Rhythmic Licensing Theory: An extended typology

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1. Introduction

The standard model of directional stress assignment in Optimality Theory uses two gradient alignment constraints which assess the distance between edges of feet and words (McCarthy & Prince 1993). This model predicts a large amount of symmetry in metrical typology, in terms of directionality and in terms of foot type. Yet major gaps occur in the typology, such as leftward binary iambs. Kager (2001) diagnoses the ill-formedness of the missing patterns as rhythmic, and rooted in the avoidance of lapses. Grid-based constraints are proposed to license lapses in specific contexts, such as the end of a domain, while other constraint types ban lapses, contextually or generically. Gradient alignment is eliminated, and replaced by categorical modes of evaluation (McCarthy 2003). This paper assesses the factorial typology of the new, rhythmic constraint set, while comparing it to gradient alignment. Modifications are proposed which further restrict the typological predictions, which are tested using automated techniques for constraint ranking (Hayes, Tesar & Zuraw, 2003).

1.2 Metrical directionality in standard alignment theory

Strictly binary trochaic feet are highly common in stress patterns. The two simplest cases, with unidirectional parsing, appear below:

(1) Pintupi (Hansen & Hansen 1969): binary trochees from left to right
8σ ('ku.ra).(ˌɳu.lu).(ˌlim.pa).(ˌtju.ɻa) 'the first one (who is) our relation'
9σ ('yu.ma).(ˌɻiŋ.ka).(ˌma.ra).(ˌtja.ɻa).ka 'because of mother-in-law'

(2) Warao (Osborn 1966): binary trochees from right to left
8σ (ˌja.pu).(ˌru.ki).(ˌta.ne).('ha.se) 'verily to climb'
9σ e.(ˌna.ho).(ˌro.a).(ˌha.ku).('ta.i) 'the one who caused him to eat'

Rule-based metrical theory (Hayes 1995) accounts for directionality by parameters. The standard OT analysis (McCarthy & Prince 1993) models directionality effects by a pair of foot alignment constraints, measuring the distance between a foot and a designated word edge. Violations are assessed gradiently, by intervening syllables.

(3) a. **ALL-FT-L** (gradient version)
The left edge of every foot is aligned with the left edge of PrWd.
b. **ALL-FT-R** (gradient version)
The right edge of every foot is aligned with the right edge of PrWd.

(4) Foot alignment analysis of Pintupi
FT-BIN » PARSE-SYL » **ALL-FT-L** » **ALL-FT-R**

(5)

Input: /yumaɻiŋkamaratjaɻaka/	FT-BIN	PARSE-SYL	ALL-FT-L	ALL-FT-R
☞ (ˈyu.ma).(ˌɻiŋ.ka).(ˌma.ra).(ˌtja.ɻa).ka		*	2/4/6=12	16
(ˈyu.ma).(ˌɻiŋ.ka).(ˌma.ra).tja.(ˌɻa.ka)		*	2/4/7=13!	15
(ˈyu.ma).(ˌɻiŋ.ka).ma.(ˌra.tja).(ˌɻa.ka)		*	2/5/7=14!	14
(ˈyu.ma).ɻiŋ.(ˌka.ma).(ˌra.tja).(ˌɻa.ka)		*	3/5/7=15!	13
yu.(ˈma.ɻiŋ).(ˌka.ma).(ˌra.tja).(ˌɻa.ka)		*	1/3/5/7=16!	12
(ˈyu.ma).ɻiŋ.ka.ma.ra.tja.ɻa.ka		7!		7
(ˈyu.ma).(ˌɻiŋ.ka).(ˌma.ra).(ˌtja.ɻa).(ˌka)	*!		19	18

Note how cumulative violations of ALL-FT-L affect the location of every foot in the word. Directionally, Warao is just the mirror image of Pintupi. R-to-L parsing requires a minimal re-ranking of foot alignment constraints (in addition to a change in the location of the head foot):

(6) Foot alignment analysis of Warao
FT-BIN » PARSE-SYL » **ALL-FT-R** » **ALL-FT-L**

(7)

Input: /enahoroahakutai/	FT-BIN	PARSE-SYL	ALL-FT-R	ALL-FT-L
(ˌe.na).(ˌho.ro).(ˌa.ha).(ˈku.ta).i		*	1/3/5/7=16!	12
(ˌe.na).(ˌho.ro).(ˌa.ha).ku.(ˈta.i)		*	3/5/7=15!	13
(ˌe.na).(ˌho.ro).a.(ˌha.ku).(ˈta.i)		*	2/5/7=14!	14
(ˌe.na).ho.(ˌro.a).(ˌha.ku).(ˈta.i)		*	2/4/7=13!	15
☞ e.(ˌna.ho).(ˌro.a).(ˌha.ku).(ˈta.i)		*	2/4/6=12	16
e.na.ho.ro.a.ha.ku.(ˈta.i)		7!		7
(ˌe.na).(ˌho.ro).(ˌa.ha).(ˌku.ta).(ˈi)	*!		18	19

The antagonist constraint pair ALL-FT-L / ALL-FT-R, which measure the location of foot boundaries rather than of grid marks, predicts a large amount of symmetry in metrical typology, not only between rightward and leftward stress systems, but also between trochaic and iambic systems. The symmetric nature of gradient alignment theory derives from its parametric ascendant (Hayes 1980, 1995; Halle & Vergnaud 1987). Yet, asymmetries occur in metrical typology which are unexpected under gradient alignment. In particular, an iambic directionality asymmetry was observed by Kager (1993): universally, binary iambs are assigned rightward (see 8).

(8) Araucanian (Echeverría & Contreras 1965): binary iambs from left to right
5σ (e.ˈlu).(a.ˌe).new — 'he will give me'
6σ (ki.ˈmu).(fa.ˌlu).(wu.ˌlaj) — 'he pretended not to know'

The (hypothetical) leftward counterpart of Araucanian, which is also the iambic counterpart of Warao, would have the metrical pattern (9):

(9) Unattested pattern: binary iambs from right to left
8σ (σ ˌσ) (σ ˌσ) (σ 'σ)
9σ σ (σ ˌσ) (σ ˌσ) (σ 'σ)

Unlike the rhythmically perfectly leftward trochaic pattern of Warao, the leftward iamb is imperfect since it contains a lapse, a sequence of unstressed syllables, right at the left edge. Such 'double upbeats' are avoided both in language and in music (Prince 1983; Lerdahl & Jackendoff 1983). The iambic gap is schematized in (10):

(10) The gap in the typology of strictly binary systems

foot type	L-to-R	R-to-L
trochee	Pintupi	Warao
iamb	Araucanian	*none*

The diagnosis that a domain-initial lapse in the hypothetical pattern (9) causes its being avoided in stress systems is supported by the following observation. Leftward iambs are not cross-linguistically excluded, as they occur in languages such as Weri (11). Interestingly, all known leftward iambic languages place a unary foot in initial position in odd-parity words.

(11) Weri (Boxwell & Boxwell 1969): binary/unary iambs from right to left.
6σ (lɪ.ˌlɪ).(ŋe.ˌwe).(ɺɪ.'aɺ) 'two ladders'
7σ (ˌmoɺ).(mo.ˌɺa).(i.ˌmen).(tɪ.'aɺ) 'two tomatoes'

This pattern is rhythmically perfect, having an initial beat where the hypothetical pattern in (9) has a lapse. Standard alignment theory cannot explain this connection between foot type, directionality, and tolerance for unary feet.

1.3 Metrical directionality in rhythmic licensing theory

Kager (2001) suggests that a purely rhythmic factor, initial lapse avoidance, causes the R-to-L iambic gap. He proposes to reinterpret directional footing in terms of rhythmic targets, in particular locations in which clashes and lapses occur. From a grid-based perspective, the Warao pattern is unique among strictly binary trochaic patterns: it is the single one in which stress alternates perfectly, without violations of *LAPSE (Prince 1983; Selkirk 1984).

(12) ***LAPSE**
No two adjacent unstressed syllables.

Lapse-wise, leftward binary trochees cannot be improved. Under foot binarity, odd-numbered strings of syllables cannot be exhaustively parsed by binary feet. Hence, lapse is only avoidable by locating the unparsed syllable in initial position, where it is immediatialy followed by a stress.

(13) Lapse-based analysis of Warao
FT-BIN, *LAPSE

(14)

Input: /enahoroahakutai/	FT-BIN	*LAPSE
(ˌe.na).(ˌho.ro).(ˌa.ha).(ˈku.ta).i		*!
(ˌe.na).(ˌho.ro).(ˌa.ha).ku.(ˈta.i)		*!
(ˌe.na).(ˌho.ro).a.(ˌha.ku).(ˈta.i)		*!
(ˌe.na).ho.(ˌro.a).(ˌha.ku).(ˈta.i)		*!
☞ e.(ˌna.ho).(ˌro.a).(ˌha.ku).(ˈta.i)		
e.na.ho.ro.a.ha.ku.(ˈta.i)		******
(ˌe.na).(ˌho.ro).(ˌa.ha).(ˌku.ta).(ˈi)	*!	

A lapse-based re-interpretation is possible for the Pintupi pattern as well: lapses occur at the word end in odd-parity words. To guarantee initial stress, Kager (2001) uses the categorical word alignment constraint ALIGN-WD-L, requiring every word to start with a foot, outranking the anti-lapse constraint *LAPSE.

(15)

Input: /yumaɻiŋkamaratjaɻaka/	FT-BIN	ALIGN-WD-L	*LAPSE
☞ (ˈyu.ma).(ˌɻiŋ.ka).(ˌma.ra).(ˌtja.ɻa).ka			*
☞ (ˈyu.ma).(ˌɻiŋ.ka).(ˌma.ra).tja.(ˌɻa.ka)			*
☞ (ˈyu.ma).(ˌɻiŋ.ka).ma.(ˌra.tja).(ˌɻa.ka)			*
☞ (ˈyu.ma).ɻiŋ.(ˌka.ma).(ˌra.tja).(ˌɻa.ka)			*
yu.(ˈma.ɻiŋ).(ˌka.ma).(ˌra.tja).(ˌɻa.ka)		*!	
(ˈyu.ma).ɻiŋ.ka.ma.ra.tja.ɻa.ka			**!*****
(ˈyu.ma).(ˌɻiŋ.ka).(ˌma.ra).(ˌtja.ɻa).(ˌka)	*!		

A strictly binary trochaic system which satisfies ALIGN-WD-L necessarily accepts a lapse in words of odd parity. Yet, as tableau (15) shows, exact locations of lapses are not predictable by *LAPSE alone. Without gradient ALL-FT-L, a new constraint is needed to select among the four remaining candidates in (15). Pintupi selects the candidate which has a lapse in *final* position. Accordingly, Kager (2001) posits a lapse licensing constraint LAPSE-AT-END, which attracts the lapse to the word end:

(15) **LAPSE-AT-END**
Lapse must be adjacent to the right edge.

This pushes the single unparsed syllable rightward so that the pattern gets the looks of L-to-R directionality.

(16) Lapse-based analysis of Pintupi
Ft-Bin, Align-Wd-L, Lapse-at-End » *Lapse

(17)

Input: /yumaɻiŋkamaratjaɻaka/	Ft-Bin	Align-Wd-L	Lapse-at-End	Lapse
☞ (ˈyu.ma).(ˌɻiŋ.ka).(ˌma.ra).(ˌtja.ɻa).ka				*
(ˈyu.ma).(ˌɻiŋ.ka).(ˌma.ra).tja.(ˌɻa.ka)			*!	*
(ˈyu.ma).(ˌɻiŋ.ka).ma.(ˌra.tja).(ˌɻa.ka)			*!	*
(ˈyu.ma).ɻiŋ.(ˌka.ma).(ˌra.tja).(ˌɻa.ka)			*!	*

In sum, for uni-directional binary systems, such as Pintupi and Warao, gradient foot alignment can simply be abolished.

Bi-directional patterns have one stress fixed at one edge with remaining stresses alternating from the opposite edge. Such patterns occur in Piro and Garawa.

(18) Piro (Matteson 1965): fixed foot at right edge, alternating feet left to right
6σ (ˌpe.tʃi).(ˌtʃhi.ma).(ˈtlo.na) ‘they say they stalk it’
7σ (ˌru.slu).(ˌno.ti).ni.(ˈtka.na) ‘their voices already changed’

(19) Garawa (Furby 1974): fixed foot at left edge, alternating feet right to left
6σ (ˈja.ka).(ˌla.ka).(ˌlam.pa) ‘loose’
7σ (ˈŋan.ki).ɽi.(ˌki.rim).(ˌpa.ji) ‘fought with boomerangs’

Here, a foot occurs at both edges of the word, hence the lapse occurs internally.

(20)

Input: /ruslunotinitkana/	Align-Wd-R	Align-Wd-L	*Lapse
ru.(ˌslu.no).(ˌti.ni).(ˈtka.na)		*!	
☞ (ˌru.slu).no.(ˌti.ni).(ˈtka.na)			*
☞ (ˌru.slu).(ˌno.ti).ni.(ˈtka.na)			*
(ˌru.slu).(ˌno.ti).(ˈni.tka).na	*!		*

(21)

Input: /ŋankiɽikirimpaji/	Align-Wd-L	Align-Wd-R	*Lapse
ŋan.(ˈki.ɽi).(ˌki.rim).(ˌpa.ji)	*!		
☞ (ˈŋan.ki).ɽi.(ˌki.rim).(ˌpa.ji)			*
☞ (ˈŋan.ki).(ˌɽi.ki).rim.(ˌpa.ji)			*
(ˈŋan.ki).(ˌɽi.ki).(ˌrim.pa).ji		*!	*

The generalization unifying the Piro and Garawa patterns is that in both cases, the unparsed syllable sits near the main stress. This motivates a constraint attracting a lapse to the stress peak (Kager 2001):

(22) **LAPSE-AT-PEAK**
Every lapse must be adjacent to the peak.

In Piro, this pushes the lapse rightward to immediately precede the peak.

(23)

Input: /ruslunotinitkana/	LAPSE-AT-PEAK
(ˌru.slu).no.(ˌti.ni).(ˈtka.na)	*!
☞ (ˌru.slu).(ˌno.ti).ni.(ˈtka.na)	

(24) Lapse-based analysis of Piro
FT-BIN, ALIGN-WD-R, LAPSE-AT-PEAK » ALIGN-WD-L » *LAPSE

(25)

Input: /ruslunotinitkana/	ALIGN-WD-R	LAPSE-AT-PEAK	ALIGN-WD-L	*LAPSE
ru.(ˌslu.no).(ˌti.ni).(ˈtka.na)			*!	
(ˌru.slu).no.(ˌti.ni).(ˈtka.na)		*!		*
☞ (ˌru.slu).(ˌno.ti).ni.(ˈtka.na)				*
(ˌru.slu).(ˌno.ti).(ˈni.tka).na	*!			*

The Garawa pattern is equally straightforward. The peak lodges on the first foot, hence the lapse shifts backward to meet the peak:

(26) Lapse-based analysis of Garawa
FT-BIN, ALIGN-WD-L, LAPSE-AT-PEAK » ALIGN-WD-R, *LAPSE

(27)

Input: /ŋankiɽikirimpaji/	ALIGN-WD-L	LAPSE-AT-PK	ALIGN-WD-R	*LAPSE
ŋan.(ˈki.ɽi).(ˌki.rim).(ˌpa.ji)	*!			
☞ (ˈŋan.ki).ɽi.(ˌki.rim).(ˌpa.ji)				*
(ˈŋan.ki).(ˌɽi.ki).rim.(ˌpa.ji)		*!		*
(ˈŋan.ki).(ˌɽi.ki).(ˌrim.pa).ji		*!	*	*

Rhythmic licensing theory needs no pair of antagonist constraints to account for the minimal difference in directionality between Piro and Garawa. In both patterns, the location of the unparsed syllable follows from LAPSE-AT-PEAK, which assesses a local rhythmic configuration.

Thus far, nothing has been said about the mechanism to locate the peak. Kager (2004) adopts McCarthy's (2003:111) proposal:

(28) a. **END-RULE-L**
The head foot is not preceded by another foot within the prosodic word.
b. **END-RULE-R**
The head foot is not followed by another foot within the prosodic word.

These are categorical alignment constraints, which are violated when the head foot is not 'leftmost' or 'rightmost' in PrWd. Violations are measured as in (29).

(29)

	END-RULE-L	END-RULE-R
σ(ˌσσ)(ˌσσ)(ˌσσ)(**'σσ**)	*	
σ(**'σσ**)(ˌσσ)(ˌσσ)(ˌσσ)		*
(**'σσ**)(ˌσσ)(ˌσσ)(ˌσσ)σ		*
σσσσσσσ(**'σσ**)		
σσσσ(**'σσ**)σσσ		
(**'σσ**)σσσσσσσ		

Note that no violation results when a sequence of unparsed syllables intervenes between the head foot and the designated edge of the word. Moreover, if both are undominated, a single foot patterns results.

Assuming these seven constraints, Kager (2001) presents a preliminary factorial typology of strictly binary patterns. (These are patterns in which FT-BIN » PARSE-SYL holds.) The set of six trochaic patterns generated by this constraint set is shown below for a seven-syllable word. Lapses have been underlined for clarity.

(30)

binary trochees, 7 syllables	*LAPSE	LAPSE-AT-PEAK	LAPSE-AT-END	END-RULE-L	END-RULE-R	ALIGN-WD-L	ALIGN-WD-R	Example
('σσ)(ˌσσ)(ˌσ$\underline{\sigma}$)$\underline{\sigma}$	*	*			*		*	Pintupi
('σσ)(ˌσ$\underline{\sigma}$)$\underline{\sigma}$(ˌσσ)	*	*	*		*			*harm. bnd.*
('σ$\underline{\sigma}$)$\underline{\sigma}$(ˌσσ)(ˌσσ)	*		*		*			Garawa
σ('σσ)(ˌσσ)(ˌσσ)					*	*		Wargamay
σ(ˌσσ)(ˌσσ)('σσ)				*		*		Warao
(ˌσ$\underline{\sigma}$)$\underline{\sigma}$(ˌσσ)('σσ)	*	*	*	*				*harm. bnd.*
(ˌσσ)(ˌσ$\underline{\sigma}$)$\underline{\sigma}$('σσ)	*		*	*				Piro
(ˌσσ)(ˌσσ)('σ$\underline{\sigma}$)$\underline{\sigma}$	*			*			*	C. Arabic

All predicted stress patterns are attested in some language. (Wargamay and Cairene Arabic share their foot distributions with Warao and Pintupi, respectively, but with their peaks shifted to the opposite edge of the word.) Note that two shaded patterns (second and sixth from the top), generated by gradient alignment theory, cannot be generated under any possible ranking of the current constraint set. We will refer to these patterns as anti-Garawa and anti-Piro, respectively, since their metrifications are identical to Garawa's and Piro's, except that their medial unparsed syllables fall next to a peripheral secondary stress foot. Both are *harmonically bounded* (Samek-Lodovici & Prince 1999). Pairs of cells included in double margins indicate fatal violations in one pattern (the harmonically bounded one) which is crucially lacking in its close competitor, which otherwise has the same violations.

The preliminary set of iambic patterns is even more restricted:

(31)

binary iambs, 7 syllables	*LAPSE	LAPSE-AT-PEAK	LAPSE-AT-END	END-RULE-L	END-RULE-R	ALIGN-WD-L	ALIGN-WD-R	Example
(σ'σ)(σˌσ)(σˌσ)σ					*		*	Araucanian
(σ'σ)(σˌσ)$\underline{\sigma}$($\underline{\sigma}$ˌσ)	*	*	*		*			*harm. bnd.*
(σ'σ)$\underline{\sigma}$($\underline{\sigma}$ˌσ)(σˌσ)	*		*		*			**n.a.**
$\underline{\sigma}$($\underline{\sigma}$'σ)(σˌσ)(σˌσ)	*		*		*	*		*harm. bnd.*
$\underline{\sigma}$($\underline{\sigma}$ˌσ)(σˌσ)(σ'σ)	*	*	*	*		*		*harm. bnd.*
(σˌσ)$\underline{\sigma}$($\underline{\sigma}$ˌσ)(σ'σ)	*	*	*	*				*harm. bnd.*
(σˌσ)(σˌσ)$\underline{\sigma}$($\underline{\sigma}$'σ)	*		*	*				**n.a.**
(σˌσ)(σˌσ)(σ'σ)σ				*			*	Creek

Here, four out of eight logically possible iambic patterns are harmonically bounded. In particular, note how leftward binary iambs (with initial lapses) are harmonically bounded. Interestingly, the constraints dealing fatal blows are LAPSE-AT-PEAK and ALIGN-WD-L. No constraint specifically bans initial lapses (Paula Adan p.c.). Only two predicted patterns are not attested: the iambic equivalents of Garawa and Piro. Since both of these are also generated by gradient alignment theory, the preliminary conclusion is that rhythmic licensing theory is more restrictive. (The question why the iambic typology contains no bidirectional patterns is beyond the present paper.)

1.4 At issue in this paper

The remainder of this paper will compare two metrical theories, standard alignment and rhythmic licensing, using automated techniques for factorial typology. We will construct factorial typologies of complete sets of forms from 2 up until 9 syllables, which offers a much harder test than the inspection of 7-syllable forms in isolation. To make the test maximally objective, we use constraint ranking software (OTSoft; Hayes, Tesar & Zuraw 2003) to generate factorial typologies. Before the results are presented and discussed in Section 4, we will first scrutinize the constraint set of rhythmic licensing theory: it has some typological flaws which need instant repairs.

2. Revising Rhythmic Licensing Theory

Revisions of Rhythmic Licensing Theory (Kager 2001, 2004, 2005) proposed here affect four ingredients.

First, a novel constraint is required to trim the typology of single stress systems, those in which both END-RULE-L and END-RULE-R are undominated. Table (32) shows the need for a tie-breaker.

(32)

	*LAPSE	LAPSE-AT-END	ALIGN-WD-L	ALIGN-WD-R
a. σσσσ('σσ)	***	***	*	
b. σσσ('σσ)σ	***	**	*	*
c. σσ('σσ)σσ	***	**	*	*
d. σ('σσ)σσσ	***	**	*	*
e. ('σσ)σσσσ	****	***		*

Observe how *LAPSE disfavours a left-aligned trochee, because this takes away the occasion for a weak beat to immediately precede a strong one. This adds a violation of *LAPSE to (32e) as compared to non-initial foot candidates (32a-d). Observe also how LAPSE-AT-END disfavours a right-aligned trochee, because this takes away the occasion for lapse to be licensed by the word end, effectively adding a violation of LAPSE-AT-END to (32a) as compared to non-final foot candidates (32b-d). The total effect is that single foot candidates with medial (rather than peripheral) feet become optimal in single stress systems when word alignment ALIGN-WD-L/R is dominated by a rhythmic constraint. Hence, a tie-breaking constraint is needed to select among medial foot candidates (32b-d). This can be done by a constraint against long lapses at the end of a word (after Green & Kenstowicz 1995)

(33) ***FINAL-LONG-LAPSE**
No long lapse occurs at the end of PrWd.

This effectively models the three-syllable window restriction found in Macedonian and other languages. Moreover, antepenultimate stress is the preferred location for non-peripheral single foot systems. Its violation pattern is shown below – barring any final sequence of three or more unstressed syllabes.

(34)

	*FINAL-LONG-LAPSE
σσσ('σσ)σ	
σσ('σσ)σσ	*!
σ('σσ)σσσ	*!

Adding this constraint alone causes a massive reduction of the factorial typology by nearly 90%. Interestingly, effects of *FINAL-LONG-LAPSE for single stress systems occur regardless of its ranking, which is the hallmark of a tie-breaker constraint.

A second change with respect to Kager (2001) is the elimination of LAPSE-TO-PEAK. This functioned as a tie-breaker, deciding among otherwise indistinguishable parsings in which a medial lapse is forced by some constraint dominating *LAPSE, in particular ALIGN-WD-L/R » *LAPSE. In Garawa and Piro, the medial lapse shifts to meet the peak (see 25-27). Simultaneously, LAPSE-TO-PEAK explained two gaps in the trochaic typology (30), anti-Piro and anti-Garawa. However, LAPSE-TO-PEAK was correctly blamed by Alber (2002) for its bad typological behaviour, referred to as 'licensor attraction' (Kager 2004). The peak, in order to license a lapse, shifts to meet the lapse in odd-parity forms, while staying in default position in even-parity forms. Consider, for example (35):

(35) Ranking exemplifying licensor attraction
LAPSE-AT-PEAK, LAPSE-AT-END, ALIGN-WD-L » END-RULE-L

This ranking produces a pattern with antepenult stress in odd-numbered words, and initial stress in even-numbered forms.

(36a)	trochees, odd	LAPSE-AT-PEAK	END-RULE-L
	('σσ)(ˌσσ)(ˌσσ)σ	*!	
	☞ (ˌσσ)(ˌσσ)('σσ)σ		*
(36b)	trochees, even	LAPSE-AT-PEAK	END-RULE-L
	☞ ('σσ)(ˌσσ)(ˌσσ)		
	(ˌσσ)(ˌσσ)('σσ)		*!

Kager (2004) attacks the licensor attraction problem by stipulating that either END-RULE-L or END-RULE-R must occupy the top constraint stratum. However, there is a simpler way to produce the same result: eliminating LAPSE-AT-PEAK, replacing it by another constraint which captures its effects.

(37) ***LAPSE-IN-TROUGH**
No lapse occurs between secondary stresses.

*LAPSE-IN-TROUGH penalizes secondary stresses separated by exactly two syllables (38a), but not secondary stresses separated by three syllables (38b), nor an initial or final lapse flanked by a secondary stress (38c-d).

(38)

	comment	*LAPSE-IN-TROUGH	LAPSE-AT-PEAK
a. ('σσ)(ˌσσ)σ(ˌσσ)	anti-Garawa	*	*
b. ('σσ)(ˌσσ)σσ(ˌσσ)	long lapse		**
c. ('σσ)(ˌσσ)σ	final lapse		*
d. σσ(ˌσσ)('σσ)	initial lapse		*

*LAPSE-IN-TROUGH acts as a tie-breaker in Garawa (compare Tableau 27):

(39)

Input: /ŋankiɽikirimpaji/	*LAPSE-IN-TROUGH
☞ ('ŋan.ki).ɽi.(ˌki.rim).(ˌpa.ji)	*!
('ŋan.ki).(ˌɽi.ki).rim.(ˌpa.ji)	

*LAPSE-IN-TROUGH does not penalize a final lapse flanked by a secondary stress. This effectively solves the licensor attraction problem:

(40a)

trochees, odd	*LAPSE-IN-TROUGH	END-RULE-L
☞ ('σσ)(ˌσσ)(ˌσσ)σ		
(ˌσσ)(ˌσσ)('σσ)σ		*!

(40b)

trochees, even	*LAPSE-IN-TROUGH	END-RULE-L
☞ ('σσ)(ˌσσ)(ˌσσ)		
(ˌσσ)(ˌσσ)('σσ)		*!

Replacing LAPSE-AT-PEAK by *LAPSE-IN-TROUGH causes another reduction of the factorial typology by more than 50%.

The third change is adopting categorical versions of foot alignment constraints, ALIGN-FT-L/R. This is motivated by the need to generate dual stress patterns, those having two feet at opposite edges of the word. For these patterns, some mechanism is needed to keep the number of feet below two. Consider a schematic example of a six-syllable word in Sibutu Sama (Kager 1999), which has penultimate main stress and an initial secondary stress.

(41)

	ALIGN-WD-R	END-RULE-R	ALIGN-WD-L	END-RULE-L	ALIGN-FT-L	ALIGN-FT-R
('σσ)(ˌσσ)(ˌσσ)		*!			**	**
(ˌσσ)(ˌσσ)('σσ)				*	**!	**
('σσ)σσ(ˌσσ)		*!			*	*
☞ (ˌσσ)σσ('σσ)				*	*	*

Feet at opposite edges are accounted for by high-ranked ALIGN-WD-R and ALIGN-WD-L, but the choice for a two-foot parse over a three-foot parse can only come from foot-reducing constraints, here ALIGN-FT-L/R.

3. The test of factorial typology

3.1 Method

Ultimately, the hardest test for an OT constraint set is the calculation of its factorial typology. A factorial typology is the total set of output patterns which is derived by a set of constraints when all of its logically possible rankings are considered. The extent to which a constraint set matches the attested patterns in natural languages, that is, by generating all attested patterns in some linguistic domain, while not over-generating patterns that are unlike anything found in natural languages, is a major indication of its fitness for inclusion in *Con*.

Factorial typologies were computed using OTSoft 2.1 (Hayes, Tesar & Zuraw 2003), an OT constraint ranking software package. As its input, the constraint ranking programme uses a database file containing every candidate for every input form, plus violation marks which these incur for every constraint. The programme arranges its results in a text file, listing the individual patterns generated (a factorial typology), and including full information about rankings for each pattern, tableaus for all ouput forms, as well as a list of winners (which specifies for each candidate whether there is at least one ranking that derives it), plus a report on any anomalies in the candidate set, such as candidates which incurred identical violation marks for the constraint set. (Such inconclusiveness is resolved by OTSoft by listing each of the variable outcomes as a separate pattern.)

Candidate sets included all logically possible metrifications for input forms of 2 up until 9 syllables, using only strictly binary feet. Each candidate included exactly one main stress. Trochaic and iambic metrifications were evaluated separately, thus mimicking the effect of undominated FT-FORM=TROCHEE and FT-FORM=IAMB, respectively. The total number of candidates for each foot type amounted to 274, distributed over input forms with different lengths as follows:

(42) Numbers of candidates for inputs of different length, plus examples

σ	N	examples of trochaic candidates	
2	1	(tá.ta)	
3	2	(tá.ta).ta ta.(tá.ta)	
4	5	(tá.ta).ta.ta ta.(tá.ta).ta ta.ta.(tá.ta)	(tá.ta).(tà.ta) (tà.ta).(tá.ta)
5	10	(tá.ta).ta.ta.ta ta.(tá.ta).ta.ta ta.ta.(tá.ta).ta ta.ta.ta.(tá.ta)	(tá.ta).(tà.ta).ta (tà.ta).(tá.ta).ta (tá.ta).ta.(tà.ta) (tà.ta).ta.(tá.ta) ta.(tá.ta).(tà.ta) ta.(tà.ta).(tá.ta)

6	20	(tá.ta).ta.ta.ta.ta ta.(tá.ta).ta.ta.ta ta.ta.(tá.ta).ta.ta ta.ta.ta.(tá.ta).ta ta.ta.ta.ta.(tá.ta)	(tá.ta).(tà.ta).ta.ta (tà.ta).(tá.ta).ta.ta (tá.ta).ta.(tà.ta).ta (tà.ta).ta.(tá.ta).ta (tá.ta).ta.ta.(tà.ta) (tà.ta).ta.ta.(tá.ta) ta.(tá.ta).(tà.ta).ta ta.(tà.ta).(tá.ta).ta ta.(tá.ta).ta.(tà.ta) ta.(tà.ta).ta.(tá.ta) ta.ta.(tá.ta).(tà.ta) ta.ta.(tà.ta).(tá.ta)	(tá.ta).(tà.ta).(tà.ta) (tà.ta).(tá.ta).(tà.ta) (tà.ta).(tà.ta).(tá.ta)
7	38	(tá.ta).ta.ta.ta.ta.ta	etc.	
8	71	(tá.ta).ta.ta.ta.ta.ta.ta	etc.	
9	127	(tá.ta).ta.ta.ta.ta.ta.ta.ta	etc.	

Sub-section 3.2 presents the factorial typologies of the two constraint sets, Gradient Alignment Theory (GAT) and Rhythmic Licensing Theory (RLT).

3.2 Constraint sets

For maximal accuracy, the two constraint sets used in the calculation of factorial typology are given below.

The set for standard Gradient Alignment Theory (GAT) included 8 constraints:

(43) **ALIGN-WORD-LEFT** (gradient version)
Align (PrWd, Left, Foot, Left) "Every PrWd starts with a foot."
(One violation for every unparsed syllable between the left edge of PrWd and nearest foot.)

(44) **ALIGN-WORD-RIGHT** (gradient version)
Align (PrWd, Right, Foot, Right) "Every PrWd ends in a foot."
(One violation for every unparsed syllable between the right edge of PrWd and nearest foot.)

(45) **ALIGN-FOOT-LEFT** (gradient version)
Align (Foot, Left, PrWd, Left) "Every foot is initial in PrWd."
(For each foot, calculate the distance in syllables from its left edge to the left edge of PrWd. Add violations for all feet.)

(46) **ALIGN-FOOT-RIGHT** (gradient version)
Align (Foot, Right, PrWd, Right) "Every foot is final in PrWd."
(For each foot, calculate the distance in syllables from its left edge to the left edge of PrWd. Add violations for all feet.)

(47) **ALIGN-HEAD-LEFT** (gradient version)
Align (HdFt, Left, PrWd, Left) "The head foot is leftmost in PrWd."
(One violation mark for every syllable standing between the left edge of the head foot and the left edge of PrWd.)

(48) **ALIGN-HEAD-RIGHT** (gradient version)
Align (HdFt, Right, PrWd, Right) " The head foot is rightmost in PrWd."
(One violation mark for every syllable standing between the left edge of the head foot and the left edge of PrWd.)

(49) **PARSE-SYL**
Every syllable is parsed by some foot.
(One violation mark for every unparsed syllable in PrWd.)

(50) **NONFINALITY(FOOT)**
No foot is final in the word.
(One violation mark if a foot is strictly final in PrWd.)

The set for Rhythmic Licensing Theory (RLT), modified as discussed above, included 11 constraints:

(51) **ALIGN-WORD-LEFT** (categorical version)
Align (PrWd, Left, Foot, Left) "Every PrWd starts with a foot."
(One violation mark for every PrWd that does not start with a foot.)

(52) **ALIGN-WORD-RIGHT** (categorical version):
Align (PrWd, Right, Foot, Right) "Every PrWd ends with a foot."
(One violation mark for every PrWd that does not end in a foot.)

(53) **ALIGN-FOOT-LEFT** (categorical version)
Align (Foot, Left, PrWd, Left) "Every foot is initial in PrWd."
(One violation mark for every foot that is not strictly initial.)

(54) **ALIGN-FOOT-RIGHT** (categorical version):
Align (Foot, Right, PrWd, Right) "Every foot is final in PrWd."
(One violation mark for every foot that is not strictly final.)

(55) **END-RULE-LEFT**
No foot stands between the head foot and the left edge of PrWd.
(One violation mark in case this requirement is not met.)

(56) **END-RULE-RIGHT**
No foot stands between the head foot and the right edge of PrWd.
(One violation mark in case this requirement is not met.)

(57) ***LAPSE**
No sequences of two unstressed syllabes.
(One violation mark for every pair of unstressed syllables.)

(58) LAPSE-AT-END
Every sequence of two unstressed syllables is strictly final in PrWd.
(One violation mark for every pair of unstressed syllables that is non-final.)

(59) *FINAL-LONG-LAPSE
No sequence of three or more unstressed syllabes occurs at the end of PrWd.
(One violation for a final sequence of three or more unstressed syllables.)

(60) *LAPSE-IN-TROUGH
No sequence of two unstressed syllabes occurs between secondary stresses.
(One violation for a pair of unstressed syllables between secondary stresses.)

(61) PARSE-SYL
Every syllable is parsed by some foot.
(One violation mark for every unparsed syllable in PrWd.)

We now turn to the results of the factorial typologies of GAT and RLT, calculated by OTSoft, which will be split between trochees and iambs.

3.3 Trochees

3.3.1 Gradient Alignment Theory (GAT)
With 8 constraints, the number of logically possible grammars is 40,320. The full typology contains 35 output patterns. Of these 35 output patterns, 13 (or 37.1%) are attested. An initial breakdown into five broad types of patterns is presented in (62):

(62) Break-down into broad types of pattern
3 single stress patterns (3 attested = 100%)
8 dual stress patterns (4 attested = 50%)
8 uni-directional patterns (4 attested = 50%)
8 bi-directional patterns (2 attested = 25%)
8 complex patterns (0 attested = 0%)

The full typology is below. Numbers refer to the listing of patterns in OTSoft.

(63) The factorial typology of binary trochees under Gradient Alignment Theory

#	type	description	attestation
17	single	initial	Tunica
26	single	antepenult	Macedonian
35	single	penult	Chamorro
4	dual	initial + penult (ERL)	Watjarri
8	dual	initial + penult (ERR)	unattested
12	dual	initial + antepenult (ERL)	unattested
16	dual	initial + antepenult (ERR)	unattested
20	dual	antepenult + initial (ERL)	Walmatjarri

24	dual	antepenult + initial (ERR)	Georgian
29	dual	penult + initial (ERL)	Walmatjarri
33	dual	penult + initial (ERR)	S. Sama
1	uni-directional	L-to-R (ERL)	Pintupi
5	uni-directional	L-to-R (ERR)	C. Arabic
9	uni-directional	L-to-R, no final feet (ERL)	unattested
13	uni-directional	L-to-R, no final feet (ERR)	unattested
21	uni-directional	R-to-L, no final feet (ERL)	unattested
25	uni-directional	R-to-L, no final feet (ERR)	unattested
30	uni-directional	R-to-L (ERL)	Wargamay
34	uni-directional	R-to-L (ERR)	Warao
3	bi-directional	initial + R-to-L (ERL)	Garawa
7	bi-directional	initial + R-to-L (ERR)	unattested
11	bi-directional	initial + R-to-L no final feet (ERL)	unattested
15	bi-directional	initial + R-to-L no final feet (ERR)	unattested
18	bi-directional	antepenult + L-to-R (ERL)	unattested
22	bi-directional	antepenult + L-to-R (ERR)	unattested
27	bi-directional	penult + L-to-R (ERL)	unattested
31	bi-directional	penult + L-to-R (ERR)	Piro
2	complex	initial + penult + L-to-R (ERL)	unattested
6	complex	initial + penult + L-to-R (ERR)	unattested
10	complex	initial+ antepenult + L-to-R (ERL)	unattested
14	complex	initial+ antepenult + L-to-R (ERR)	unattested
19	complex	antepenult+ initial + R-to-L (ERL)	unattested
23	complex	antepenult+ initial + R-to-L (ERR)	unattested
28	complex	penult + initial + R-to-L (ERL)	unattested
32	complex	penult + initial + R-to-L (ERR)	unattested

The typology covers the cross-linguistic variation, but is otherwise fairly rich. It overgenerates most among uni-directional and bi-directional patterns, where only 6 out of 16 patterns are attested (or 37.5%). Given the focus of Gradient Alignment Theory on 'iterative directional' patterns, this area of overgeneration is a liability.

A note on patterns #20-#29. Walmatjarri (Hudson & Richards 1969; Hammond 1994) has a stress system with free variation. Each word of sufficient length may occur in two patterns. In one pattern, the antepenult is stressed, while an initial stress occurs in words of 5 syllables or more. Regardless of the pattern, the main stress falls on the leftmost foot.

(64) Summary of variable patterns in Walmatjarri

	Antepenult + initial	Penult + initial
3σ	('σσ)σ	σ('σσ)
4σ	σ('σσ)σ	('σσ)(ˌσσ)
5σ	('σσ)(ˌσσ)σ	('σσ)σ(ˌσσ)
6σ	('σσ)σ(ˌσσ)σ	?

The Walmatjarri penult + initial pattern matches pattern #20, while the antepenult + initial pattern matches #29. This variable system, when broken down into its atomic patterns, leads to the attestation of two predicted patterns.

The occurrence of 8 bi-directional, all but 2 of which unattested, and 8 complex patterns, all unattested, arguably poses a typological problem for the constraint set. Yet, fairness demands to note that patterns of this type are indistinguishable from simpler patterns when syllable numbers are below 7, so that predictions are difficult to test for linguists. Language learners have diminished chance of internalizing the essential input, which is aggravated by the characteristic morphological derivedness of long words.

One type of case stands out, however. The constraint set predicts patterns such as #7, which wil be discussed in the context of RLT below.

3.3.2 Rhythmic Licensing Theory (RLT)

With 11 constraints, the number of logically possible grammars is 39,916,800. The typology contains 25 output patterns. Of these 25 patterns, 14 (or 56%) are attested.

(65) Break-down into broad types of pattern

5 single stress patterns (3 attested = 60%)
8 dual stress patterns (5 attested = 62.5%)
4 uni-directional patterns (4 attested = 100%)
2 bi-directional patterns (2 attested = 100%)
6 complex patterns (0 attested = 0%)

The full typology is below.

(66) The factorial typology of binary trochees under Rhythmic Licensing Theory

#	type	description	attestation
9 (=17)	single	initial	Tunica
14 (=26)	single	antepenult	Macedonian
15	single	penult (antepenult in 3σ)	unattested
24	single	antepenult (penult in 3σ)	unattested
25 (=35)	single	penult	Chamorro
2	dual	initial + antepenult (penult in 4σ) (ERL)	Walmatjarri
4 (=4)	dual	initial + penult (ERL)	Watjarri
6	dual	initial + antepenult (penult in 4σ) (ERR)	unattested
8 (=8)	dual	initial + penult (ERR)	unattested
11 (=20)	dual	antepenult + initial (ERL)	Walmatjarri
13 (=24)	dual	antepenult + initial (ERR)	Georgian
17 (=29)	dual	penult + initial (ERL)	Walmatjarri
20 (=33)	dual	penult + initial (ERR)	S. Sama
1 (=1)	uni-directional	L-to-R (ERL)	Pintupi
5 (=5)	uni-directional	L-to-R (ERR)	C. Arabic
18 (=30)	uni-directional	R-to-L (ERL)	Wargamay
21 (=34)	uni-directional	R-to-L (ERR)	Warao
3 (=3)	bi-directional	initial + R-to-L (ERL)	Garawa
19 (=31)	bi-directional	penult + L-to-R (ERR)	Piro
7 (=6)	complex	initial + penult + L-to-R (ERR)	unattested
10	complex	L-to-R (antepenult in 4σ) (ERL)	unattested
12	complex	L-to-R (antepenult in 4σ) (ERR)	unattested
16 (=28)	complex	penult + initial + R-to-L (ERL)	unattested
22	complex	R-to-L (antepenult in 4σ) (ERL)	unattested
23	complex	R-to-L (antepenult in 4σ) (ERR)	unattested

The typology is maximally adequate in predicting uni-directional and bi-directional patterns (both 100%), which is not surprising given the initial focus of the theory (Kager 2001). It also seems sufficiently restrictive in dual stress patterns, where it matches most predictions of alignment theory. The special cases are patterns #2-#6, to be discussed below.

An apparent weakness of RLT resides in single stress patterns. Patterns #15 and #24 are unlike anything that is typologically attested. Pattern #15 stresses the penult except in 3-syllable forms, which have initial stress, while pattern #24 shows the even stranger reverse case of antepenultimate stress except in 3-syllable words, which stress the penult. Both patterns stem from the rankings *FINAL-LONG-LAPSE » ALIGN-WD-L or LAPSE-AT-END. Clearly, the gaps present an empirical challenge to the constraint set, which may turn out to be fundamental to RLT. In defence of RLT, it should be observed that GAT predicts three similar patterns which share the main stress distribution of #15, but with iterative footing. See GAT patterns #6-7-8. In turn, these patterns are not generated by RLT.

The 'attested' status of pattern #2 needs clarification. Essentially, this is a dual stress pattern of the type initial+antepenult, in which four-syllable forms deviate by an initial+penult pattern. There are two ways of interpreting this pattern. First, since #2 exactly copies #1 (Pintupi) for words with length 2-5 syllables. For this reason, attestation of #2 may be difficult: it minimally takes a 6-syllable word to appreciate its dual nature, which may escape from the researcher's (learner's) attention. (Note that the same holds for #6, which happens to be identical to #5 (Cairene Arabic) for words of 2-5 syllables.) Second, #2 may be interpreted as being an integral part of the variable system of Walmatjarri, which was introduced above:

(67) Ambiguity of variable patterns in Walmatjarri

	Antepenult + initial #11 (=20)	Penult + initial #17 (=29)	Initial + antepenult #2	Initial + penult #4 (=4)
3σ	('σσ)σ	σ('σσ)	('σσ)σ	('σσ)σ
4σ	σ('σσ)σ	('σσ)(ˌσσ)	('σσ)(ˌσσ)	('σσ)(ˌσσ)
5σ	('σσ)(ˌσσ)σ	('σσ)σ(ˌσσ)	('σσ)(ˌσσ)σ	('σσ)σ(ˌσσ)
6σ	('σσ)σ(ˌσσ)σ	?	('σσ)σ(ˌσσ)σ	?

Four-syllable words are special as compared to longer words by not being able to stress both the initial and antepenultimate syllable using binary feet only. Here, a final long lapse at word end is avoided by placing the second foot right at the end. However, the prediction is that patterns #2 and #6 should also occur in a pure form, that is, not mixed with other patterns, which would allow unambiguous attestation.

Four complex patterns are not shared with gradient alignment theory (#10, #12, #22, #23). These are closely related, differing only by directionality and location of the peak. Hence, discussion of one pattern suffices. Pattern #10 is nearly identical to #1, the single difference being that four-syllable words display antepenultimate, rather than initial stress. This pattern might seem pathological, since an otherwise regular pattern is broken in just a single context. However, to its defence, it should be noted that diachronic changes have been documented from left-oriented systems (e.g. Old Latin) into right-oriented systems with antepenultimate default stress (e.g. Modern Latin). Plausibly, the paucity of forms longer than six syllables may have weakened learners' evidence for the system's directionality. Considering forms of three-to-five-syllables only, change might occur along the following steps:

(68) R-to-L | Antepenult + initial (ERL) | Antepenult + initial (ERR)

(68)	R-to-L	**Antepenult + initial (ERL)**	**Antepenult + initial (ERR)**
	3σ ('σσ)σ	('σσ)σ	('σσ)σ
	4σ ('σσ)(ˌσσ)	σ('σσ)σ	σ('σσ)σ
	5σ ('σσ)(ˌσσ)σ	('σσ)(ˌσσ)σ	(ˌσσ)('σσ)σ
	#1	#10	#13

In this scenario, pattern #10 may be viewed as an essential intermediary step to link attested patterns #1 and #13. This essential status of #10 is weakened, however, by the availability of another pattern, #11 (=#20) within both factorial typologies. This issue clearly needs further study.

4.3.3 Trochees: a comparison between the constraint sets

The balance between the constraint sets has not been shifted. Overall, the factorial typology of RLT is tighter than that of GAT, and in particular in the important area of uni-directional and bi-directional stress patterns. However, this is compensated by flaws in RLT in single stress patterns. Complex patterns do not seriously affect the comparison: these are difficult to judge because of the relative rarity of the long forms that are needed to test the predictions.

3.4 Iambs

3.4.1 Gradient Alignment Theory (GAT)

The iambic typology of GAT is fully symmetrical with its trochaic typology. With 8 constraints, the number of logically possible grammars is 40,320. Of its 35 output patterns, 5 (or 14.3%) are attested.

(69) Break-down into broad types of pattern
3 single stress patterns (2 attested = 66.7%)
8 dual stress patterns (0 attested = 0%)
8 uni-directional patterns (3 attested = 37.5%)
8 bi-directional patterns (0 attested = 0%)
8 complex patterns (0 attested = 0%)

The full typology is presented below.

(70) The factorial typology of binary iambs under Gradient Alignment Theory

#	type	description	attestation
17	single	second	Lakota
26	single	penult (final in 2σ)	unattested
35	single	final	Persian
4	dual	second + final (ERL)	unattested
8	dual	second + final (ERR)	unattested

12	dual	second + penult (ERL)	unattested
16	dual	second + penult (ERR)	unattested
20	dual	penult + second (ERL)	unattested
24	dual	penult + second (ERR)	unattested
29	dual	final + second (ERL)	unattested
33	dual	final + second (ERR)	unattested
1	uni-directional	L-to-R (ERL)	Araucanian
5	uni-directional	L-to-R (ERR)	Creek
9	uni-directional	L-to-R, no final feet (ERL)	unattested
13	uni-directional	L-to-R, no final feet (ERR)	Cayuga
21	uni-directional	R-to-L, no final feet (ERL)	unattested
25	uni-directional	R-to-L, no final feet (ERR)	unattested
30	uni-directional	R-to-L (ERL)	unattested
34	uni-directional	R-to-L (ERR)	unattested
3	bi-directional	second + R-to-L (ERL)	unattested
7	bi-directional	second + R-to-L (ERR)	unattested
11	bi-directional	second + R-to-L, no final feet (ERL)	unattested
15	bi-directional	second + R-to-L, no final feet (ERR)	unattested
18	bi-directional	penult + L-to-R (ERL)	unattested
22	bi-directional	penult + L-to-R (ERR)	unattested
27	bi-directional	final + L-to-R (ERL)	unattested
31	bi-directional	final + L-to-R (ERR)	unattested
2	complex	second + final + L-to-R (ERL)	unattested
6	complex	second + final + L-to-R (ERR)	unattested
10	complex	second + penult + L-to-R (ERL)	unattested
14	complex	second + penult + L-to-R (ERR)	unattested
19	complex	penult + second + R-to-L (ERL)	unattested
23	complex	penult + second + R-to-L (ERR)	unattested
28	complex	final + second + R-to-L (ERL)	unattested
32	complex	final + second + R-to-L (ERR)	unattested

The typology includes four 'initial lapse' patterns: #21, #25, #30, #34. Discussion in Section 1 already underscored the problems posed to GAT. More generally, this is an overly rich typology, when measured against the very small number of attested iambic patterns. Focussing on single stress and uni-directional patterns (considering the fact that iambic languages seem not to display any dual stress patterns, no bi-directional, nor complex patterns), we find that the typology has an attestation rate of 5 out of 11 (=3+8) patterns (45.5%). Among the single stress patterns generated, pattern #26 presents a strange blend of 'trochaic' penultimate and iambic final stress in disyllables. Among the uni-directional patterns, we observe strange patterns with a basic penultimate stress (#21, 25) combined with an initial lapse. When measured by its uni-directional patterns alone, this is a fairly poor typology. Needless to say, this cannot be an absolute qualification, simce only comparison with the second set of constraints (RLT) will be informative.

3.4.2 Rhythmic Licensing Theory (RLT)

With 11 constraints, the number of logically possible grammars is 39,916,800. The typology contains 24 output patterns. Of its 24 patterns, 5 (or 20.8%) are attested.

(71) Break-down into broad types of pattern
4 single stress patterns (2 attested = 50%)
7 dual stress patterns (0 attested = 0%)
6 uni-directional patterns (3 attested = 50%)
3 bi-directional patterns (0 attested = %)
3 complex patterns (0 attested = %)

The full typology is presented below.

(72) The factorial typology of binary iambs under Rhythmic Licensing Theory

#	type	description	attestation
17 (=17)	single	second	Lakota
18	single	antepenult (penult 3σ, final 2σ)	unattested
19	single	final (antepenult 3σ, final 2σ)	unattested
24 (=35)	single	final	Persian
3 (=4)	dual	second + final (ERL)	unattested
6 (=8)	dual	second + final (ERR)	unattested
9	dual	second + antepenult (penult 5σ) (ERL)	unattested
12	dual	second + antepenult (penult in 5σ) (ERR)	unattested
14	dual	second + final except 4σ (ERL)	unattested
16	dual	second + final except 4σ (ERR)	unattested
21 (=29)	dual	final + second (ERL)	unattested
23 (=33)	dual	final + second (ERR)	unattested
1 (=1)	uni-directional	L-to-R (ERL)	Araucanian
4 (=5)	uni-directional	L-to-R (ERR)	Creek
7	uni-directional	L-to-R (no final ft in 4σ) (ERL)	unattested
8 (=9)	uni-directional	L-to-R, no final feet (ERL)	unattested
10	uni-directional	L-to-R (no final ft in 4σ, ERR)	unattested
11 (=13)	uni-directional	L-to-R, no final feet (ERR)	Cayuga
2 (=3)	bi-directional	second + R-to-L (ERL)	unattested
13	bi-directional	second + R-to-L (no final ft in 4σ) (ERL)	unattested
22 (=31)	bi-directional	final + L-to-R (ERR)	unattested

5 (=6)	complex	second + final + L-to-R (ERR)	unattested
15	complex	second + final + L-to-R (no final ft in 4σ) (ERR)	unattested
20 (=28)	complex	final+second + R-to-L (ERL)	unattested

This typology contains no initial lapse patterns, yet is clear that it has a number of pathological patterns (specifically single stress #18 and #19 and uni-directional #7 and #10). Focussing on single stress and uni-directional patterns, as we did above for GAT, we find that 5 out of 10 (=4+6) patterns are attested (50%), which is only a marginal improvement over GAT. Among uni-directional patterns, the attestation rate is 50%, somewhat better than GAT. Here, the strange patterns are those which combine a regular rightward alternation with a nonfinality effect in 4-syllable forms (#7, 10). In sum, we do not find a clear superiority of RLT over GAT in the iambic typology as initially hypothesized on the basis of Kager (2001, 2004).

3.5 Further reductions

Here we will discuss the possibility of reducing the factorial typologies even further by elimination of constraints. We will find that such reductions are possible indeed, but splits may occur between trochaic and iambic typologies. That is, a successful reduction in the iambic typology may be accompanied by a loss of attested patterns in the trochaic typology, and vice versa. For this reason, this section should be read essentially as a set of possible directions for overall reductions of the typologies in future research.

For Gradient Alignment Theory, a drastic reduction of the typology from 35 to 18 patterns results which only marginally affects the generation of attested patterns. This overwhelming reduction is accomplished by simply eliminating the constraint pair ALIGN-WD-L/R. The remaining patterns are:

(73) Break-down into broad types of pattern
3 single stress patterns (3 trochaic attested = 100%; 2 iambic = 66.7%)
3 dual stress patterns (3 trochaic attested = 100%; 0 iambic = 0%)
8 uni-directional patterns (4 trochaic attested = 50%; 3 iambic = 37.5%)
4 bi-directional patterns (2 trochaic attested = 50%; 0 iambic attested = 0%)

Illustration comes from the trochaic typology. Below, pattern numbers are identical with those of the full GAT typology above.

(74) The maximally reduced factorial typology of binary trochees under Gradient Alignment Theory

#	type	description	attestation
17	single	initial	Tunica
26	single	antepenult	Macedonian
35	single	penult	Chamorro
4	dual	initial + penult (ERL)	Watjarri
24	dual	antepenult + initial (ERR)	Georgian
33	dual	penult + initial (ERR)	S. Sama
1	uni-directional	L-to-R (ERL)	Pintupi
5	uni-directional	L-to-R (ERR)	C. Arabic
9	uni-directional	L-to-R, no final feet (ERL)	unattested
13	uni-directional	L-to-R, no final feet (ERR)	unattested
21	uni-directional	R-to-L, no final feet (ERL)	unattested
25	uni-directional	R-to-L, no final feet (ERR)	unattested
30	uni-directional	R-to-L (ERL)	Wargamay
34	uni-directional	R-to-L (ERR)	Warao
3	bi-directional	initial + R-to-L (ERL)	Garawa
11	bi-directional	initial + R-to-L no final feet (ERL)	unattested
22	bi-directional	antepenult + L-to-R (ERR)	unattested
31	bi-directional	penult + L-to-R (ERR)	Piro

The overall assessment of this constraint set is much more positive than the original one. In particular, the typology of bi-directional patterns is cut by 4 patterns, while all 8 complex patterns are gone. Only two attested patterns are lost: the Walmatjarri double pattern (#20, #29). However, given the ambiguities in the Walmatjarri stress pattern, this might not be a serious empirical loss.

The discovery that ALIGN-WD-L/R appear to be superfluous in the typology of Gradient Alignment Theory has drastic consequences for a comparison of models. If no drastic compensating cuts take place in RLT, the GAT typology will actually be more restrictive than GAT's (with 18 GAT patterns against 24 RLT patterns in the trochaic typology, and similarly in the iambic typology). Nevertheless, is should be noted that in spite of the reductions, GAT still fails to overcome the initial lapse problem in the iambic typology. It seems clear that we should now turn to RLT.

For Rhythmic Licensing Theory, a drastic reduction of the iambic typology by 50% (from 24 to 12 patterns) is achieved by dropping three constraints: the word-alignment pair ALIGN-WD-L/R and PARSE-SYL. The typology of this reduced set of 8 constraints preserves all five attested iambic patterns:

(75) Break-down into broad types of pattern
4 single stress patterns (2 attested = 50%)
2 dual stress patterns (0 attested = 0%) (lost 5 patterns)
6 uni-directional patterns (3 attested = 50%)
0 bi-directional patterns (0 attested) (lost 3 patterns)
0 complex patterns (0 attested) (lost 3 patterns)

(76) The maximally reduced factorial typology of binary iambs under Rhythmic Licensing Theory (8 constraints)

#	type	description	attestation
17	single	second	Lakota
18	single	antepenult (penult in 3σ, final in 2σ)	unattested
19	single	final (antepenult in 3σ, final in 2σ)	unattested
24	single	final	Persian
9	dual	second+ antepenult (penult 5σ) (ERL)	unattested
12	dual	second+ antepenult (penult 5σ) (ERR)	unattested
1	uni-directional	L-to-R (ERL)	Araucanian
4	uni-directional	L-to-R (ERR)	Creek
7	uni-directional	L-to-R (no final foot in 4σ) (ERL)	unattested
8	uni-directional	L-to-R, no final feet (ERL)	unattested
10	uni-directional	L-to-R (no final foot in 4σ) (ERR)	unattested
11	uni-directional	L-to-R, no final feet (ERR)	Cayuga

This typology of 12 patters is notably smaller than the 18 pattern typology of GAT, which suffers from the additional problem of generating initial lapse patterns. This is tantamount to claiming that RLT is superior to GAT in the iambic typology.

Unfortunately, a similar reduction is impossible for the trochaic typology, since that would lose three vital patterns: Garawa, Piro and Sunama. Although dropping PARSE-SYL alone loses no patterns at all (in the iambic, nor the trochaic typology), all other constraints are essential in full empirical coverage. For example, dropping ALIGN-WD-L/R while keeping PARSE-SYL reduces the typology by 2 patterns, but one of these is Sunamu. The tentative conclusion is that GAT (18 patterns) is still superior to RLT (25 patterns) in the trochaic typology, at least if no reduction of the RLT typology is possible.

4. General discussion

Perhaps the main discovery of this study is that ALIGN-WD-L/R can be eliminated without any negative typological consequences in Gradient Alignment Theory. This result has a certain amount of robustness since it also holds for Rhythmic Licensing Theory in the iambic typology, where even PARSE-SYL can be profitably cut, with a notable empirical advantage for RLT over GAT in terms of patterns generated, and an accompanying advantage related to initial lapse patterns in GAT. Nevertheless, it remains to be seen if similar cuts can be made in RLT's trochaic typology, where RLT carries the advantage of superior typological restrictiveness.

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