The Stress-to-Pitch Principle: Evidence from Wanano

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0. INTRODUCTION

Stress in Wanano typically falls on the last syllable of the lexical root (Stenzel 2004, 2007; Waltz 2002). There are no quantity sensitive factors that play a role. When roots are affixed stress is not affected. Roots in Wanano are always bimoraic. A typical root with stress has the form CV.CV́ or CV.V́; acute accents stand for stress. However, exceptional roots may have stress on the first syllable: CV́.V. Additionally, Wanano is a tone language with three tones H(igh), L(ow) and HL. Placement of H tone is lexically contrastive, for example *jóa* 'do/make' and *joá* 'be long/far;' bold represents H tone. All root forms in Wanano must have a prominent H tone. I argue that tone and stress interact to the effect that stress is attracted to the most sonorant syllable in the root. That is, stress falls on the first left-edge High tone. This explains the exceptional CV́.V cases of stress that fall on the first syllable and not the last: stress is attracted to the lexically preserved H tone in cases such as *jóa* 'do/make.' Stenzel (2004) provides comparative-historical evidence for this explanation, which I review. My account is within an Optimality Theory framework (Kager 1999; de Lacy 1999, 2002; Yip 2002). I use the Wanano data to point out a parallel to the weight-to-stress principle (WSP) and stress-to-weight principle (SWP) that I call the stress-to-pitch principle (SPP). I introduce the stress-to-pitch principle in the last section and show that it is the result of grouping together a specific subset of tone and stress constraints that interact to produce what de Lacy calls "tone-driven stress languages."

1. WANANO DATA

In this section I show the syllable form of roots and other morphemes and how these syllables are organized into feet. I will suggest OT constraints based on observations of the data but will not rank them until section 2.

1.1. Root Forms

Stenzel builds the syllable according to a commonly accepted autosegmental algorithm (Stenzel 2004: 72): (i) assign each vowel a nucleus; (ii) consonants to the left of nuclei are assigned onsets; (iii) consonants to the right of nuclei are assigned as codas. Onsets are also maximized, though Stenzel does not state this explicitly. Roots do not have codas except when a glottal stop is followed by a consonant. TABLE 1 shows typical root syllables in Wanano. This leads Stenzel (2004: 73) to the observation that due to this "no-coda" restriction "weight is not [the] product of syllable shape." In fact, it appears Wanano disprefers heavy syllables in general; instances of heavy syllables cannot be found. The WSP cannot be a factor in Wanano stress.[1]

TABLE 1 Root Syllables in Wanano[2]

a. *mãnɨ́*	b. *dié*	c. *ã.ŋá*	d. *a?.rí*	e. *du?.té*
CV.V́	CV.V́	V.CV́	V?.CV́	CV?.CV́
'husband'	'dog'	'snake'	'this'	'chop'

In words that have a high amount of affixation to the root the original root stress is preserved. Example (1):

[1] NO-CODA is highly ranked for syllable construction in Wanano but I do not deal with it here.
[2] The question mark '?' stands for glottal stop.

(1). *diérore*
di. é - ro - re
CV.V́ - CV. - CV
'to/at/for the dog'

This pattern is stable throughout Wanano except in a limited set of data shown in (2):

(2).	Gloss		Tatuyo	Tukano	Wanano
	'water'	(a)	*ʉ.kó*	*a.kó*	*ko [kó.o]*
	'tooth'	(b)	*o.pî*	*u.pî*	*pi [pí.i]*
	'rock'	(c)	*ɨ.tã́*	*ɨ.tã́*	*ta [tã́.ã]*
	'come'	(d)	*a.tá*	*aa.tá*	*ta [tá.a]*
	'be hot'	(e)	-	*a.sí*	*si [sí.i]*
					(Stenzel 2004: 75)

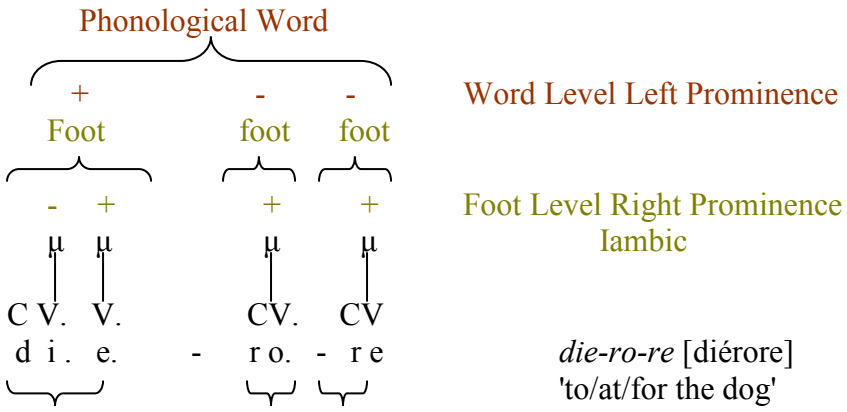
In (2.a) - (2.e) of the Wanano examples the stress occurs on the first syllable (e.g. CV́.V). Comparing these Wanano forms to examples from Tatuyo and Tukano, two closely related languages, Stenzel proposes a historical process of initial vowel loss and subsequent compensatory lengthening in Wanano. This suggests that the stress prominent syllable in a hypothesized proto-Wanano form is preserved even if the language has to allow an uncharacteristic foot (i.e. allowing a trochee). The preservation of the prominent syllable position outweighs the need for a general iambic rhythm in feet. This may not be surprising given that trochaic feet are more typologically frequent in the world's languages (Goedemans and van der Hulst 2005). A possible general strategy for stress in Wanano is to preserve pitch prominence by allowing a less marked trochaic foot. I will show in later sections that this is in fact what occurs in Wanano. The data in (2) also suggest that it is more important for roots in Wanano to be binary (bimoraic) than for prominent syllables to be at the right edge. For example (2.a): *kó.o* ≻ *kó*; a bimoraic word

with a deviant stress pattern is more harmonic than a monomoriac word with the typical stress pattern. OT constraints for the data in (2) will be given in §1.2.

1.2 Foot Form

Stenzel claims that Wanano has degenerate feet. Root forms are bimoraic feet and bound or derivational morphemes are monomoraic feet. Example (3) is taken from Stenzel (2004: 77):

(3).



The bimoraic root form is *di.é* 'dog' and the monomoraic footed suffixes are *-ro* and *-re*. The structure in (3) is representative of most words in Wanano and from it we can see that bimoraic syllables have weak-strong rightward prominence (+), they are iambic. Stenzel shows prominence (+) in the monomoraic feet but they can never carry stress. I interpret monomoraic feet as having an unspecified prominence. Since only lexical roots can be bimoraic and all bimoraic feet are iambs I propose the constraint IAMB-RT to account for this. We can also see that the prosodic word has left prominence. This results in LEFTMOST and GRWD=PRWD. Furthermore, PARSE-σ must be included to account for feet-parsed syllables. For now, the existence of degenerate (monomoraic) feet will be

accepted given Stenzel's analysis but it will later be revised (c.f. 11 - 13). Lastly, FT-BIN will help ensure that at least roots will be binary feet. See 2.2 for more explanation and ranking of constraints.

2. CONSTRAINTS, INCONSISTENT STRESS, AND PITCH

2.1 Co-incidence of Stress and Tone

The placement of stress on the last syllable of a lexical root in Wanano is a straightforward matter except for the limited set of data that contradict this. Since there is no weight prominence (i.e. WSP, SWP) to attract stress a natural assumption is that stress is assigned by positional faithfulness[3] (c.f. Smith 1997, 1998 for an account of this in Tuyuca, a closely related language to Wanano). However, stating a position for stress in terms of feet or syllables results in a conflict between the Wanano examples in (2) and the forms in TABLE 1 and TABLE 2: *jóa* 'do/make' versus *joá* 'be long/far.' If we state the positional faithfulness of stress in terms of the alignment of feet to a particular edge such as 'always stress the left-most binary foot' the syllabic conflicts are still active because there is no specification for which syllable within the left-most binary foot should be stressed. If we re-define the foot parsing so that inconsistent stress patterns line-up as a result of extrametrical foot patterns we are left with this very unnatural result: *<j>(ó.a)* 'water' and *<di>(é)* 'dog.' This is only one possible foot re-definition but it represents some of the problems of an extrametrical foot redefinition: different numbers of left elements are extrametrical, degenerate feet are stressed, and lexical items may be bimoraic and/or monomoraic. An alternative path for explaining stress assignment is to

[3] I assume that duration as a phonetic correlate of stress is realized as a long vowel (Hargus and Beavert 2006; Hayes 1995) and thus equal to a bimoraic syllable, which is weight prominent. Stenzel does not mention observing any duration or vowel-lengthening occurring with stress. Lastly, in light of the syllabification patterns in Wanano one would expect a long vowel to syllabify as (V.V), or better yet (V.?V) epenthesizing a glottal stop as onset, instead of (V:); see examples in (2).

find another type of prominence besides weight. If Wanano expresses a regularized pitch prominence on roots then we may be able to say that stress is attracted to the prominence of this pitch.

Wanano, in fact, has lexically contrastive tone on roots as TABLE 2 and example (4) show; I assume as does Stenzel that the tone-bearing-unit in Wanano is the mora. Tone spreads across monomoraic morphemes, example (5), not specified for tone; all data from Stenzel (2004). Stress is represented by acute accents, low tone by L and high tone by H and bold font. The first L tone in Tukanoan languages is commonly analyzed as extrametrical (c.f. Gomez-Imbert 2000; Gomez-Imbert and Kenstowicz 2000; Stenzel 2004).[4]

TABLE 2 Lexically Contrastive Tone in Wanano

Tone Form:	Ø	H	<L>H
Syllable Form:	-CV	CV́.V	CV.V́
	a. *-da* $NCL_{threadlike}$	d. ***dá**.a* 'be small'	
	b. *-kĩ* NCL_{bunch}	e. ***kí**.i* 'mandi fish'	
	c. *-ka* $NCL_{rounded}$	f. ***ká**.a* 'monkey'	
		g. ***tú**.a* 'enjoy'	i. *tu.**á*** 'be strong
		h. ***jó**.a* 'do/make'	j. *jo.**á*** 'be long/far'

(4). a. *mã. nú.*
<L> **H**
CV.C**V**
'husband'

b. *tí-*
H
C**V**.
'they'

c. *di. **é***
<L> **H** L[5]
CV.**V**
'dog'

(5). a. *mã. nú. -ro*
<L> ~~**H**~~
CV.C**V**.CV
'husband'

b. *tí. -nã*
~~**H**~~
C**V**.CV
'they'

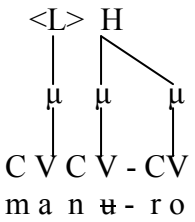
c. *di. **é**. -re.- ro*
<L> **H** ~~L~~
CV.**V**.CV.CV
'to the dog'

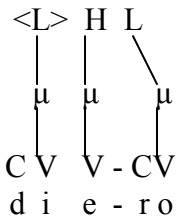
[4] Wanano has H, L, and HL lexically contrastive tones. One H tone per word is allowed and most other positions are assumed to be low tone if not stated otherwise. Tone spreading is abundant.

[5] This is analyzed as a floating tone (Gomez-Imbert 2000; Gomez-Imbert and Kenstowicz 2000; Stenzel 2004).

The last tone in (5) spreads to the nuclei of the following monomoraic syllables. Example (6) shows the autosegmental association for (5.a) and (5.c), also from Stenzel (2004: 86).

(6). a. *mãnʉ́ro* 'husband' b. *diérero* 'to the dog'





Comparing examples (4) - (6) with TABLES 1 and 2 and example (2) we see a co-incidence of stress and the leftmost H tone. Additionally, the data from (3) show a V.CV́ form in the closely related languages Tatyuo and Tukano that appears as CV́.V in Wanano. Stenzel explains the CV́.V as the result of historical loss of the initial vowel with subsequent compensatory lengthening. This form displays an inconsistent stress assignment with other lexical items in Wanano (TABLE 1 and example 2). However, if we argue that stress is attracted to the rightmost prominent pitch of the H tone then the deviant stress assignment can be explained as stress preservation by way of a highly ranked preservation of tone in the lexical item. This motivates the constraint on tone: IDENTLEX-T, which says informally that lexical root tones have to be identical in the input to output. I will discuss this in more depth in section 2.3.1.

2.2 Constraints for Stress and their Ranking

The listing in (7) shows constraints particular to stress. I will deal with tone in 2.3.

(7). 1. IAMB-RT: weak-strong rhythms in root foot
2. FT-BIN: feet are binary
3. LEFTMOST: accounts for the left-prominence of prosodic word
4. PARSE-σ: syllables are parsed by feet
5. GRWD=PRWD: one prominent position culminates as stress in prosody

The first ranking must ensure iambic lexical roots and allow monomoraic feet:

(8). **PARSE-σ >> FT-BIN**
All syllables must be parsed into feet whether or not they are binary, and
LEFTMOST >> IAMB-RT
More important that prominence of prosodic word be left than roots be iambic

(di.é).(ro).(re) ≻ (dí.e).(ro).(re) ≻ di.(é.ro).re

These rankings ensure that all lexical roots are binary footed at the cost of degenerate feet and conforms to Stenzel's (2004: 77) observation that "Since the leftmost foot in the word is always the root, we find a confluence of morphological and phonological prominence." Wanano only allows suffixation to roots, which must occur to the right. LEFTMOST and GRWD=PRWD in (9) ensure that not only will the grammatical word culminate to define a prominent position at the prosodic level but that prominence will be to the leftmost edge (c.f. example 3).

(9). **GRWD=PRWD >> FT-BIN**
This defines a minimum bimoraic size for binary feet
LEFTMOST >> FT-BIN
It's more important for left prominence than binary feet
LEFTMOST >> IAMB-RT
It's more important that prominence of prosodic word be to the left than the root be iambic

(di.é).re.ro ≻ di.e. (ré.ro) ≻ di.e.re.ro

A final ranking for these constraints is shown in (10). Tableau for the two possible stress forms are shown in (11) for CV.V́ and (12) for CV́.V. These represent full rankings for stress and do not yet incorporate the crucial constraints for tone; see 2.3.

(10). GRWD=PRWD, LEFTMOST >> IAMB-RT, PARSE-σ >> FT-BIN

(11) **[di.é.ro.re]** Stress assigning Tableau

Input: /dierore/	GRWD= PRWD	LEFT-MOST	IAMB-RT	PARSE-σ	FT-BIN
a. ⬇ (di.é).(ro).(re)					**!
b. dierore	*!				
c. (di.e).(ró).(re)		*!	*		**
d. (dí.e).(ro).(re)			*!		**
e. di.(é.ro).(re)			*!	*	*
f. (di.é).ro.re				**!	
g. (dí).(e).(ro).(re)					****!
h. ☞ (di.é).(ro.re)					

(12) **[jó.a.ro.se]** Stress assigning Tableau

Input: /joarose/	GRWD= PRWD	LEFT-MOST	IAMB-RT	PARSE-σ	FT-BIN
a. ⬇ (jó.a).(ro).(se)			*!		**
b. joarose	*!				
c. (jo.a).(ró).(se)		*!	*		
d. (jó.a).(ro).(se)			*!		**
e. jo.(á.ro).(se)			*!	*	*
f. (jo.á).ro.se				**!	
g. (jó).(a).(ro).(se)					****
h. ☞ (jo.á).(ro.se)					

In (11) and (12) the correct choice should be (a) but it is not selected; represented by down arrow. The pointing finger in candidate (h) signifies the winning but incorrect candidate. The crucially violated constraints are FT-BIN for (11) and (12) and IAMB-RT for (12). IAMB-RT is genuinely problematic as is the entire Tableau in (12), but FT-BIN may not be not be a problem. Notice in (11) that candidate (h) does not predict the wrong stress assignment. It, in fact, is the candidate that would be chosen if Wanano re-syllabified two linear degenerate feet into a bimoraic foot. And in fact, degenerate feet are typologically rare. For these reasons I stand behind the prediction of the Tableau in (11): monomoraic syllables resyllabify into an unstressed bimoraic foot in Wanano. A word with an odd number of syllables violates FT-BIN, allowing degenerate feet. The Tableau in (13) shows an input with an odd number of syllables. The candidates are the same as in (11) and the optimal candidate (a) is chosen correctly. I leave in-depth issues of resyllabification in Wanano unsettled for now because it has no direct influence on stress-assignment in Wanano.

(13) **[di.é.ro]** Stress assigning Tableau

Input: /diere/	GRWD=PRWD	LEFT-MOST	IAMB-RT	PARSE-σ	FT-BIN
a. ☞ (di.é).(ro)					*
b. diero	*!				
c. (di.e).(ró)		*!	*		*
d. (dí.e).(ro)			*!		*
e. di.(é.ro)			*!	*	*
f. (di.é).ro				*!	*
g. (dí).(e).(ro)					***!

2.3 Interaction and Co-incidence of Stress and Tone

A full analysis of tone constraints for Wanano is beyond the scope of this paper. What is crucial to the interaction of the tone and stress is a subset of constraints interacting in a crucial way. What follows only represents tone constraints important for accounting for the stress of Wanano.[6]

2.3.1 Adopting de Lacy's System

Here I look more closely at constraint rankings for determining the interaction of stress and tone following de Lacy's (1999, 2002) notion of "tone-driven stress." I adopt his terminology as well as his basic arguments for constraints and their rankings using only what is relevant for the analysis of Wanano. de Lacy begins by proposing a tone hierarchy analogous to the sonorant hierarchy (14). From this he establishes constraints that incorporate the tonal scale and foot head/foot non-head positions (15). Wanano needs only foot head positional constraints.

(14) H > M > L
(15) *HD/L >> *HD/M

The *HD/L constraint incurs a violation mark for every L toned foot head. That is, every stressed syllable (i.e. the prominent syllable of the foot) of the prominent foot in the prosodic word that has a low tone will be assigned a violation. It is ranked higher than *HD/M because "low-toned heads are predicted to be universally less desirable than mid-tones" (de lacy 2002: 2). Wanano has no mid tones but based on the hierarchy in (14) it is

[6] For example, some constraints that may play important roles in Wanano tone include: SPREAD, *CONTOUR, MAX-T, NONINITIALITY. See Yip (2002) for tonal constraints and crucially (2002: 248) for a criticism of de Lacy's (1999) theory applied to Barasana, a closely related language to Wanano.

predicted that low-toned heads are also less desirable than high-toned heads: *HD/L >> *HD/H. In fact, for Wanano, only *HD/L is needed to account for stress.

The next constraint deals with the faithfulness of the tone-bearing-unit (assumed to be the mora) from input to output called IDENTLEX-T and is an adaptation of de Lacy's (2002) IDENT(T). It says that that any mora *x* that bears lexically contrastive tone T in the input must bear it in the same place in the output. Remember that tone position is lexically contrastive in Wanano as *joa* 'do/make' and *joa* 'be long/far' show (accent shows stress and bold signifies H tone); see also example (2) and TABLE 2. The Tableau in (16) shows that IDENTLEX-T and *HD/L do not have to dominate each other but must both dominate IAMB-RT. If this were not the case then candidates (16.b) or (16.c) would be selected over the optimal (16.a).

(16) **[jó.a.ro.se]** Tone assigning Tableau

Input: /j**o**arose/ H	IDENTLEX-T	*HD/L	IAMB-RT
a. ☞ (j**ó**.a).(ro.se) H			*
c. (j**o**.á).(ro.se) H L		*!	*
d. (jó.**a**).(ro).(se) H	*!		

The Tableau in (17) shows the same constraint rankings as (16) but adds a new re-ranking of two constraints not previously ranked in the stress assignment of Tableau (11), (12), and (13). The optimal candidate must be *jóarose* with the root *jóa* as non-iambic.

This forces a re-ranking of the iambic root and parse syllable constraints as IAMB-RT >> PARSE-σ while still allowing IDENTLEX-T, *HD/L >> IAMB-RT. These account for the harmony *(j**ó**.a).(ro.se)* ≻ *(jo.**á**).ro.se* ≻ *(jó**a**).ro.se*; (accent is stress and bold is H tone). If this were not the case then candidate (17.e) would be selected as optimal instead of (17.a).

(17) **[jó.a.ro.se]** Tone assigning Tableau

Input: /j**o**arose/ H	IDENTLEX-T	*HD/L	PARSE -σ	IAMB-RT
a. ☞ (j**ó**.a).(ro.se) H				*
c. (j**o**.á).(ro.se) H L		*!		
d. (jó.**a**).(ro).(se) H	*!			*
e. (jo.**á**).ro.se H			*!*	

2.3.2 Final Rankings and Typology

The final rankings of tone and stress constraints that interact to predict the seemingly contradictory stress positions in Wanano are in TABLE 3.

TABLE 3

IDENTLEX-T >> IAMB-RT
It's more important to preserve lexical tone than have iambic roots
IDENT-LEX-T, *HD/L >> GRWD=PRWD, LEFT-MOST
Not evident in Wanano but according to de Lacy's (2002) typology the tone-placement and tone-head constraints must dominate the stress constraints
LEFTMOST >> IAMB-RT
It's more important the head foot be to the left than the lexical root be iambic
PARSE- σ >> IAMB-RT
It's more important that syllables are parsed than the lexical root is iambic
IAMB-RT >> FT-BIN
More important for roots to be iambic than for all feet to be binary

IDENTLEX-T, >> GRWD=PRWD, >> PARSE-σ >> IAMB-RT >> FT-BIN
*** HD/L LEFTMOST**

3. THE STRESS-TO-PITCH PRINCIPLE (SPP)

The proposal for a stress-to-pitch principle is a natural result of the observation that a crucial subset of constraints dealing with tone and stress interact in interesting ways that result in tone-driven stress languages. I provide a list of constraints used in the analysis of Wanano in (18). The listing is in order of importance or general constraint ranking but crucially does not include all the possible constraints that make-up the subset of definitive SPP constraints. The reason for this is that Wanano does not employ all the constraints of the subset, nor should it be expected that any language would. Additionally, more typological research needs to be done in order to propose a complete subset. My goal here is to simply make the observation, based on a preliminary analysis of Wanano, that there seems to be a principled explanation for the interaction of tone and stress that

utilizes a specific subset of constraints particular to the two phenomena and results in what de Lacy (2002) terms "tone-driven stress."

(18). Subset of interacting constraints for tone-driven stress and SPP
1. Tone positional faithfulness: IDENTLEX-T
2. Tone sonority hierarchy: H >> M >> L
3. Head foot sonority/prominence: *HD/L
4. Non-head foot sonority/prominence: not needed in Wanano
5. Head foot positions: GRWD=PRWD, LEFTMOST
6. Stress assigning constraints: PARSE-σ, IAMB-RT, FT-BIN

This listing conforms to de Lacy's (2002: 5) schema of rankings that puts tone-placement and tone-head constraints >> stress-placement constraints. The listing in (18) goes well with the often noted intuition that there is an "affinity between higher tone and [foot] heads" (de Lacy 2002: 3) as well as falling under the purvey of Goldsmith's (1987) "*Tone-Accent Attraction Condition*: A tone-to-grid structure is well-formed iff there is no tone-bearing syllable which has a lower level of accent than a toneless syllable;" also noted by de Lacy.

5. CONCLUSION

I have shown that contradictory stress assignment in Wanano forms such as *jóa* 'do/make' and *joá* 'be long/far' can be explained by appeal to the notion that main word stress is attracted to the most sonorant-prominent syllable of the lexical root, which happens to be a contrastively placed High tone. The preservation of this H tone prominence is more important than the root form's natural iambic rhythm (see TABLE 3). I have also shown that regular iambic footed root forms in Wanano prefer to be a trochaic foot rather than a degenerate (monomoraic) foot with stress on the last syllable. That is, the binary structure of the foot is more important than keeping stress on the last syllable.

In the course of accounting for deviant stress patterns as H tone preservation I have also shown that Wanano probably resyllabifies two degenerate footed suffixes when they are next to each other (see 11 - 13); though this has no direct impact on stress assignment. I have also shown that specific constraints not ranked by stress alone are forced to be re-ranked by active tone constraints (see 16 - 17). Lastly, the interaction of tone and stress in Wanano provides evidence for typologically grouping together a subset of constraints for tone and stress under a principle that explains tone-driven stress languages. That principle is called, analogous to the stress-to-weight principle, the stress-to-pitch principle (SPP).

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