald head'		
c. tʰyt	'take off'	*tʰut	

Note that the combination of a back vowel with one adjacent coronal consonant is allowed, but not two. The fronting effect of a coronal consonant is not strong enough to trigger vowel fronting: two triggers are needed.

There are at least two logical ways of dealing with phonological teamwork. In a phonetically grounded approach, the cumulative effect at work may be seen as the result of the ganging up of weak phonetic effects to make a single strong influence, as proposed by Flemming (1997, 2001, 2002) or Lionnet (2014). Alternatively, one may propose a purely grammar-driven analysis, by allowing two or more weak grammatical constraints, each of which wants a categorical assimilation, to team up in order to overcome a strong faithfulness requirement.

In this paper I explore the latter, grammar-driven option, by proposing an analysis of phonological teamwork couched in Harmonic grammar (Legendre et al. 1990, Smolensky and Legendre 2006), which allows for a straightforward formalization of cumulative constraint interactions. This account rests on the analysis of two cases of phonological teamwork that illustrate the two types of cumulative constraint interaction identified by Jäger and Rosenbach (2006): Woleaian *a*-raising (Sohn 1971, 1975; Suzuki 1997), which is a case of "counting cumulativity" (multiple violations of one weak constraint overcoming one violation of a strong constraint), and the Laal doubly triggered rounding harmony (Lionnet 2014, in preparation a, b), which illustrates "ganging cumulativity" (one violation of multiple weak constraints at the same time, overcoming one violation of a stronger constraint).

I first describe the Woleaian and Laal alternations (section 2), and then develop my analysis, implementing the latest version of Agreement by Correspondence theory (Hansson 2014) in Harmonic Grammar (section 3). Finally in Section 4, I propose a brief evaluation of this Harmonic Grammar account against alternative approaches, and highlight a few problems to be solved in future research.

2. Phonological teamwork: Woleaian and Laal

2.1. Woleaian *a*-raising

In Woleaian, a Micronesian language whose vowel inventory is presented in Table 1, the vowel /a/ is raised to [e] whenever the two flanking syllable nuclei are [+high]. This typical double-sided effect, similar to the Cantonese alternation in (1) above, is illustrated in (2), where the two (potential) triggers are underlined.

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Table 1: Woleaian vowel system (Sohn 1971)

	Short vowels			Long vowels			
	-back		+back	-back		+back	
+high	i	ü	u	ii	üü	uu	
-high	e		o	ee	öö	oo	-low
	a			aa		ɔɔ	+low
	-rd	+rd		-rd	+rd		

2) Woleaian *a*-raising: a → e / $V_{[+hi]}$(C) ___(C)$V_{[+hi]}$ (Sohn 1971, 1975; Suzuki 1997)

a. /ü̲wa-li̲/	→	üwel-i	b. /i̲ta-ʃa/	→	ita-ʃe
/ülü̲ma-mʷu̲/	→	ülüme-mʷu	c. /li̲bbeya-i̲/	→	libbeya-i
/i̲ta-i̲/	→	ite-i	d. /i̲-taai̲/	→	i-taai

As can be seen, raising does not apply if only one of the two flanking vowels is [+high] as in ex. 2b; if the two [+high] vowels are not directly adjacent to the target as in 2c; or if the target is long, as in 2d.[1]

2.2. Laal doubly triggered harmony

Laal is a language isolate spoken by ca. 800 people in two villages in southern Chad. All the data presented in this paper come from my own fieldwork (twelve months between 2010 and 2015). The vowel inventory of Laal is presented in table 1 below.[2]

Table 2: Laal vowels

V_1 (and $V{:}_1$)				V_2 (*$V{:}_2$)			
[+front]		[-front]		[+front]		[-front]	
i	ü	ɨ	u	i	--	ɨ	u
e	üo	ə	o	e	--	ə	o
ia	üa	a	ua	--	--	a	--

The doubly triggered rounding harmony of Laal applies under very restrictive conditions. First, it is parasitic: the trigger and target vowels need to be of equal height (αHeight condition) and backness (βFront condition). Second, and more interestingly, it is particularly unusual in requiring two triggers: a round vowel can round the previous syllable's vowel only with the help of a labial consonant. However, contrary to better-known cases of teamwork like Cantonese (ex. 1 above) and Woleaian (ex. 2 above), this doubly triggered harmony does not involve a double-sided effect: the two triggers may be on either side of the target as in 3a, or both on the same side as in 3b-c.

3) $V_{2[rd]}$, C_{labial}, αHeight, βFront → rounding

a. /ɓɨ̀r-ú/	→ ɓùr-ú	'hooks'	($C_{labial} = C_1$)
b. /tə̀b-ó/	→ tòb-ó	'fishes sp.'	($C_{labial} = C_2$)
c. /dɨ̀lm-ú/	→ dùlm-ú	'types of houses'	($C_{labial} = C_3$)
d. /pə́b-ó/	→ pób-ó	'cobras'	($C_{labial} = C_1$ and C_2)
e. /mə̂lm-ó/	→ môlm-ó	'Koranic school teachers	($C_{labial} = C_1$ and C_3)

Given the reduced V2 inventory, the only two potential trigger vowels are /o/ and /u/, and the only two targets /ə/ and /ɨ/, as shown in Figure 1. Additionally, since words are maximally disyllabic in Laal, the harmony involves only one target vowel: V1.[3]

[1] The vowel /a/ raises to [e] in two more environments in Woleaian: word-finally (as in ex. 2b), and preceding a syllable whose nucleus is also /a/. These two other types of *a*-raising are left aside, for lack of space, and because they are not directly relevant to the double-sided raising described here.

[2] The transcription system used here is based on Africanist conventions: /j,ɟ,ɲ/ are transcribed <y,j,ny> respectively, and <ü> stands for the high front rounded vowel /y/. The diphthongized vowels /ia, ua, üo, üa/ behave phonologically like the monophthongs /ɛ, ɔ, ø, œ/ respectively.

[3] Non-derived words are maximally disyllabic (CV_1:C.CV_2C): of the 2413 dictionary entries, only 66 are trisyllabic, and 12 tetrasyllabic. Most of these 78 words of more than two syllables are ideophones, frozen compounds, reduplicative forms and/or loanwords, which can be expected to display irregular phonotactics, and will be ignored

The harmony is both an exceptionless morpheme structure constraint, and an active morpho-phonological process, applying between roots and stem-level suffixes, mainly number marking suffixes on nouns and verbs. As can be seen from the examples in table 3 below, all four conditions (the two triggers $V2_{[rd]}$ and C_{labial}, and the two additional conditions αHeight and βFront) must be met in order for rounding of V1 to occur. If any one of the four conditions is missing, as in the examples in a, the harmony fails to apply. The examples in b and c show that, as expected, the harmony does not apply either when more than one condition is missing.[4]

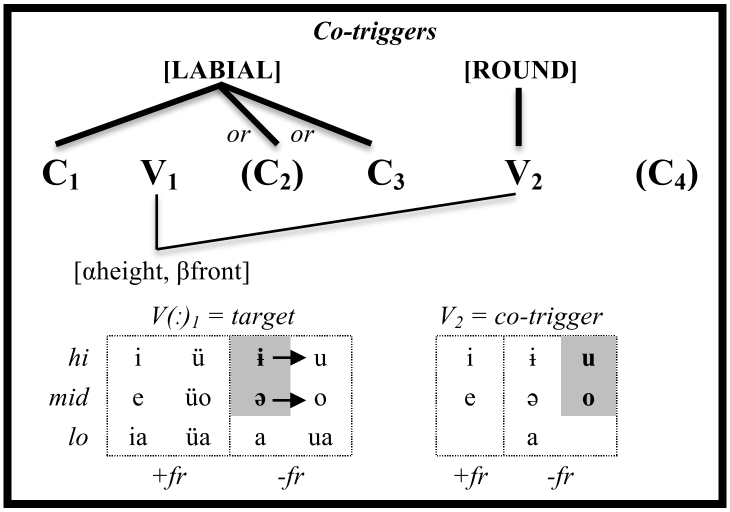

Figure 1. Laal doubly triggered rounding harmony

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

				$V2_{[rd]}$	C_{labial}	αHeight	βFront
a.	Only three of the four conditions are met						
	/kə̀ə̀m-ə́/	kə̀ə̀m-ə́	'trees (sp)'	*			
	/gɨ́n-ù/	gɨ́n-ù	'hunting nets'		*		
	/sə̀g-ó/	sə̀g-ó	'bags'				
	/mə̀ə̀g-ú/	mə̀ə̀g-ú	'tamarind trees'			*	
	/ɓə̀r-ú/	ɓə̀r-ú	'plants sp.'				
	/píl-ù/	píl-ù	'types of mats'				*
	/bìrú/	bìrú	'burn'				
b.	Only two of the four conditions are met						
	/mèn-ù/	mèn-ù	'hoes'			*	*
	/mèèg-ú/	mèèg-ú	'kaolin (pl.)'				
	/də́n-ú/	də́n-ú	'trees sp.'		*	*	
	/jə̀g-ú/	jə̀g-ù	'throwing knives'				
	/jíŋ-ù/	jíŋ-ù	'harpoons'		*		*
	/tíl-ù/	tíl-ù	'sands'				
c.	Only one of the four conditions is met						
	/nèn-ù/	nèn-ù	'pus (pl.)'		*	*	*
	/tèèr-ú/	tèèr-ú	'grasses sp.'				

here. V_1 is thus always stem-initial, and V_2 may be part of the stem, or of a suffix. Note that Laal has no prefixes.

[4] See Lionnet (in prep. a) for more detail on this harmony.

3. A Harmonic Grammar account: quantal markedness

3.1. Woleaian *a*-raising: counting cumulativity

Only one markedness constraint is needed to account for the Woleaian data: *SKIPHEIGHT, defined in 4) below, which penalizes adjacent syllables whose nuclei are maximally distinct in height. The faithfulness constraint violated by the raising of /a/ is IDENT[LO], penalizing any change in the value of the feature [±low].

4) *SKIPHEIGHT:

Let X and Y be vowels. If X and Y are nuclei of adjacent syllables, X and Y may not differ in height by more than one height level. Assign one violation per pair of adjacent syllables whose nuclei are maximally distinct in height.

The weights in all the tableaux below, calculated with the OT-Help software (Staubs et al. 2010), are the minimum weights necessary to make the correct predictions, with weights restricted to positive real numbers and the minimal weight set to 1. Weight values are to be understood as relative to each other within the constraint system: an infinity of other weight combinations would predict the same results, as long as the relations between constraint weights are maintained. Crucially, the relative weights of the faithfulness (IDENT[LO]) and markedness (*SKIP-HEIGHT) constraints need to be such that the former is weaker than the latter, and two violations of *SKIP-HEIGHT incur a penalty greater than one, but lesser than two violations of IDENT[LO]. This is necessary to model the "counting cumulativity" (Jäger and Rosenbach 2006) effect at work in Woleaian, and illustrated in Tableau 1 below, where the raised vowels are underlined (see also Table 3 in section 4).

Tableau 1: Counting cumulativity (simplified tableau)

	Weights	*3*	*2*	
		IDENT[LO]	*SKIPHEIGHT	
a. /üwa-li/	üwali		-2	*-4*
	☞üweli	-1		*-3*
b. /üwa-le/	☞üwale		-1	*-2*
	üwele	-1		*-3*
/laüli-yara/	☞laüliyara		-2	*-4*
	leüliyara	-1	-1	*-5*
	laüliyera	-1	-1	*-5*
	leüliyera	-2		*-6*

As seen in Tableau 1, the candidate in which raising has applied as a repair to *SKIPHEIGHT may only be optimal if 1) it violates IDENT[LO] only once, and 2) the faithful candidate violates *SKIPHEIGHT twice. In other words, both violations of *SKIPHEIGHT need to be incurred by the same segment, as in (a) /üwa-li/ → üweli, but not in (b) /üwa-le/ → *üwale* (**üwele*) where both *SKIPHEIGHT is violated only once, or in (c) /laüli-yara/ → *laüliyara* (**leüliyera*)[5] where the two violations of *SKIPHEIGHT in the faithful candidate are incurred by two different segments, thus violating IDENT[LO] twice, i.e. one time two many.

Two more faithfulness constraints are needed to explain why /a/ changes to mid front [e] rather than any other vowel. IDENT[HI], penalizing changes to the feature [±high], with a weight of 2, both prevents /a/ from raising to a high vowel (candidates (f, g and i in Tableau 2), and explains why lowering either or both of the two high trigger vowels is not the solution to the phonotactically ill-formed hi-lo-hi sequence (candidates c, d and e). IDENT[BACK] (or IDENT[ROUND]) additionally accounts for the fact that /a/ is raised to front [e] rather than back/round [o] (candidate h).[6]

[5] The surface form of /laüli-yara/ is actually *laüliyare*, the final /a/ being raised to [e] through word-final *a*-raising (Sohn 1971, 1975). Since this type of *a*-raising is orthogonal to the issue at stake here, I have decided to ignore it for the sake of brevity and simplicity.

[6] The limited number of violations of this constraint in Tableau 1 explains why it only needs a weight of 1.

Tableau 2: /üwa-li/ → üweli

Weights	*3*	*2*	*2*	*1*	
/üwa-li/	IDENT[LO]	IDENT[HI]	*SKIP-HEIGHT	IDENT[BK]	
a. üwali			-2		*-4*
☞ b. üweli	-1				*-3*
c. ewali		-1	-1		*-4*
d. üwale		-1	-1		*-4*
e. ewale		-2			*-4*
f. üwili	-1	-1			*-5*
g. üwuli	-1	-1			*-5*
h. üwoli	-1			-1	*-4*
i. üwuli	-1	-1		-1	*-6*

Finally a faithfulness constraint protecting long vowels from any featural changes (IDENT-$V_{\mu\mu}$) is needed to explain why long /aa/ doesn't undergo the assimilation.[7]

Tableau 3: /itaa-i/ → itaai

Weights	*3*	*2*	*1*	
/itaa-i/	IDENT[LO]	*SKIP-HEIGHT	IDENT-Vμμ	
☞itaai		-2		*-4*
iteei	-1		-2	*-5*

3.2. Laal doubly-triggered rounding harmony

The Laal doubly triggered rounding harmony illustrates another kind of phonological teamwork, involving what Jäger and Rosenbach (2006) call "ganging cumulativity", i.e. a case of teamwork arising through the additive violations of two (or more) weak faithfulness constraints overcoming the protecting effect of a strong faithfulness constraint.

3.2.1. Agreement by Correspondence

The analysis I propose here uses Hansson's (2014) revision of Agreement by Correspondence (ABC) theory, a theory of assimilation and dissimilation couched in Optimality Theory (Prince and Smolensky 1993, 2004) that was initially developed for long-distance consonant agreement (Walker 2000a,b, 2001; Hansson 2001, 2010; Rose & Walker 2004). It was then extended to vowel harmony (Sasa 2009; Walker 2009; Rhodes 2012), long-distance consonant dissimilation (Bennett 2013, 2015), and local effects of assimilation and dissimilation (Inkelas and Shih 2013, 2014; Shih 2013; Sylak-Glassman 2013; Lionnet 2014).

The central insight of ABC is that (dis)harmony is driven by similarity threshold effects. Similarity is built into the system, rather than stipulated: harmony between segments is viewed, not as spreading, but as agreement between segments in a correspondence relationship based on phonological similarity. This surface correspondence is unstable (Inkelas and Shih 2013): two (or more) segments are sufficiently similar to interact (they are in correspondence), but are too uncomfortably similar to co-exist within a certain distance. Two repairs are possible: harmony (more similarity) and disharmony (less similarity). This theory seems particularly suited to parasitic vowel harmony, which involves specific similarity threshold effects between targets and triggers.

The basic mechanics of ABC theory involve two types of Output-Output correspondence constraints: CORR-[αG, βH] constraints establish surface correspondence between segments that are similar in a particular feature or set of features (e.g. obstruents, coronals, liquids etc.), while IDENT-XX[F] constraints enforce agreement in the feature [F] between segments in a correspondence set. Both types of constraints are ranked higher than the constraints enforcing faithfulness to the assimilating feature.

Based on a diagnosis of pathological properties of the division of labor between IDENT-XX[F] and CORR-XX[αG, βH], Hansson (2014) proposes to conflate the work of both constraints into a single targeted

[7] Resistance of long vowels to coarticulation effects (and their phonologized counterparts, in synchrony and diachrony) is both phonetically natural and very frequent in the world's languages.

Markedness constraint, which penalizes disagreement in one or more features among segments of a correspondence set defined by featural similarity:

6) *[αF][-αF]/[βG, ɣH]:
Let X and Y be segments; X and Y may not disagree in the feature [F] (≈IDENT-XX[F]) if they are adjacent in the ordered set of output segments specified as [βG, ɣH] (≈ CORR-XX[βG, ɣH])

In this paper, I implement this new version of ABC theory in Harmonic Grammar, using weighted instead of ranked constraints.

3.2.2. Laal: ganging cumulativity

Two such markedness constraints are needed in Laal: $*C_{[\alpha LAB]}V_{[-\alpha LAB]}$/ADJACENT and *[-LAB][+LAB]/[αHEIGHT, βFRONT], defined in 7) and 8) below.

7) $*C_{[\alpha LAB]}V_{[-\alpha LAB]}$/ADJACENT:
A vowel and a (near-)adjacent consonant (i.e. adjacent or separated from the vowel by only one consonant) may not disagree in the feature [labial]. Assign one violation per pair of adjacent C and V violating this requirement.[8]

8) *[-LAB][+LAB]/[αH, βFR]:
Let X and Y be segments; X and Y may not disagree in the feature [labial] iff 1) X is [-lab] and precedes Y, and 2) X and Y are adjacent in the ordered set of output segments sharing the same height and [front] features. Assign one violation per pair of segments failing to comply.

The constraint in 7) militates in favor of labial assimilation between a labial consonant and a (near-) adjacent vowel. The one in 8) militates in favor of categorical, unconditional rounding harmony from V_2 to V_1. The mechanism is the same as for Woleaian, except this time the two markedness constraints, each weaker than faithfulness to labiality (IDENT[lab]), "team up" to strike down any output candidate where they are both violated by the same segment. This case of "ganging cumulativity" is illustrated in Tableau 4 below (see also Table 3 in section 4).

Tableau 4: Ganging cumulativity in Laal

	Weights	*5*	*4*	*2*	
		IDENT[LAB]	*[-LAB][+LAB]/[αH, βFR]	$*C_{[\alpha LAB]}V_{[-\alpha LAB]}$/ADJACENT	
a. /ɓɨr-ú/	ɓɨrú		-1	-1	*-6*
	☞ ɓùrú	-1			*-5*
	ɓɨrɨ́	-1			*-7*
b. /gɨ́n-ù/	☞ gɨ́nù		-1		*-4*
	gúnù	-1			*-5*
	gɨ́nɨ̀	-1			*-5*
c. /ɓə̀r-ú/	☞ ɓə̀rú			-1	*-2*
	ɓòrú	-1			*-5*
	ɓə̀rɨ́	-1		-1	*-5*
d. /pɨ́rmɨ́n/	☞ pɨ́rmɨ́n			-3	*-6*
	púrmɨ́n	-1		-1	*-7*
	pɨ́rmún	-1	-1	-2	*-13*
	púrmún	-2			*-10*

Rounding of the target vowel is optimal in (a) /ɓɨr-ú/ → *ɓùrú* because one violation of IDENT[lab] is preferable to one violation of each of the two markedness constraints, but not in (b) /gɨ́n-ù/ → *gɨ́nù* and (c) ɓə̀r-ú/ → *ɓə̀rú*, where the faithful candidate, which violates only one of the two markedness constraints, is optimal.

[8] Assuming that only potential bearers of the feature [labial] (i.e. vowels and labial consonants) may violate the constraint, and that similarity can be defined in terms of either featural identity or distance.

Note that in this case, the weight difference between faithfulness and $*C_{[\alpha LAB]}V_{[-\alpha LAB]}$/ADJACENT needs to be sufficient to prevent any counting cumulativity teamwork effect: although the faithful candidate in (d) /pɨ́rmɨ́n/ → *pɨ́rmɨ́n* violates $*C_{[\alpha LAB]}V_{[-\alpha LAB]}$/ADJACENT three times, it is still less costly than to violate IDENT[LAB] even once.

Since words are maximally disyllabic in Laal, there is no word illustrating the two-to-one only ratio between the ganging markedness constraints and faithfulness, i.e. the necessity for both markedness constraints to be violated by the same segment (similar to Woleaian *laüliyara* in Tableau 1-c above). However, the weights assigned here do predict such a limitation, as shown by the toy example /bɨtɨku/ → *bɨtɨku* (and not **butuku*) in Tableau 5 below, where only rounding of both V_1 and V_2 is a repair to both markedness constraints, which incurs two fatal faithfulness violations.

Tableau 5: /bɨtɨku/ → bɨtɨku

Weights	5	4	2	
/bɨtɨku/	IDENT[LAB]	*[-LAB][+LAB]/[αH, βFR]	$*C_{[\alpha LAB]}V_{[-\alpha LAB]}$/ADJACENT	
a. ☞ bɨtɨku		-1	-1	*-6*
b. butɨku	-1	-1	-1	*-11*
c. bɨtuku	-1	-1		*-9*
d. butuku	-2			*-10*

4. Summary and discussion

I have shown that phonological teamwork can easily be modeled in Harmonic Grammar. One of its definitional properties – the fact that several triggers are needed to affect one and the same target – is straightforwardly accounted for in Harmonic Grammar through the fine-tuning of constraint weights, as we saw: teamwork arises when two or more violations of weak markedness, incurred by one and the same segment, induce a penalty that is greater than one violation of the faithfulness constraint violated by the candidate in which teamwork has taken place, as schematized in Table 3 below.

I have also shown that the two types of cumulative effects predicted by a model based on weighted constraints – "counting" and "ganging" cumulativity, as shown by Jäger and Rosenbach (2006) – are indeed attested in phonological teamwork: Woleaian *a*-raising illustrates the former, the doubly triggered rounding harmony of Laal the latter.

Table 3: Counting and ganging cumulativity in phonological teamwork

	FAITHFULNESS		COUNTING MARKEDNESS		GANGING MARKEDNESS 1 + MARKEDNESS 2	
Violations:	1	>	1	,	1 + 0 (~ 0 + 1)	
	1	**<**	**2**	,	**1 + 1**	**= teamwork**
	2	>	2	,	1 + 1	

Another crucial characteristic of phonological teamwork is that the two triggers at work need to aspire to cause the same phonological process. For the Harmonic Grammar account proposed here, this means that the two (or more) weak markedness constraints involved in the type of teamwork driven by "ganging cumulativity" need to share some feature(s). Teamwork is thus a quantal rather than just cumulative markedness effect. This quantal restriction is not easy to implement in Harmonic Grammar, which can only model blind cumulative effects. The theory as it presently is over-generates, in that it predicts that any two or more markedness constraints can team up in order to overcome a stronger faithfulness constraint. For example, a language where nasal assimilation and rounding harmony can only take place if they both target the same segment at the same time is predicted to be possible, if $*C_{[+nas]}V_{[-nas]}$ and $*V_{[\alpha rd]}V_{[\beta rd]}$ (or similar markedness constraints) are in a ganging cumulativity relation with IDENT-V. In order to enforce this quantal restriction in this case, one would have to make sure that only very specific faithfulness constraints (e.g. only feature-specific IDENT[feature]) may be overcome by weak markedness constraints through cumulativity effects. This may imply that general faithfulness constraints such as IDENT-V, IDENT-C, MAX or DEP may have to be eliminated from the constraint system altogether. Leaving a full investigation of this problem for future research, I will simply conclude by briefly outlining how two alternative approaches compare to Harmonic Grammar on this and other issues, to set a tentative research agenda.

The first alternative is another grammar-driven approach: Local Constraint Conjunction theory (Smolensky 1993, 1995), couched in parallel Optimality Theory, which is also frequently invoked to account for ganging cumulativity effects: two constraints C1 and C2, both ranked lower than C3, can be conjoined into a separate local constraint conjunction C1$\&_{LC}$C2, ranked higher than C3. As a result only a violation of both C1 and C2 (hence of their conjunction as well) will incur a penalty higher than one violation of C3. Suzuki (1997) accounts for Woleaian *a*-raising with Local Constraint Conjunction: the two weak markedness constraints are *HI-LO and *LO-HI, penalizing a $V_{[+hi]}V_{[+lo]}$ and $V_{[+lo]}V_{[+hi]}$ sequence respectively. Both are ranked lower than IDENT[LO], but their conjunction *HI↔LO (= *HI-LO $\&_{LC}$ *LO-HI) is ranked higher, allowing raising of /a/ only when it is flanked by to [+high] nuclei, as shown in Tableau 6.[9]

Tableau 6: Local Constraint Conjunction in Woleaian a-raising (Suzuki 1997)

		*HI↔LO	IDENT[LO]	*HI-LO	*LO-HI
a. /üwa-li/	üwali	*!		*	*
	☞üwe̲li		*		
b. /üwa-le/	☞üwale			*	
	üwe̲le		*!		
c. /laüli-yara/	☞laüliyara			*	*
	le̲üliyara		*!	*	
	laüliye̲ra		*!		*
	le̲üliye̲ra		*!*		

Local Constraint Conjunction offers the advantage of making it possible to state restrictions on the types of constraint conjunctions that the system should allow, thus restricting the types of cumulative effects predicted. Bakovic (2000:34), for instance, proposes that in order to be conjoined, a faithfulness and a markedness constraint need to be "co-relevant", i.e. share some feature(s). Such a restriction, extended to all types conjunctions, would do a better job at accounting for the quantal markedness effects operating in phonological teamwork.

However, additionally to the fact that it is much less simple and elegant than Harmonic Grammar in that it requires the addition of a specific (and suspiciously convenient) kind of complex constraint to the inventory, Local Constraint Conjunction requires the further stipulation of the same-segment restriction that is crucial to the definition of teamwork. Indeed, what explains why candidate (c) in Tableau 6 does not violate *HI↔LO is that the constraint conjunction can only be violated if the two constraints it is made of are violated *locally*, i.e. in this case by the same segment (Suzuki 1997). This stipulation is unnecessary in the Harmonic Grammar account, where the same-segment requirement is an emergent property that follows from the interaction of constraints standing in a specific weighting relation.

Finally, a very different alternative was mentioned in the introduction: phonetic grounding. One argument in favor of a phonetically grounded approach to the Laal doubly triggered rounding harmony and against such a purely grammar driven approach as the one proposed above lies in the phonetic underpinnings of the harmony. As shown in Figure 2 and Table 4 below, labial consonants in Laal have a very strong and significant F2 lowering effect on a (near-)adjacent [ɨ] or [ə], while the effect of a round vowel on a preceding [ɨ] or [ə] is not significant.

This suggests that the two triggers are not equal in this case of teamwork, and that this difference of effect needs to be accounted for, which the analysis presented here does not. The fact that the Harmonic Grammar account says nothing about the phonetic realization of the harmony may be seen as non-problematic: after all, phonetic implementation does not have to be taken care of by the phonological grammar. However, the significance of the effect of labial consonants suggests that this is not simply a question of phonetic implementation: there seems to be a generalization here that the Harmonic Grammar account is missing (cf. Lionnet 2014, Lionnet in prep.)

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[9] Note that the constraint *SKIPHEIGHT proposed above could be translated into the two markedness constraints *HI-LO and *LO-HI, which would make Woleaian *a*-raising a case of ganging cumulativity similar to the Laal doubly triggered rounding harmony. *HI-LO and *LO-HI seem to be two sides of the same coin, however, making *SKIPHEIGHT a better, as well as more explicitly functionally grounded statement of the markedness constraint at work here.

Table 4: Effect of (near-)adjacent C[lab] and following V[rd] on [ɨ] and [ə]

	Average Δ	Significance
Δ_{F2}(ɨ, ɨ^{b})	399 Hz	$p < 2.2 \times 10^{-16}$
Δ_{F2}(ə, ə^{b})	286 Hz	$p < 2.2 \times 10^{-5}$
Δ_{F2}(ə, V[rd])	110 Hz	$p = 0.11$

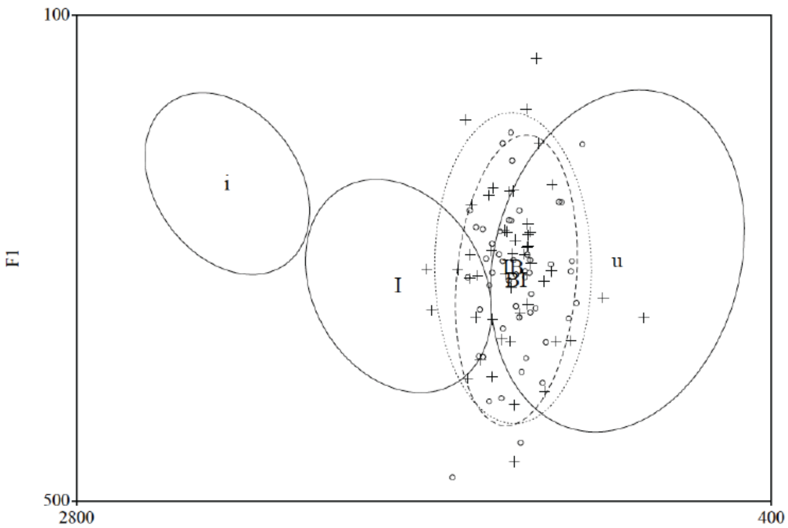

Figure 2: Labialization of /ɨ/ by (near-)adjacent labial C in Laal

In conclusion, the Harmonic Grammar account of phonological teamwork presented here has many advantages, but still has two important problems to solve: over-generation, and the lack of prediction about the possible asymmetric behaviors and phonetic effects of the two triggers involved in ganging-cumulativity driven teamwork.

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