

Match Theory and Prosodic Wellformedness Constraints

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1 Introduction¹

Several strands of work in prosodic theory have recently converged on a number of common themes, from different directions. Selkirk (2009) (see also Elfner 2012) has developed a vastly simplified approach to the syntax-prosody mapping which distinguishes only three levels (word, phrase, and clause), and syntactic constituents are systematically made to correspond to phonological domains ("Match Theory"). In an independent line of research, a long string of papers reaching back into the 1980s has convincingly demonstrated that recursive structures are by no means an exclusive property of syntax, but also play a crucial role in phonology. Even though at variance with Strict Layering (Selkirk 1984, Nespor and Vogel 1986), the empirical existence of recursive prosody is undeniable, as first demonstrated by Ladd 1986, 1988, whose findings have been corroborated by Kubozono 1988, 1989, Schreuder and Gilbers 2004, Gussenhoven 2005, Wagner 2005, 2010, Schreuder 2006, Kabak and Revithiadou 2009, Ito and Mester 2009b, Féry 2010, van der Hulst 2010, to name a few, undermining a central tenet of orthodox prosodic hierarchy theory that supposedly sets phonology apart from syntax. Building on these empirical findings, Ito and Mester (2007, 2009a, 2013) have gone on to argue that, beyond its sheer existence, prosodic recursion allows for a vast, and much-needed, simplification in the inventory of prosodic categories themselves. The empirically necessary subcategories that the data of individual languages

often seem to demand (such as the minor vs. the major phonological phrase of Japanese, long established under these names since McCawley 1968, and rechristened into "accentual" vs. "intermediate phrase" by Pierrehumbert and Beckman 1988) are not separate categories each existing on its own in some (or all?) languages, but are rather instances of a single recursively deployed basic category. These results are very much in harmony with central ideas in Match Theory, and recent work (Selkirk 2011, Ishihara 2014) has successfully connected the two theories into a larger framework.

One of the hallmarks of Match Theory is the idea that the main force interfering with syntax-prosody isomorphism is not some kind of non-isomorphic mapping algorithm flattening out the structure, as first contemplated in SPE (Chomsky and Halle 1968:372) and more fully worked out in later proposals, such as the edge-based theory built on one-sided alignment (Selkirk 1986). It is rather the effect of genuine phonological wellformedness constraints on prosodic structure: Whenever such constraints dominate a MATCH constraint, prosodic structure is forced to diverge from its syntactic model, often in significant ways. A large part of the explanation of syntax-prosody mismatches, then, lies in the precise content of these wellformedness constraints that conflict with the entailments of isomorphism.

We will here survey four types of constraints that interact with MATCH constraints in this way: NOLAPSE (against tonal lapses, see Ito and Mester 2013), EQUALSISTERS (against sister nodes in prosodic trees of different levels in the prosodic hierarchy, see Myrberg 2013), and constraints enforcing binary branching in prosodic trees, both minimally (BINMIN) and maximally (BINMAX), which have been widely discussed in the literature.

The goal of this paper is to cast a critical eye on the way these kinds of prosodic constraints interact with MATCH constraints in recent work in prosodic theory, our own included, and to isolate a number of issues that are in need of deeper investigation. We restrict ourselves to work within optimality-theoretic phonology (OT, see Prince and Smolensky

1993), and will make concrete proposals and conjectures at various junctures, identifying problem areas along the way.

The primary data we will use as a testing ground are taken from an area we are familiar with, the prosodic form of Tokyo Japanese utterances (henceforth "Japanese"), and leave for future exploration the more detailed investigation of other languages that might provide equally valuable or even better cues. Our overall goal, however, is not to provide a comprehensive analysis of Japanese, but rather to subject a number of theories and ideas to an empirical test. That being said, at the end we hope to end up with some understanding of the kinds of constraints that are necessary to explain a prosodic system.

2 Tonal antilapse constraints

The first type of constraint we will take up militates against tonal lapses: stretches of low-toned material exceeding a certain limit, typically at the ends of words and phrases. In this section, we will first review relevant data from Japanese and their analysis, and then turn to a comparison with Basque.

2.1 NOLAPSE in Japanese

Ito and Mester 2013 develop an analysis of the way Japanese utterances are parsed into phonological phrases where NOLAPSE plays a central role in forcing the accentual fall to occur late in the word. A virtue of this approach is that the orientation of the accent towards the end of the word is explained by substantive tonal factors, not by stipulated formal right alignment.² The facts here are well-known since Kubozono (1988, 1989), we illustrate them with phrases consisting of two content words (after Vance 2008:181). The parses assigned to these examples by the theory proposed in Ito and Mester 2013 appear in the second column in (1), where (1cd) crucially involve recursive phrasing, as first recognized by Kubozono.

(1)	S:	P:	Example:	Gloss:
a.	[XP [XP u] u]	(φ u u)	[[Hiroshima-no] sakana-to]	'Hiroshima fish and ...'
b.	[XP [XP u] a]	(φ u a)	[[Hiroshima-no] tamágo-to]	'Hiroshima eggs and ...'
c.	[XP [XP a] a]	(φ (φ a) (φ a))	[[Okáyama-no] tamágo-to]	'Okayama eggs and ...'
d.	[XP [XP a] u]	(φ (φ a) (φ u))	[[Okáyama-no] sakana-to]	'Okayama fish and ...'

Here and in what follows, φ stands for "phonological phrase", ω for a "phonological word", a for "accented ω ", u for "unaccented ω ", and syntactic and prosodic phrasing are labelled "S" and "P" and indicated by [...] and (...), respectively. The differences between these parses—flat phrasing in (1ab), recursive phrasing in (1cd)), but never exactly mirroring the syntax—are entirely due to the locations of accented and unaccented words. The beginning of a phonological phrase is in Japanese cued by a tonal rise. It is always possible, in careful pronunciation, to parse each word as a separate φ , with its own initial rise, but this is not the usual pattern. While two a 's are each parsed as a separate phrase (because each accent has to be the head of a minimal phrase), u is typically phrased together with an adjacent a or u (because one-word phrases violate binarity). This is where Kubozono 1988:150-154 discovered a directional asymmetry: While two u are phrased together, u is only phrased together with a following a , not with a preceding a . So the results are (1a) (uu) and (1c) ($((a)(a))$), but (1d) ($((a)(u))$) with an initial rise at the beginning of the second word and (1b) (ua) without such a rise. The data are subject to considerable variation, we focus here exclusively on the majority patterns.

The analysis in Ito and Mester 2013 involves the four constraints in (2). Following Elfner 2012:28, we sharpen the definition of matching in the following way: In order for a phonological constituent p to *match* a syntactic constituent s , p must exhaustively dominate all and only the phonological exponents of the terminal nodes that s exhaustively dominates.

As a result, syntactic constituents introducing no overt terminal elements are invisible to the matching process, and do not need to be separately matched.

- (2) a. ACCENTASHEAD: Every accent is the head of a minimal phrase ϕ_{\min} .³ Assign one violation for each accent that is not the head of a ϕ_{\min} .
- b. NOLAPSE-L: No tonal lapses. Assign one violation for each fully L-toned ω in ϕ .
- c. MINIMALBINARITY- ϕ/ω : ϕ is minimally binary. Assign one violation for each ϕ that does not dominate at least two ω .
- d. MATCH-XP-TO- ϕ : A phrase XP in syntactic constituent structure is matched by a corresponding phonological phrase ϕ in phonological representation.

Ranked as in tableau (3),⁴ these constraints derive the different parses in (1). The syntactic pattern $[[u]x]$, where $x=a$ or u , is parsed as the non-isomorphic single ϕ (3ae) (ux), violating bottom-ranked MATCH-XP but satisfying higher-ranked BINMIN in the optimal way. However, $[[a]x]$ is parsed as (3im) ($(a)(x)$), violating BINMIN: Isomorphic (3l) ($(a)a$) is out because the second a violates ACCASHEAD.

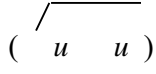
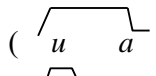
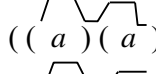
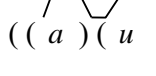
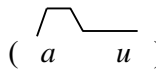
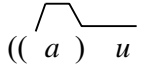
(3)

<i>Japanese with NOLAPSE</i>		NOLAPSE-L	ACCASHD	BINMIN	MATCH-XP
$[[u]u]$	a. ► (uu)				*
	b. (u(u))			*W	*
	c. ((u)u)			*W	L
	d. ((u)(u))			**W	L
$[[u]a]$	e. ► (ua)				*
	f. (u(a))			*W	*
	g. ((u)a)		*W	*W	L
	h. ((u)(a))			**W	L
$[[a]a]$	i. ► ((a)(a))			**	
	j. (aa)		*W	L	*W
	k. (a(a))		*W	*L	*W
	l. ((a)a)		*W	*L	

<i>Japanese with NOLAPSE</i>		NOLAPSE-L	ACCASHD	BINMIN	MATCH-XP
[[a]u]	m. ▶ ((a)(u))			**	
	n. (au)	*W		L	*W
	o. (a(u))		*W	*L	*W
	p. ((a)u)	*W		*L	

The most interesting case is [[a]u] parsed as (3m) ((a)(u)), with a rise on *u*, as depicted in (4d). The main tonal events in these examples are indicated with schematic pitch arrows.

(4) Tonal profiles of candidates in (3), depicting NOLAPSE-L violations

a. =(3a)		} NOLAPSE-L fulfilled in the winning candidates, where no ω is fully L-toned.
b. =(3e)		
c. =(3i)		
d. =(3m)		
e. =(3n)		} NOLAPSE-L violated: the final u is fully L-toned after the accentual fall.
f. =(3p)		

A fully L-toned ω arises after an accentual fall unless it is in its own ϕ (thereby receiving the tonal rise on its own). The tonally low final *u* in the losing candidates (3np) violates NOLAPSE-L. By contrast, the leading *u* in (3ae) is tonally high, and does not violate NOLAPSE-L. In this analysis, the directional asymmetry thus has an explanation rooted in the very shape of the tonal melody of (Tokyo) Japanese (%LH- and %LH-H*L).

2.2 Comparison with Basque

Selkirk and Elordieta 2010 propose a slightly different analysis of Japanese along similar lines, the chief difference being that the phrasing (*au*) is ruled out not because the post-

accentual *u* is a tonal lapse, but because it separates the accentual head *a* from the end of its phrase. Instead of NOLAPSE-L, their analysis appeals to the alignment constraint ALIGN-RIGHT(φ_{\min} -HEAD, φ_{\min}), which requires the accented word *a* to be at the right edge of its φ_{\min} . Among the relevant candidates in (6), both ((*a*)*u*) (6p) and ((*a*)*(u)*) (6m), but not (*au*), fulfil ALIGN-R. In order to select (6g) over (6i), they introduce a further constraint in (5) into the analysis.

- (5) EQUALSISTERS: Sister nodes in prosodic structure are instantiations of the same prosodic category.

Ranked above BINMIN, EQUALSISTERS⁵ (Myrberg 2013:75) selects the correct candidate ((*a*)*(u)*) in (6m).⁶

(6)

<i>Japanese with ALIGN-R and EQUALSIS</i>			ACCASHD	ALIGN-R	EQUALSIS	BINMIN	MATCH-XP
[[u]u]	a. ▶	(uu)					*
	b.	(u(u))			*W	*W	*
	c.	((u)u)			*W	*W	L
	d.	((u)(u))				**W	L
[[u]a]	e. ▶	(ua)					*
	f.	(u(a))			*W	*W	
	g.	((u)a)	*W	*W	*W	*W	L
	h.	((u)(a))				**W	L
[[a]a]	i. ▶	((a)(a))				**	
	j.	(aa)	*W	*W		*L	*W
	k.	(a(a))	*W	*W	*W	L	
	l.	((a)a)	*W	*W	*W	*L	
[[a]u]	m. ▶	((a)(u))				**	
	n.	(au)		*W		L	*W
	o.	(a(u))		*W	*W	*L	*W
	p.	((a)u)			*W	*L	

Selkirk and Elordieta 2010 insightfully contrast the Japanese phrasings in (1) with the minimally different phrasings of corresponding examples in Northern Bizkaian Basque

(henceforth "Basque"), which has a pitch accent system tantalizingly close to that of Japanese, including a very similar word melody (for an overview, see Gussenhoven 2004:170-184). The chief difference is that the *u* of $[[a]u]$, in Japanese parsed as its own phrase $((a)(u))$, is in Basque not parsed as a separate phrase. Selkirk and Elordieta 2010 express this by assigning the parse $((a)u)$ (where nothing in the data seems to signal the presence of the phrase (a) , however).

(7) *Japanese*: $[[a]u] \rightarrow ((a)(u))$ [EQUALSISTERS >> BINMIN]

Basque: $[[a]u] \rightarrow ((a)u)$ [BINMIN >> EQUALSISTERS]

They derive the different outcomes in Japanese and Basque by the ranking scenario in (7), with the result shown in (8).

(8)

<i>Basque with ALIGN-R and EQUALSIS</i>		ACCASHD	ALIGN-R	BINMIN	EQUALSIS	MATCH-XP
[[u]u]	a. ▶ (uu)					*
	b. (u(u))			*W	*L	*
	c. ((u)u)			*W	*L	W
	d. ((u)(u))			**W		W
[[u]a]	e. ▶ (ua)					*
	f. (u(a))			*W	*W	*
	g. ((u)a)	*W	*W	*W	*W	L
	h. ((u)(a))			**W		L
[[a]a]	i. ▶ ((a)(a))			**		
	j. (aa)	*W	*W	L		*W
	k. (a(a))	*W	*W	*L	*W	*W
	l. ((a)a)	*W	*W	*L	*W	
[[a]u]	m. ▶ ((a)u)			*	*	
	n. (au)			*W	L	*W
	o. (a(u))			*W	*	*W
	p. ((a)(u))			**W	L	

In our own analysis with NOLAPSE instead of ALIGN-R and EQUALSISTERS, the Basque system emerges when NOLAPSE ranks below BINMIN, as shown in (9).⁷

(9) <i>Basque with NO LAPSE</i>		ACCASHD	BINMIN	NO LAPSE=L	MATCH-XP
[[u]u]	a. ► (uu)				*
	b. (u(u))		*W		*
	c. ((u)u)		*W		L
	d. ((u)(u))		**W		L
[[u]a]	e. ► (ua)				*
	f. (u(a))		*W		*
	g. ((u)a)	*W	*W		L
	h. ((u)(a))		**W		L
[[a]a]	i. ► ((a)(a))		**		
	j. (aa)	*W	L		*L
	k. ((a)a)	*W	*L		
	l. (a(a))	*W	*L		*W
[[a]u]	m. ► (au)			*	*
	n. (a(u))		*W	L	*
	o. ((a)u)		*W	*	L
	p. ((a)(u))		**W	L	L

In section 3, we look more closely at the workings of EQUALSISTERS in larger structures, and encounter some advantages for an analysis building on a tonal NO LAPSE constraint.

3 Constraints on sister nodes

EQUALSISTERS (Myrberg 2013) is a new member of the set of separate and violable constraints that takes the place of traditional Strict Layering (Ito and Mester 1992, Selkirk 1996): Daughter nodes are not required to be exactly one level below their mother nodes in the hierarchy, but they need to be of the same level.

An interesting problem arises when we consider three-member syntactic constituents of the form $[[[x]y]z]$. In order to keep things simple, we restrict our attention to left-branching structures, which conform to the basic pattern of Japanese phrase structure (see Ito and Mester 2013 for right-branching structures). Complex noun phrases as in (10) are examples.

equal $((uu)(u))$, we need $\text{BINMIN} \gg \text{EQUALSISTERS}$ (12a). But in order for the sister-wise equal $((ua)(u))$ to win over the competing $((ua)u)$, which has one less unary phrase, we need $\text{EQUALSISTERS} \gg \text{BINMIN}$ (12b).

(12)

	input	winner	loser	ACCASHD	ALIGN-R	BINMIN	EQUALSIS	MATCH-XP
a.	[[[u]u]u]	$((uu) u)$	$((uu) (u))$			W	L	
b.	[[[u]a]u]	$((ua) (u))$	$((ua) u)$			L	W	

The ranking contradiction disappears once NOLAPSE-L takes the place of ALIGN-R , since it is able to differentiate between the two cases: $((\uparrow ua\downarrow) u)$, but not $((\uparrow uu) u)$, ends on a low u , as indicated by the pitch arrows, violating NOLAPSE-L . This is shown in (13).

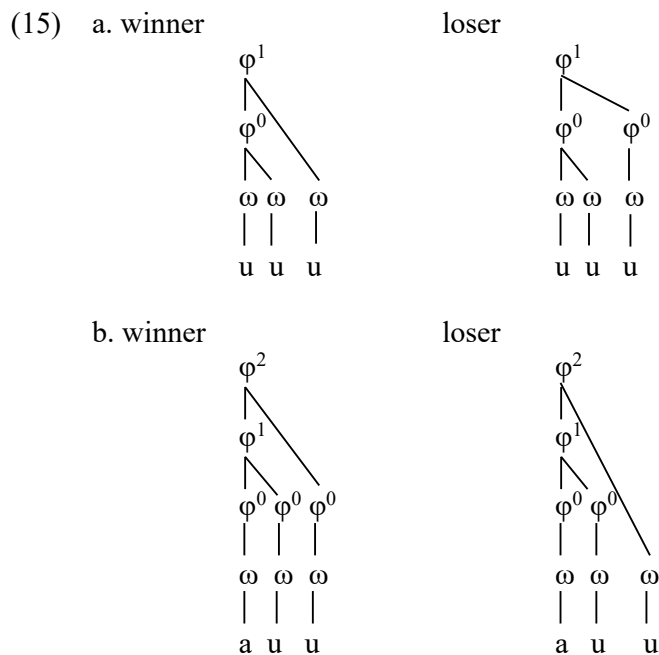
(13)

	input	winner	loser	ACCASHD	NOLAPSE-L	BINMIN	EQUALSIS	MATCH-XP
a.	[[[u]u]u]	$((\uparrow uu) u)$	$((\uparrow uu) (u))$			W	L	
b.	[[[u]a]u]	$((\uparrow ua\downarrow)(\uparrow u))$	$((\uparrow ua\downarrow) u)$		W	L	W	

But all is not well in EQUALSISTERS -land: A different confrontation of winner-loser pairs shows that the ranking contradiction between BINMIN and EQUALSISTERS persists even with NOLAPSE-L . All that is needed is a case where NOLAPSE-L does not differentiate the candidates. Let us take the inputs $[[[u]u]u]$ and $[[[a]u]u]$, as in (14). In order for $((uu)u)$ to win over $((uu)(u))$, we again need $\text{BINMIN} \gg \text{EQUALSISTERS}$ (14a). But in order for $((a)(u)(u))$ to win over the competing $((a)(u)u)$, which has one less unary phrase, we need $\text{EQUALSISTERS} \gg \text{BINMIN}$ (14b). This time, NOLAPSE-L fails to resolve the ranking contradiction between EQUALSISTERS and BINMIN .

(14)	input	winner	loser	ACCASHD	NOLAPSE	BINMIN	EQUALSIS	MATCH-XP
a.	[[[u]u]u]	((↑u u) u)	((↑u u)(↑u))			W	L	
b.	[[[a]u]u]	(((↑a _i)(↑u))(↑u))	(((↑a _i)(↑u) u)			L	W	

As we consider the two pairs, a way out might suggest itself since the two cases differ in terms of the severity of sister inequality. This becomes clearer when we inspect more detailed representations, with explicit indications of projection levels, as in (15).



Whereas the winner in (15a) has a pair of sister nodes (ω , ϕ^0), the loser in (15b) has a pair (ω , ϕ^1). EQUALSISTERS theorists might seize on this difference and expand the constraint, in the familiar OT manner, into a family of constraints penalizing sister inequality of different degrees of severity. Let us assume, for concreteness, that besides the general EQUALSISTERS constraint (5) penalizing any difference in category between sister nodes, there is a more stringent constraint penalizing a situation where a category inequality is aggravated by a concomitant projection level inequality. We might call the more stringent constraint

EQUALSISTERS-2, violated when λ^j is sister to κ^i , with $\lambda > \kappa$ and $j > i$. Ranked above BINMIN, EQUALSISTERS-2 removes the problem, as (16b) shows.

(16)

input	winner	loser	ACCASHD	NOLAPSE	EQUALSIS-2	BINMIN	EQUALSIS	MATCH-XP
a. [[u]u]u	((uu) u)	((uu) (u))				W	L	
b. [[a]u]u	(((a)(u)) (u))	(((a)(u)) u)			W	L	W	
c. [[u]a]u	((ua) (u))	((ua) u)		W		L	W	
d. [[u]a]a	((ua) (a))	((ua) a)	W			L	W	
e. [[[u]u]a]	((uu) (a))	((uu) a)	W			L	W	
f. [[[a]a]a]	(((a)(a)) (a))	(((a)(a)) a)	W		W	L	L	
g. [[[a]u]a]	(((a)(u)) (a))	(((a)(u)) a)	W		W	L	L	
h. [[[a]a]u]	(((a)(a)) (u))	(((a)(a)) u)		W	W	L	L	

Given the two versions of EQUALSISTERS, all eight accented-unaccented combinations of three-member syntactic constituents (11) emerge in (16) with their correct prosodic structure. We leave it for future research in Japanese and other languages to determine whether admitting different/stringent versions of EQUALSISTERS is a fruitful avenue to explore, and if so, what other types of EQUALSISTERS might play a role in a grammar.

4 Prosodic binarity constraints

Besides the minimal version of binarity (17a) (repeated from (2) above), the maximal version (17b) also plays a crucial role in larger syntactic configurations.

(17) Binariness constraints

MINIMALBINARITY- φ/ω : φ is minimally binary. Assign one violation for each φ that does not dominate at least two ω .

MAXIMALBINARITY- φ/ω : φ is maximally binary. Assign one violation for each φ that dominates more than two ω .

For four-member left-branching structures of the form [[[1]2]3]4], Kubozono (1988, 1989) (see also Shinya, Selkirk and Kawahara 2004) has convincingly shown that the prosodic structure is always such that the immediate daughters of the maximal φ contain two ω 's, as exemplified with all accented words in (18a) (from Ishihara 2014) and all unaccented words in (18b).

(18) Left-branching structure [[[1]2]3]4]

a. S: [[[a]a]a]a] [[[Máriko-ga] nónda] wáin-no] niói]

Mariko-NOM drank wine-GEN smell

'the smell of wine that Mariko drank'

P: (((a)(a))((a)(a))) (((↑Má↓riko-ga)(↑nó↓nda)) ((↑wá↓in-no)(↑niói↓)))

b. S: [[[u]u]u]u] [[[Mamoru-ga] yonda]gakuchoo-no] uwasa]

Mamoru-NOM invited (college) president-GEN rumour

'the rumour of the college president that Mamoru invited'

P: (((uu)(uu))) ((↑Mamoru-ga yonda) (↑gakuchoo-no uwasa))

The evidence for these strictly binary prosodic parses (due to Kubozono 1988, 1989) are the initial rises (marked by up-arrows) in every φ and, in the case of accented sequences, by the extra rhythmic boost before the third ω (indicated by the larger up-arrow). As shown earlier in (3), because of undominated NOLAPSE-L and ACCENTASHEAD, there are only four licit 2ω -

structures: (uu) , (ua) , $((a)(a))$, and $((a)(u))$, and joined into 4ω -structures they yield the $4 \times 4 = 16$ combinatorial possibilities depicted in (19).

$$(19) \left\{ \begin{array}{l} (uu) \\ (ua) \\ ((a)(a)) \\ ((a)(u)) \end{array} \right\} \left\{ \begin{array}{l} (uu) \\ (ua) \\ ((a)(a)) \\ ((a)(u)) \end{array} \right\}$$

Why $((12)(34))$, rather than the more closely matching $((12)3)4$? Ishihara 2014, following up on an informal suggestion in Selkirk 2011, gives an explicit OT analysis summarized in (20).

(20)

S:	P:	BINMAX- ϕ	BINMIN- ϕ	MATCH-XP
[[[[u] u] u] u]	a. $\blacktriangleright ((u u) (u u))$	*		**
	b. $((u u) u) u)$	**W		*L
	c. $((u)u) u) u)$	**W	*W	L
	d. $(u u u u)$	*		***W
[[[[a] a] a] a]	e. $\blacktriangleright (((a)(a) ((a)(a)))$	*	****	*
	f. $((((a)(a) (a))(a))$	**W	****	L
	g. $((a) (a) (a) (a))$	*	****	**W

The strictly binary candidate $((uu)(uu))$ wins because it does perfectly on BINMIN- ϕ and has only one violation on BINMAX- ϕ , at the cost of two unmatched XPs. The same holds for winning $((a)(a)((a)(a)))$, with the difference that each a also constitutes its own ϕ because its accent needs to be the head of a phrase. The candidates considered here are all parsed into a single ϕ at the top level, violating BINMAX- ϕ at least once. This is the more important point made by Ishihara: There is a need for a separate, and higher-ranking, match constraint requiring XP_{\max} to correspond to a ϕ , ruling out the prosodically non-cohering $(uu)(uu)$. We

will return to the details in the next section, and here focus on the workings of the binarity constraints.

Low-ranking MATCH-XP decides in favor of $((uu)(uu))$ against the completely flat $(uuuu)$ (16d). The same holds for 3ω -structure (21), where $((uu)u)$ beats (uuu) —even though here, the empirical consequences are the same, with no medial rise predicted (there are no known cues for the end of a ϕ in Japanese), and Ishihara 2014 considers (uuu) to be the winner.

(21)

S	P	BINMAX- ϕ	BINMIN- ϕ	MATCH-XP
[[[[u] u] u]	a. \blacktriangleright $((u u) u)$	*		*
	b. $(u u u)$	*		**W
	c. $((u u)(u))$	*	*W	*

Further inspection reveals, however, that we cannot rely on low-ranking MATCH-XP to determine the winner once more constraints are in place. It turns out that we need an additional binarity constraint not counting ω 's, but insisting on maximal binary branching. BINMAXBRANCH- ϕ (22) rules out, for example, the flat (uuu) and $(uuuu)$ which do not just contain more than 2 ω 's, but have ternary and quaternary branching.

(22) BINMAXIMALBRANCH- ϕ : ϕ obeys maximal binary branching: $*(\phi \alpha\beta\gamma\dots)$. Assign one violation for each ϕ that branches into more than two daughter nodes.

The following tableau anticipates this point and shows that BINMAX- ϕ/ω does not distinguish between (23a) and (23d), but BINMAXBRANCH- ϕ does. On the other hand, BINMAXBRANCH- ϕ does not distinguish between (23a-c).

(23)

S:	P:	BINMAXBRANCH- ϕ	BINMAX- ϕ	BINMIN- ϕ	MATCH-XP
[[[[u] u] u] u]	a. \blacktriangleright ((u u) (u u))		*		**
	b. ((u u) u) u)		**W		*L
	c. ((u)u) u) u)		**W	*W	L
	d. (u u u u)	*W	*		***W

We will see below that while BINMAX- ϕ is crucially dominated by other constraints, BINMAXBRANCH- ϕ is undominated and never violated in winning candidates. Pending further investigation into other systems, it is perhaps worth keeping in mind whether the undominated nature of this constraint may be an indication that GEN only produces unary and binary prosodic constituents.

Questions about further types of binarity constraints remain to be explored, such as binarity requirements on $\phi_{[+max]}$, $\phi_{[-max]}$, or $\phi_{[-min]}$, and can only be properly addressed with additional empirical evidence. Thus Selkirk and Elordieta (2010), based on earlier work by Elordieta (2007), have proposed a constraint requiring exact binarity (at the ϕ -level) for IP-initial ϕ in Basque (BINMINMAX- ϕ/ϕ , in our terms), a type of STRONGSTART constraint (Selkirk 2011), and we expect additional findings along these lines.

5 Syntax-prosody matching constraints

Just as there are several versions of binarity constraints, previous research has uncovered that the syntax-prosody mapping in Japanese calls for higher-ranking specific versions of MATCH constraints requiring maximal XP's (24b) and non-minimal XP's (24c) to correspond to phonological phrases.

(24) MATCH-XP constraints

- a. MATCH-XP-TO- ϕ (repeated from (2) above): A phrase XP in syntactic constituent structure is matched by a corresponding phonological phrase ϕ in phonological representation.
- b. MATCH-XP_[+max]-TO- ϕ : A maximal phrase XP in syntactic constituent structure is matched by a corresponding phonological phrase ϕ in phonological representation (Ishihara 2014).⁸
- c. MATCH-XP_[-min]-TO- ϕ : A non-minimal phrase XP in syntactic constituent structure is matched by a corresponding phonological phrase ϕ in phonological representation (Ito and Mester 2013).

As Ishihara 2014 correctly points, without a higher-ranking MATCH-XP_[+max], candidates (25be), without a corresponding ϕ for their maximal XPs, wrongly emerge as winners, because they do not violate BINMAX- ϕ , and the general MATCH-XP is ranked too low to rule them out.

(25)

S:	P:	MATCH-XP _[+max]	BINMAX- ϕ	MATCH-XP _[-min]	BINMIN- ϕ	MATCH-XP
[[[[u] u] u] u]	a. ► ((uu)(uu))		*	*		**
	b. (uu) (uu)	*W	L	*		***W
	c. ((uu)u)u		**W	L		*L
[[[[a] a] a] a]	d. ► (((a)(a))(a)(a))		*	*	****	**
	e. ((a)(a) ((a)(a))	*W	L	*	****	***W
	f. (((a)(a))(a)(a))		**W	L	****	*L

[MATCH-XP_[+max] >> BINMAX- ϕ] is determined by the WL pairing in candidate rows (25be).

On the other hand, the nonminimal version of MATCH-XP_[-min] (24c) proposed in Ito and

Mester 2013 is violated by the winning candidates (25a and d) (where the nonminimal XP $[[[\omega]\omega]\omega]$.. does not have a corresponding ϕ), and must be ranked below $\text{BINMAX-}\phi$.

Instead of reviewing here the empirical rationale for this $\text{XP}_{[-\text{min}]}$ constraint given in Ito and Mester 2013 involving 3ω -sequences, we take a step back and explore an alternative way of thinking about this type of mismatch violation. In parallel OT, there is no need for syntax-prosody mapping to only go in one direction, from syntax to prosody, and it is also possible to check whether the surface prosody matches the syntax, as in fact suggested in Selkirk 2011. In $((uu)_1 (uu)_2)$, $(uu)_1$ is matched by $[[u]u]$ in the syntax, but $(uu)_2$ has no syntactic correspondent. Rather than proliferating MATCH-XP constraints, we propose here that the constraint doing the crucial work is the prosody-syntax matching constraint $\text{MATCH-}\phi$ defined in (26).

(26) $\text{MATCH-}\phi$: A phonological phrase ϕ in phonological representation is matched by a corresponding syntactic constituent in syntactic representation.

As formulated, (26) only looks for a corresponding syntactic constituent, not necessarily an XP. $\text{Match-}\phi$ can simply take the place of $\text{MATCH-XP}_{[-\text{min}]}$ in (25) above without any violation difference. We leave it as a questions for future research whether $\text{MATCH-XP}_{[-\text{min}]}$ is still necessary, and similar questions can be asked about $\text{Match-}\phi_{[+\text{min}]}$, $\text{Match-}\phi_{[+\text{max}]}$, $\text{Match-}\phi_{[-\text{min}]}$, and $\text{Match-}\phi_{[-\text{max}]}$.

Why is $\text{MATCH-}\phi$ (replacing $\text{MATCH-XP}_{[-\text{min}]}$) a necessary ingredient of the analysis? For all-accented and all-unaccented 3ω -cases, $\text{MATCH-}\phi$ is not a crucial factor (illustrated here by the all W-markings in the rows of (27ab)). On the other hand, for cases of mixed accented/unaccented 3ω -cases, the rebracketed candidates need to be ruled out by

MATCH- ϕ >> BINMIN- ϕ in (28cd). For full tableaux with relevant candidates and detailed discussion, see Ito and Mester 2013, substituting MATCH- ϕ for MATCH-XP_[-min].

(27)

3 ω -input	winner	rebracketed loser	MATCH-XP _[+max]	BINMAX- ϕ	MATCH- ϕ	BINMIN- ϕ	MATCH-XP
a. [[[u]u]u]	((uu) u)	(u (uu))			W		W
b. [[[a]a]a]	(((a)(a) (a)))	((a) ((a)(a)))			W		W
c. [[[a]u]a]	(((a)(u) (a)))	((a) (ua))			W	L	W
d. [[a]u]u]	(((a)(u) (u)))	((a) (uu))			W	L	W

Moving on to the various 4 ω -combinations in (28), rebracketed candidates are actually winners, and are selected by [BINMAX- ϕ >> MATCH- ϕ].

(28)

4 ω -input	rebracketed winner	loser	MATCH-XP _[+max]	BINMAX- ϕ	MATCH- ϕ	BINMIN- ϕ	MATCH-XP
a. [[[u]u]u]u]	((uu) (uu))	(((uu) u) u)		W	L		W
b. [[[a]a]a]a]	(((a)(a) ((a)(a))))	(((a)(a) (a))(a))		W	L		W
c. [[[a]u]u]u]	(((a)(u) (uu)))	(((a)(u) u) u)		W	L		W
d. [[[a]u]u]u]	(((a)(u) ((a)(u))))	(((a)(u) (a))(u))		W	L		W

The overall interplay of constraints from the MATCH and BINARITY families has the interleaved structure in (29).

(29)

MATCH	BIN	MATCH	BIN	MATCH
MATCH-XP _[+max]	>>BINMAX- ϕ	>>MATCH- ϕ	>>MINBIN- ϕ	>>MATCH-XP

6 Summary and conclusion

Throughout our research reported in this paper, we have relied on OTW(orkplace)⁹ to guide us in precisely formulating the constraints, and verifying proper (non-contradictory) rankings. With all ten constraints discussed in this paper (ranging from syntax-prosody match constraints, structural constraints requiring binarity/equal sisters, and accentual/tonal constraints), OTW allows us to check our proposed constraints and rankings, and in the process, to also pinpoint problem areas, contradictory rankings, as well as find unintended consequences, unwanted winners, etc. In (30) and (31), we present the OTW tableaux for two examples with crucial candidates showing the established rankings.

(30)

		MATCH-MAXXP	NOLAPSE-L	ACCASHD	BINMAXBRANCH-φ	BINMAX-φ	MATCH-φ	EQUALSIS-2	BINMIN-φ	MATCH-XP	EQUALSIS
S:	P:										
[[[a]u]u]	a. ► (((a)(u))(u))					1			3		
	b. (((a)(u))u)					1		1W	2L		1W
	c. ((a)(uu))					1	1W		1L	1W	
	d. ((a(u))(u))			1W		1			2L	1W	1W
	e. ((au)u)		1W			1			L	1W	1W

In (30), the leftmost sequence of WL in row (b) shows [EQUALSIS>>BINMIN-φ], in row (c) [MATCH-φ >> BINMIN-φ], in row (d) [ACCASHEAD>>BINMIN-φ], and in row (e) [NOLAPSE-L>> BINMIN-φ].

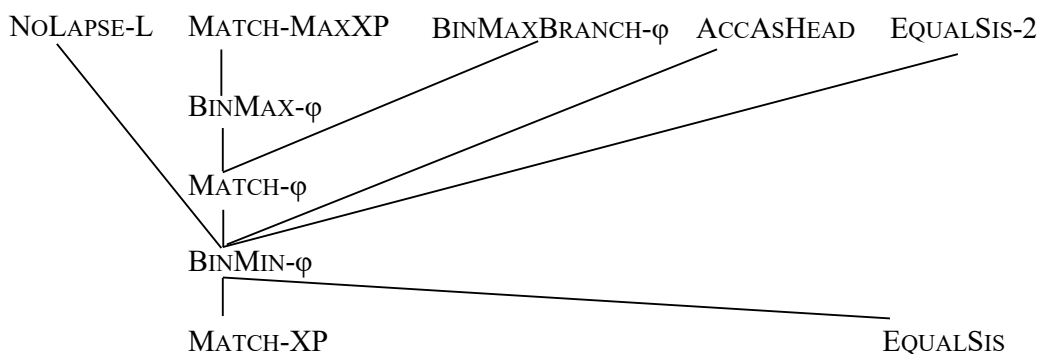
(31)

S:	P:	MATCH-MAXXP	NOLAPSE-L	ACCASHD	BINMAXBRANCH-φ	BINMAX-φ	MATCH-φ	EQUALSIS2	BINMIN-φ	MATCH-XP	EQUALSIS
[[[[u]u]u]u]	► ((uu)(uu))					1	1			2	
	((u)u(uu))					1	1		1W	1L	1W
	((uu)u)u)					2W	L	1W		1L	2W
	(uuuu)				1W	1	L			3W	
	(uu)(uu)	1W				L	1			3W	

In (31), the leftmost WL sequence in row (b) shows [BINMIN-φ >> MATCH-XP], in row (c) [BINMAX-φ >> MATCH-φ,] in row (d) [BINMAXBRANCH-φ >> MATCH-φ], and in row (e) [MATCH-MAXXP >> BINMAX-φ].

The overall constraint ranking, as diagrammed by OTW, is shown in (32), where we see five undominated constraints, alternating types of Match and Binarity constraints as the main axis, and remaining interleaving constraints.

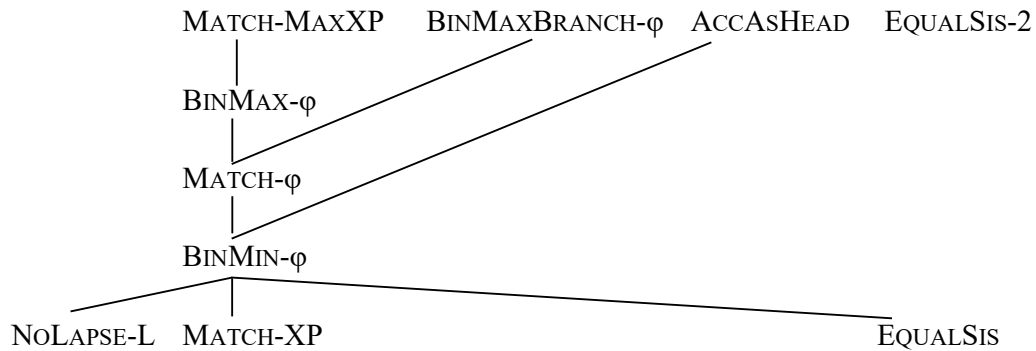
(32) Japanese constraint ranking:



An additional bonus of OTW is that it not only produces the OT grammar under investigation, but also the full factorial typology of the underlying constraint set. Within this typology, we

indeed find the grammar generating the Basque system (section 2.2), as shown in (33). It is instructive to compare it to the grammar of Japanese in (32) above.

(33) Basque constraint ranking:



The only crucial difference between the two systems is the ranking of NO LAPSE-L and BINMIN-φ:

(34) Japanese: [NO LAPSE-L >> BINMIN-φ]

Basque: [BINMIN-φ >> NO LAPSE-L]

Less important is a difference in the ranking OF EQUALSISTERS-2. In the Basque system, it is not ranked w.r.t. BINMIN-φ because the input [[[a]u]u] comes out as (((au)u), i.e., with the last *u* unphrased. This candidate fulfils both EQUALSISTERS-2 and BINMIN-φ, so no ranking of the two is required. In the Japanese system, the outcome is (((a)(u))(u)), fulfilling EQUALSISTERS-2 but violating BINMIN-φ. This means [EQUALSISTERS-2 >> BINMIN-φ].

The core data and their OT analysis, as summarized by OTW in its skeletal basis, appear in a comparative tableau format in (35).

(35) Skeletal basis for Japanese
syntax-prosody mapping

Input	Winner	Loser	MATCH-MAXXP	NOLAPSE-L	ACCASHD	BINMAXBRANCH-φ	EQUALSIS-2	BINMAX-φ	MATCH-φ	BINMIN-φ	MATCH-XP	EQUALSIS
a. [[[u]u]u]u]	((uu)(uu))	(uu)(uu)	W					L	L		L	
b. [[a]u]	((a)(u))	(au)		W						L	W	
c. [[a]u]	((a)(u))	(a(u))			W					L	W	W
d. [[[u]u]u]u]	((uu)(uu))	(uuuu)				W			L		W	
e. [[[a]u]u]	((a(u))(u))	((a(u))u)					W			L		W
f. [[[u]u]u]u]	((uu)(uu))	((uu)u)(u)						W	L	W	L	W
g. [[[u]u]a]	((uu)(a))	(u(ua))							W	L	W	W
h. [[u]u]	(uu)	((u)u)								W	L	W
i. [[[u]u]u]	((uu)u)	((uu)(u))								W		L

(36) Skeletal basis for Basque
syntax-prosody mapping

Input	Winner	Loser	MATCH-MAXXP	ACCASHD	BINMAXBRANCH-φ	EQUALSIS-2	BINMAX-φ	MATCH-φ	BINMIN-φ	NOLAPSE-L	MATCH-XP	EQUALSIS
a. [[[u]u]u]u]	((uu)(uu))	(uu)(uu)	W				L	L			L	
b. [[a]a]	((a)(a))	(aa)		W					L		W	
c. [[[u]u]u]u]	((uu)(uu))	(uuuu)			W		L				W	
d. [[[u]u]u]u]	((uu)(uu))	((uu)u)(u)					W	L	W		L	W
e. [[[u]u]a]	((uu)(a))	(u(ua))						W	L		W	W
f. [[a]u]	(au)	((a)(u))							W	L	L	
g. [[[u]u]u]	((uu)u)	((uu)(u))							W			L

In conclusion, it is remarkable that Match Theory (Selkirk 2011) has not only resulted in a more principled and more streamlined understanding of syntax-prosody mapping relations, but has also opened up new perspectives on many prosodic wellformedness constraints, as they impinge on the otherwise expected isomorphism between syntactic structure and prosodic form. Using well-known generalizations about the way phrasal structures in Japanese are parsed into prosodic units as a testing ground, this paper has reported on some preliminary results regarding the role of anti-lapse constraints in pitch accent systems (section

2), the finer details of hierarchical equality requirements on sister nodes (Myrberg 2013, section 3), the diversity of binarity constraints (section 4), and the necessity of distinguishing separate instantiations of syntax-prosody mapping constraints for higher-level syntactic constituents (Ishihara 2014, section 5). Finally, we have ended up with an initial analysis of the Japanese data under consideration (section 6) that gives some idea of the complexity of the system underlying these facts, and of the variety of constraints needed to capture them.

7 References

- Chomsky, Noam, and Halle, Morris. 1968. *The Sound Pattern of English*. New York: Harper & Row.
- Elfner, Emily. 2012. *Syntax-Prosody Interactions in Irish*, Department of Linguistics, University of Massachusetts, Amherst: Doctoral dissertation.
- Elordieta, Gorka. 2007. Minimum size constraints on intermediate phrases.
<http://www.icphs2007.de/conference/Papers/1682/1682.pdf> (retrieved 8/15/2015).
- Féry, Caroline. 2010. Recursion in prosodic structure. *Phonological Studies* 13:51-60.
- Gussenhoven, Carlos. 2004. *The Phonology of Tone and Intonation*. Cambridge, U.K.: Cambridge University Press.
- Gussenhoven, Carlos. 2005. Procliticized phonological phrases in English: Evidence from rhythm. *Studia Linguistica* 59:174-193.
- Hulst, Harry van der. 2010. A note on recursion in phonology. In *Recursion and human language*, ed. Harry van der Hulst. Berlin: Mouton de Gruyter. 301-342.
- Ishihara, Shinichiro. 2014. Match Theory and the recursivity problem. In *Proceedings of FAJL 7: Formal Approaches to Japanese Linguistics*, eds. Shigeto Kawahara and Mika Igarashi. Cambridge, MA: MIT Working Papers in Linguistics. 73. 69-88.

- Ito, Junko, and Mester, Armin. 1992. Weak layering and word binarity. Linguistic Research Center Working Paper LRC-92-09. UC Santa Cruz. Published in Takeru Honma, Masao Okazaki, Toshiyuki Tabata and Shin-ichi Tanaka, eds. 2003. *A New Century of Phonology and Phonological Theory. A Festschrift for Professor Shosuke Haraguchi on the Occasion of His Sixtieth Birthday*. Tokyo: Kaitakusha. 26-65.
- Ito, Junko, and Mester, Armin. 2007. Prosodic adjunction in Japanese compounds. In *Formal Approaches to Japanese Linguistics: Proceedings of FAJL 4*, eds. Yoichi Miyamoto and Masao Ochi. Cambridge, Massachusetts: MIT Department of Linguistics and Philosophy. 97-111.
- Ito, Junko, and Mester, Armin. 2009a. The extended prosodic word. In *Phonological Domains: Universals and Deviations*, eds. Janet Grijzenhout and Barış Kabak. Berlin: Mouton de Gruyter. 135-194.
- Ito, Junko, and Mester, Armin. 2009b. The onset of the prosodic word. In *Phonological Argumentation: Essays on Evidence and Motivation*, ed. Steve Parker. London: Equinox. 227-260.
- Ito, Junko, and Mester, Armin. 2013. Prosodic subcategories in Japanese. *Lingua* 124:20-40.
- Kabak, Barış, and Revithiadou, Anthi. 2009. An interface approach to prosodic word recursion. In *Phonological domains: universals and deviations*, eds. Janet Grijzenhout and Barış Kabak. Berlin: Mouton de Gruyter. 105-134.
- Kubozono, Haruo. 1988. *The Organization of Japanese Prosody*, University of Edinburgh: Doctoral dissertation. Published by Kurosio Publishers, Tokyo, 1993.
- Kubozono, Haruo. 1989. Syntactic and rhythmic effects on downstep in Japanese. *Phonology* 6:39-67.
- Ladd, D. Robert. 1986. Intonational phrasing: The case for recursive prosodic structure. *Phonology* 3:311-340.

- Ladd, D. Robert. 1988. Declination "reset" and the hierarchical organization of utterances. *Journal of the Acoustical Society of America* 84:530-544.
- McCawley, James D. 1968. *The Phonological Component of a Grammar of Japanese*. The Hague, The Netherlands: Mouton.
- Myrberg, Sara. 2013. Sisterhood in prosodic branching. *Phonology* 30:73-124.
- Nespor, Marina, and Vogel, Irene. 1986. *Prosodic Phonology*. Dordrecht: Foris.
- Pierrehumbert, Janet, and Beckman, Mary. 1988. *Japanese Tone Structure*. LI Monograph Series No. 15. Cambridge, MA: MIT Press.
- Prince, Alan S. 2000. Comparative tableaux. Rutgers Optimality Archive. ROA-376. <http://roa.rutgers.edu/>. (Retrieved 8/15/2015).
- Prince, Alan S., and Smolensky, Paul. 1993. Optimality Theory: Constraint Interaction in Generative Grammar. RuCCS-TR-2. Rutgers University and University of Colorado, Boulder, Brunswick, New Jersey, and Boulder, Colorado. [Published 2004, Blackwell. Malden, Mass.].
- Schreuder, Maartje. 2006. *Prosodic Processes in Language and Music*, Rijksuniversiteit Groningen, The Netherlands: PhD Dissertation.
- Schreuder, Maartje , and Gilbers, Dicky. 2004. Recursive Patterns in Phonological Phrases. In *Proceedings of Speech Prosody 2004*, eds. Bernard Bel and Isabelle Marlien. Nara, Japan: ISCA (SproSig). 341-344.
- Selkirk, Elisabeth. 1984. *Phonology and Syntax: The Relation between Sound and Structure*. Cambridge, MA: MIT Press.
- Selkirk, Elisabeth. 1986. On derived domains in sentence phonology. *Phonology* 3:371-405.
- Selkirk, Elisabeth. 1996. The prosodic structure of function words. In *Signal to Syntax*, eds. James L. Morgan and Katherine Demuth. Mahwah, NJ: Lawrence Erlbaum. 187-213.

- Selkirk, Elisabeth. 2009. On clause and intonational phrase in Japanese: The syntactic grounding of prosodic constituent structure. *Gengo Kenkyuu* 136:35-73.
- Selkirk, Elisabeth. 2011. The syntax-phonology interface. In *The Handbook of Phonological Theory. 2nd edition*, eds. John Goldsmith, Jason Riggle and Alan Yu. Oxford: Blackwell Publishing. 435-485.
- Selkirk, Elisabeth, and Elordieta, Gorka. 2010. The role for prosodic markedness constraints in phonological phrase formation in two pitch accent languages. Handout of paper presented at Tone and Intonation in Europe (TIE) 4, Stockholm University, Department of Scandinavian Languages.
<http://www.hum.su.se/pub/jsp/polopoly.jsp?d=13236&a=73666> (retrieved 08/15/2015).
- Shinya, Takahito, Selkirk, Elisabeth, and Kawahara, Shigeto. 2004. Rhythmic boost and recursive minor phrase in Japanese. In *Proceedings of the second international conference on speech prosody*. 345-348.
- Vance, Timothy J. 2008. *The Sounds of Japanese*. Cambridge, U.K.: Cambridge University Press.
- Wagner, Michael. 2005. *Prosody and Recursion*, Department of Linguistics and Philosophy, MIT: Doctoral dissertation.
- Wagner, Michael. 2010. Prosody and recursion in coordinate structures and beyond. *Natural Language and Linguistic Theory* 28:183-237.

Notes

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² NOLAPSE fits into a larger family of tonal anti-lapse constraints that are at work in pitch accent languages, such as Ancient Greek (see Ito and Mester 2013:31).

³ I.e., a ϕ not dominating another ϕ , as defined in Ito and Mester 2007, 2013.

⁴ The tableaux below are violation tableaux with added comparative markings (Prince 2000), with W's and L's appearing in the rows of losing candidates. "W" in a constraint column indicates the winner is favored by the constraint, "L" indicates the loser is favored, and no entry indicates a tie (i.e., the violation marks for the winner equal those of the loser). In order for a ranking tableau to be consistent, each L has to be preceded by a W in its row (in order to win, the winner needs to do better than each loser on the highest-ranked constraint that distinguishes the two, in Jane Grimshaw's succinct phrasing).

⁵ Formally called *ADJUNCTION, under which name it appears in Selkirk and Elordieta 2010

⁶ This tableau and the following are our interpretation (Selkirk and Elordieta 2010 provide no tableaux).

⁷ The winning candidate here is (*au*), which we take to be the correct outcome since we do

not know of any evidence showing that the leading *a* is a separate phrase, as in Selkirk and Elordieta 2010. If there is indeed reason to assign the parse $((a)u)$, it will be the predicted winner once ALIGN-R is added to the system and ranked above MINBIN.

⁸ The definition here is slightly revised from that in Ishihara 2014, which requires a matching $\phi_{[+\max]}$. We require only a matching ϕ in order to allow for prosodic cliticisation to $XP_{[+\max]}$, for example.

⁹ OTWorkplace_X_83, version of June 27, 2015. The program developed by Alan Prince, Bruce Tesar, and Naz Merchant is open-source and distributed without charge, downloadable from <https://sites.google.com/site/otworkplace/>. OTWorkplace is a software suite that, in the words of its authors, "uses Excel as a platform for interactive research with the analytical tools of modern rigorous OT."

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