Reconsidering Linearity: Evidence from CV Metathesis[1]

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1. Introduction

In correspondence-theoretic approaches to Optimality Theory, there is a single constraint demanding that the linear order of segments in the output be faithful to the linear order of the corresponding segments in the input, LINEARITY (McCarthy and Prince 1995). However, there are both formal and empirical reasons to replace this constraint with a family of constraints based on the notion of contiguity. Formally, LINEARITY is too powerful a constraint; empirically, it makes the wrong predictions in at least one language. Although the empirical evidence presented is drawn exclusively from Kwara'ae [2] (Austronesian), this language's robust process of CV metathesis (see below) makes for a good case study.

In §2, I present the formal arguments against LINEARITY. In §3, I show how and why LINEARITY makes incorrect predictions in the case of Kwara'ae. In §4, I introduce the contiguity constraints that I propose should replace LINEARITY, and in §5, I discuss the implications of these constraints and consider possible alternatives.

2. Formal Considerations

LINEARITY is defined as follows (McCarthy and Prince 1995:123):

(1) S_1 is consistent with the precedence structure of S_2, and vice versa (No Metathesis).

$$\text{Let } x, y \in S_1 \text{ and } x', y' \in S_2. \quad \text{If } x \Re x' \text{ and } y \Re y',$$

$$\text{then } x \text{ precedes } (<)\ y \text{ iff } x' \text{ precedes } (<)\ y'.$$

In other words, if a segment precedes another in the input, that precedence relation should be preserved by the corresponding segments in the output. In this sense, LINEARITY is essentially a MAX constraint, applied to precedence relations, which are ordered pairs. [3] The example given in (2) shows all the ordered pairs that stand in the precedence relation for the hypothetical word *salofidu*, which has eight segments, and 28 precedence relations.

(2)

s	a	l	o	f	i	d	u
s < a	a < l	l < o	o < f	f < i	i < d	d < u	
s < l	a < o	l < f	o < i	f < d	i < u		
s < o	a < f	l < i	o < d	f < u			
s < f	a < i	l < d	o < u				
s < i	a < d	l < u					
s < d	a < u						
s < u							

[1] I would like to thank Sophie Streeter, Kie Zuraw, Bruce Hayes, Colin Wilson, Greg Kobele, and Lauren Varner, and members of the UCLA Phonology Seminar for their assistance in this research.

[2] All the Kwara'ae data in this handout comes from Sophie Streeter, a native speaker of Kwara'ae to whom I am indebted for her time and commitment to the study of her language.

[3] We could equally well think of LINEARITY as a DEP constraint, which is violated for every new precedence relation introduced in S_2 that was not present in S_1.

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From the above table, it is easy to see that LINEARITY is a gradient constraint; the farther a segment moves, the fewer precedence relations are preserved (Hume 2001).

(3)

/salofid**u**/		LINEARITY
a.	salofi**u**d	(d < u)
b.	salo**u**fid	(f < u) (i < u) (d < u)

It is also straightforward to see from the table above, however, that the initial segment precedes seven others, the second segment precedes six others and so on. Thus, for a word of length n, there are $\sum_{i=1}^{n-1} i = (n^2 - n)/2$ ordered pairs standing in this relation.

All of the precedence relations are potentially eliminable; the candidates which reverse the string, like [udifolas], preserve none of these relations, and thus violate LINEARITY 28 times. In other words, LINEARITY belongs to a particular class of gradient constraints that are *quadratic*, in the sense of Eisner (1997). These constraints bear this label because the number of violations incurred can grow as a quadratic function of the length of the word.

Such constraints are problematic for a number of reasons. Constraints of this type have been shown to make anomalous predictions such as tone-centering (Eisner 1997) and a range of other predictions discussed by McCarthy (2003). They are also categorically more powerful than the vast majority of other constraints that phonologists employ in their analyses (Eisner 1997, McCarthy 2003). Lastly, they are formally too complex to compute optimization over using any of the current proposals in the literature, e.g. Riggle (2004).

Thus from a formal perspective, the main problem with a constraint like LINEARITY is that there are simply too many ordered pairs standing in the precedence relation whose preservation LINEARITY enforces.

3. Empirical Considerations

When LINEARITY is ranked below some markedness constraint then by the Optimality-theoretic principle of strict domination, a candidate which incurs several LINEARITY violations but which does not violate the markedness constraint is still more harmonic than candidates which violate the markedness constraint.

(4)

input		MARKEDNESS	LINEARITY
☞	cand1		*****
	cand2	*!	*

In the tableaux above, cand1 $\succ$ cand2.

Generally, the gradient nature of LINEARITY encourages local solutions to markedness (Hume 2001), but sometimes non-local solutions are in fact optimal. In other words, if metathesis is allowed in order to satisfy some markedness constraint, then any amount (and any kind) of re-ordering is allowed in order to avoid violating this markedness constraint. We will see three cases in Kwara'ae where LINEARITY wrongly predicts an illegal reordering.

There is more than one way to solve this problem: GEN can be restricted so that such candidates do not exist, or other constraints can be introduced to eliminate the candidates.[4] I will adopt the latter approach, and will propose that faithfulness constraints based on the notion of contiguity are more successful than LINEARITY.

3.1 Basic Facts

In order to understand the problem cases in Kwara'ae, the basic facts must first be established. Metathesis in Kwara'ae may occur more than once per word.[5]

[4] Another approach is to enrich the candidate representations and to place constraints on these enriched representations, cf. Candidate Chain Theory (McCarthy 2004).

[5] Appendix A describes legal Normal form vowel clusters.

(5)

	Citation	Normal	
a.	'ŋe.la	'ŋe̯al	'child'
b.	li.ˌma.ku	'li.ˌma̯uk	'my hand'
c.	'ke.ta.ˌla.ku	'ke̯at.ˌla̯uk	'my height'
d.	da.'ro.ʔa.ˌni.da	'da̯r.ʔa.ˌni̯ɛd	'to share them'
e.	'ra.ʔe.ˌra.ʔe.ˌna.ʔa	'rae̯ʔ.ˌrae̯ʔ.ˌnaˑʔ	'incline, slope'

In the Normal form, almost every stressed syllable is heavy, and surface CVCV sequences are very rare. [6] These phonotactics can be analyzed as a consequence of the Stress to Weight Principle (Norquest 2001, Heinz 2004).

(6) The Stress To Weight Principle: Stressed syllables should be heavy (Prince 1992, Kager 1999).

This constraint assesses a violation for each stressed light syllable in the output. The ranking SWP $\gg$ LINEARITY establishes the metathesis pattern.

(7)

	/ketalaku/	SWP	LINEARITY
☞	a. 'ke̯at.ˌla̯uk		**
	b. 'ke.ta.ˌla̯uk	*!	*
	c. 'ke̯at.ˌla.ku	*!	*
	d. 'ke.ta.ˌla.ku	**!	

3.2 Case One

The first class, exemplified below in (8), are those with underlying forms /$CV_1CV_2V_3CV_4CV_5$/.

(8)

	Citation	Normal	
a.	li.'ma̯u.ˌmu.lu	'li.ma̯u.ˌmuˑl	'your (pl) hands'
b.	a.'ŋi.a.ˌŋi.la	'a.ŋi̯ɛ.ˌŋi̯ɛl	'tearful'
c.	ʔa.'ʔai̯.ˌki.na	'ʔa.ʔai̯.ˌki̯ɛn	'aunts (collective)'
d.	i.'li.a.ˌla.na	'i.li̯ɛ.ˌlaˑn	'his trying'

These forms are surprising since there is a stressed light syllable on the surface. If the analysis of CV metathesis in Kwara'ae consists solely of SWP $\gg$ LINEARITY, then any candidate which does not have any surface stressed light syllables will be more harmonic than the winner. Furthermore, such candidates exist, since GEN may reorder the underlying segments in any way possible.

In particular, the current SWP $\gg$ LINEARITY analysis predicts that the diphthong should be broken up to make the first syllable heavy since ['li̯**a**.mu.ˌmu_1u_2l] appears more harmonic than winning ['li.m**a**u̯.ˌmuul].

(9)

	/limaumu$_1$lu$_2$/	SWP	LINEARITY
☮	a. 'li̯a.mu.ˌmu_1u_2l		**
☹	b. 'li.ma̯u.mu_1u_2l	*!	*
	c. 'li.ma̯u.ˌmu_1.lu_2	**!	*

Generally, ['CV_1V_2.CV_3.ˌCV_4V_5C] will be more harmonic than ['CV_1.CV_2V_3.ˌCV_4V_5C] because the former lacks stressed light syllabes on the surface. The problem extends to all words with underlying forms of the type /CVCVV(CV(C)V)^n/, where $n \geq 1$.

Also note that the spurious winning candidate (a) in the tableaux in (9) is a legal surface from of the language, but presumably only if the input is hypothetical /liamumulu/, and not /limaumulu/.

The observation made here is that CV metathesis is allowed to form new underlying vowel clusters on the surface, but it is not allowed to break up underlying ones. If a constraint along these lines existed,

[6] For this reason, I will consider underlying representations to be like the Citation form since the Normal form grammar prohibits them from surfacing faithfully.

it would have the effect of eliminating (a) in (9).[7]

3.3 Case Two

To exemplify the second class of underlying forms which are problematic, consider words with underlying forms like /$CV_1CV_2V_3CV_4$/.[8]

(10)

	Citation	Normal	
a.	'fi.ku.ˌa.ʔa	'hi.ˌkua̯ˑʔ	'gathering of them together'[9]
b.	'ho.ni.ˌa.ra	'ho.ˌnia̯ˑr	'Honiara' (capital city of the Solomon Islands)
c.	'ka.li.ˌo.ko	'ka.ˌlio̯ˑk	'clothes'

Here, the long distance-metathesis candidate *['hia̯**a**$_2$.ˌkua$_1$ʔ] is more harmonic than ['hi.ˌkua$_1$**a**$_2$ʔ].[10]

I will assume the faithful candidate is eliminated because it violates a Normal form requirement that words not end in a heavy syllable followed by a light syllable. Following Prince (1983), I attribute this to an undominated constraint banning weak moras of heavy syllables from bearing stress. (Kwara'ae Normal form regularly stresses the penultimate mora; see Heinz (2004)).

(11) *WEAKMORA=X1 incurs a violation whenever the weak mora of a heavy syllable bears stress.

(12)

/fikua$_1$ʔa$_2$/		*WEAKMORA=X1	SWP	LINEARITY
☮ a. 'hia$_2$.ˌkua$_1$ʔ				****
☹ b. 'hi.ˌkua$_1$a$_2$ʔ			*!	*
c. 'hi.ˌkua$_1$.ʔa$_2$		*!	*	

In general, the LINEARITY analysis predicts that *['CV_1V_4.ˌCV_2V_3C] is more harmonic than actual ['CV_1.ˌ$CV_2V_3V_4$C]. It is easily seen how the problem extends to all words with underlying forms /CV(CVV)^{n}CV/.

In order to rule out long distance candidates like (a) in (12), I propose that CV metathesis is constrained such that the order of the vowels in the input must be the same as in the output. The spurious winning candidate (a) violates this constraint, since it has rearranged the order of the vowels (a$_2$ is now the first vowel, whereas in the input, it was the last).

3.4 Case Three

The third class of words, exemplified in (13), have underlying forms of the type /CVCVCV/.

(13)

	Citation	Normal	
a.	li.'ma.ku	'li.ˌmau̯k	'my hands'
b.	fi.'ku.da	'hi.ˌkua̯d	'to gather them together'
c.	ma.'da.mo	'ma.ˌdao̯m	'moon, month'

This class of words, like the other classes above, is again unusual in that there is a stressed light syllable on the surface. The ranking SWP ≫ LINEARITY predicts incorrectly, for example, that *['hik.ˌd**u**a], where the [u] has moved rightward, is more harmonic than ['hi.ˌkua̯d], where the [a] has moved left-

[7]Formerly, it was believed that all CVV syllables in Kwara'ae bore (at least) secondary stress, and thus breaking up a vowel cluster would not improve the harmony of a candidate with respect to SWP (Norquest 2001). However, there is one location where CVV syllables are regularly unstressed in Kwara'ae Normal form – after a stressed light syllable in longer words like those shown in (10) above (Heinz 2004).

[8]Thanks to Donca Steriade for pointing out this problem.

[9]Citation [f] is regularly realized as Normal [h].

[10]Another candidate that is more harmonic than the surface ['hi.ˌkua̯$_1$ˑʔ] but has no long distance metathesis is *['hia̯$_1$.ˌkua̯$_2$ʔ], where the vowels have cascaded leftward. However, this candidate has broken up an underlying vowel cluster, just like the examples discussed in Case One §3.2.

ward.[11]

(14)

/fikuda/			SWP	LINEARITY
☮	a.	'hik.ˌdua		*
☹	b.	'hi.ˌkuad	*!	*
	c.	'hi.ˌku.da	*!*	

Blevins and Garrett (1998) give evidence that the directionality of CV metathesis is related to the stress pattern in the language. If we think of the vowel moving in CV metathesis as opposed to the consonant, then in trochaic languages like Kwara'ae[12] these vowels move leftward, whereas in iambic languages the vowels move rightward.

However, it is not clear how to model this fact in Optimality Theory, especially in languages with predictable stress patterns like the Normal form of Kwara'ae which differs from the Citation form stress pattern (itself predictable).

It is possible to think about the directinality in terms of the kinds of transitions that are allowed to be created (and destroyed) by the process of CV metathesis. In languages like Kwara'ae, CV transitions are never created on the surface, though underlying ones are destroyed, whereas in iambic languages (the Paman languages (Hale 1964, Blevins and Garrett 1998)) underlying VC transitions are destroyed, and CV transitions are inserted in the surface. I propose to capture the directionality facts of Kwara'ae this way: CV metathesis is not allowed to create CV transitions on the surface that do not exist in the underlying form.

3.5 Summary of the Data

Generally, there are no stressed light syllables in Kwara'ae. There are a few classes of words that are exceptions to this generalization. Such exceptions are not predicted to exist if the standard faithfulness constraint regulating linear order (LINEARITY) is outranked by SWP. However, each class violates a potential constraint regarding the manner in which CV metathesis is allowed to apply. In Case One in §3.2, CV metathesis could not break up underlying vowel clusters. In Case Two in §3.3, CV metathesis could not reorder the vowels in the input-output mapping. In Case Three in §3.4, output forms could not contain CV transitions on the surface that did not exist in the underlying form.

4. Contiguity

4.1 Main Proposal

The main proposal made here is that the formal and empirical problems can be resolved by replacing LINEARITY with a richer family of CONTIGUITY constraints. I define the *contiguity* relation ($\rightarrow$) as *immediate precedence*.[13]

Therefore, CONTIGUITY constraints are linear; that is, the potential number of violations is limited by a linear function of the length of the word.

(15)

s	a_1	l	o	f	i	d	a_2
s$\rightarrow a_1$	$a_1\rightarrow$l	l$\rightarrow$o	o$\rightarrow$f	f$\rightarrow$i	i$\rightarrow$d	d$\rightarrow a_2$	

These CONTIGUITY constraints come in two types, MAX and DEP (McCarthy and Prince 1993).

(16) MAX-CONTIGUITY:

If $x, y \in S_1$ and x immediately precedes $(\rightarrow)y$,

then $\exists x', y' \in S_2$ such that $x \Re x'$ and $y \Re y'$and x' immediately precedes $(\rightarrow)y'$.

(No deletion of contiguity relations)

[11]There is evidence that CVC syllables should be treated as heavy syllables (see Heinz (2004) for details).

[12]There is a non-foot based approach to stress in Kwara'ae given in Heinz (2004).

[13]The notation is similar to that used in Raimy (2000), but the proposal here is substantially different.

(17) DEP-CONTIGUITY:

$$\text{If } x', y' \in S_2 \text{ and } x' \text{ immediately precedes } (\rightarrow)y',$$

$$\text{then } \exists x, y \in S_1 \text{ such that } x \Re x' \text{ and } y \Re y' \text{and } x \text{ immediately precedes } (\rightarrow)y.$$

(No insertion of contiguity relations)

Violations are scored for each contiguity relation that is inserted or deleted in the input/output mapping. An example with hypothetical /salofidu/ is given in (18).

(18)

/salofidu/		MAX-CONTIG	DEP-CONTIG
a.	salofiud	(i→d) (d→u)	(i→u) (u→d)
b.	saloufid	(o→f) (d→u)	(o→u) (u→f)

Although [salofi**u**d] has only moved the vowel [u] by one segment and [salo**u**fid] has moved it farther, both earn the same number of MAX-CONTIGUITY and DEP-CONTIGUITY violations. Thus, these constraints lack the property that long-distance metathesis costs more. These constraints then are categorical in the sense of McCarthy (2003).

In Kwara'ae Normal form, both of these constraints must be ranked below SWP.

4.2 Solution to Case One

Case One presented forms in (8) that suggested that CV metathesis may create new vowel clusters on the surface, but cannot destroy ones that exist in the underlying form. Therefore, I propose an additional contiguity constraint V-V MAX-CONTIGUITY which requires that an underlying contiguity relation between two vowels be present in the surface on the skeletal tier.

(19) V-V MAX-CONTIGUITY: if V_1 immediately precedes V_2 in the input, then there exist correspondents V_1', V_2' such that V_1' immediately precedes V_2' in the skeletal tier of the output.

This constraint is ranked above SWP, eliminating the problem candidates for this class. Recall the example 'your hands' Normal ['li.mau̯.ˌmuˈl] Citation [li.ˈmau̯.ˌmu.lu].

(20)

/limaumu$_1$lu$_2$/		V-V MAX CONTIG	SWP	MAX CONTIG	DEP CONTIG
	a. 'lia.mu.ˌmu$_1$u$_2$l	(a→u)!		**	**
☞	b. 'li.mau̯.mu$_1$u$_2$l		*	**	**
	c. 'li.mau̯.ˌmu$_1$.lu$_2$		**!		

Note the violations of V-V MAX-CONTIGUITY are always a subset of the violations of the more general MAX-CONTIGUITY constraint.

4.3 Solution to Case Two

The problem presented in §3.3 (Case Two) demonstrated that the analysis with LINEARITY incorrectly predicted that Normal surface forms like those in (10) should be less preferred than candidates with long distance metathesis. One way to solve this was to recognize that CV metathesis never allows the vowels themselves to change order, which has the effect of prohibiting long distance CV metathesis.

Under the notion of contiguity explored here, this constraint can be encoded as V-TIER MAX CONTIGUITY, which is the same as MAX-CONTIGUITY except that its domain is the vocalic tier (McCarthy 1981, Clements and Keyser 1983).[14]

[14]We could equally well have used V-TIER DEP-CONTIGUITY (see §5); I use the MAX version just for the sake of exposition.

(21) V-TIER MAX-CONTIGUITY: if V_1 immediately precedes V_2 in the vowel tier of the input, then there exist correspondents V_1', v′ such that V_1' immediately precedes V_2' in the vowel tier of the output.

Recall the example with 'the gathering of them together' Normal ['hi.,kua$_1$a$_2$ʔ] Citation ['fi.ku.,a$_1$.ʔa$_2$]. The input /fikua$_1$ʔa$_2$/ has a set of contiguity relations on the vocalic tier: (i→u), (u→a$_1$), and (a$_1$→a$_2$). Ranking V-TIER MAX-CONTIGUITY above the SWPeffectively eliminates long-distance metathesis.

(22)

/fikua$_1$ʔa$_2$/		*WEAK MORA=X1	V-TIER MAX CONTIG	SWP	MAX CONTIG	DEP CONTIG
a. 'hia$_2$.,kua$_1$ʔ			(i→u)! (a$_1$→a$_2$)		(i→k) (ʔ→a$_2$)	(i→a$_2$) (a$_2$→k)
☞ b. 'hi.,kua$_1$a$_2$ʔ				∗!	(a$_1$→ʔ) (ʔ→a$_2$)	(a$_1$→a$_2$) (a$_2$→ʔ)
c. 'hi.,kua$_1$.ʔa$_2$		∗!		∗		

4.4 Solution to Case Three

The words in §3.4 in (13) (Case Three) demonstrated another failure of the LINEARITY-based analysis; it could not capture the fact that the direction of CV metathesis in Kwara'ae is always leftward (viewed as the vowel undergoing the movement). Recalling the case of 'to gather them together' Normal ['hi.,kuad] Citation [fi.'ku.da], the tableau below illustrates the contiguity relations destroyed and created in the input/output mapping between the wrong winner and the correct surface form from tableau (14).

(23)

/fikuda/		SWP	MAX-CONTIG	DEP-CONTIG
☮ a. 'hik.,dua			(k→u)(u→d)(d→a)	(k→d)(**d→u**)(u→a)
☹ b. 'hi.,kuad		∗!	(u→d)(d→a)	(u→a)(a→d)

As we can see, the spurious winner (a) inserts a contiguity relation between a consonant and a vowel (d→u), which did not exist in the input. Therefore, I propose C-V DEP-CONTIGUITY, which prohibits the insertion of CV transitions in the input/output mapping.

(24) C-V DEP-CONTIGUITY If C immediately precedes V in the skeletal tier of the output, then there exist correspondents C′, V′ such that C′ immediately precedes V′ in the input.

Ranking this constraint above SWP achieves the desired result.

(25)

/fikuda/		C-V DEP CONTIG	SWP	MAX CONTIG	DEP CONTIG
a. 'hik.,dua		(d→u)!		∗∗∗	∗∗∗
☞ b. 'hi.,kuad			∗	∗∗	∗∗
c. 'hi.,ku.da			∗!∗		

I mentioned earlier that it is not clear how to relate the stress system to directionality of CV metathesis. The notion explored here requires relating the stress pattern to the ranking C-V DEP-CONTIGUITY ≫ SWP, which remains an open problem. But this solution provides a new way of thinking about directionality of CV metathesis by showing how it is regulated by constraints on contiguity relations.

4.5 Summary of the Analysis

Both the formal and the empirical problems posed by LINEARITY are resolved by replacing this constraint with constraints based on the notion of contiguity; i.e., immediate precedence. In particular I proposed two general contiguity constraints, MAX/DEP-CONTIGUITY, and three specific constraints, V-V MAX-CONTIGUITY, V-TIER MAX-CONTIGUITY, AND C-V DEP-CONTIGUITY, which are as-

sociated with three generalizations about CV metathesis in Kwara'ae. The formal issues are resolved because none of the constraints are quadratic; in fact, they are not gradiently evaluated at all. The empirical problems are resolved because now there is ranking of the constraints that generates the attested outputs, whereas before there was not.

5. Conclusions

The five constraints introduced naturally suggest a family of CONTIGUITY constraints. The following constraints would operate on the skeletal tier...

MAX/DEP-CONTIGUITY V-V-MAX/DEP-CONTIGUITY
C-V-MAX/DEP-CONTIGUITY V-C-MAX/DEP-CONTIGUITY
C-C-MAX/DEP-CONTIGUITY

...and the following constraints would operate on the V and C tiers.

V-TIER-MAX/DEP-CONTIGUITY C-TIER-MAX/DEP-CONTIGUITY

Note further that MAX-CONTIGUITY and DEP-CONTIGUITY have the same properties of I-CONTIG and O-CONTIG (McCarthy and Prince 1995) that make deletion and epenthesis at edges cheaper than domain internally.[15] This suggests that this constraint family can replace not only LINEARITY, but I-CONTIG and O-CONTIG as well.

We may ask whether the constraint family above is phonetically grounded. It has been observed that vowels are coarticulatory even with intervening consonants (Öhman 1966) (see Keating (1988) for an overview), which may justify constraints like V-TIER-MAX/DEP-CONTIG. However, it is more difficult to justify the other members of the constraint family. There may be some advantage to restating the CONTIGUITY constraints in finer detail – for example, in the terms of gestural scores (Browman and Goldstein 1992, Gafos 2002).

Similarly, we should wonder about the typology of the proposed constraints. I have shown that the family of constraints above is sufficient to enlarge the typology to include languages like Kwara'ae. Without adopting specific fixed rankings, however, it is not sufficient to rule out unusual and unattested patterns, e.g. Kwara'ae′ in which the entire contiguity constraint family is ranked below SWP. We can ask what the necessary fixed rankings must be.

We may also wonder if there are any existing theoretical alternatives that can save LINEARITY. Candidate Chain Theory (McCarthy 2004) is one initially appealing alternative. In this theory, each candidate is represented as a chain of surface forms, with the last link being the pronounced form, and the first link the surface form faithful to the input. Each successive step in the chain must involve a minimal change which results in a more harmonic form (the final form being the one where any minimal change reduces its harmony). Assuming minimal change means swapping the positions of adjacent segments, this kind of analysis could rule out long distance metathesis (like Case Two) because the intermediate links will likely pass through stages which are not more harmonic.[16] However, it is not clear if "minimal change" could be defined to rule out the empirical problems shown in Cases One and Three.

Finally, we may wonder, despite the arguments above, whether the empirical problems above are really due to LINEARITY. If the right markedness constraint was introduced, maybe the theory would not need constraints like the ones proposed here. Space does not permit discussion; however, it can be shown that if other markedness constraints are adopted, such as *SYLLABLE, *UNSTRESSED-SYLLABLE, or FINAL-C (at the foot level), similar empirical problems crop up.

To conclude, LINEARITY is formally too powerful a constraint, and its realization as an OT constraint makes incorrect empirical predictions in Kwara'ae. Both the formal and empirical problems are resolved by replacing LINEARITY with a richer family of CONTIGUITY constraints. The analysis here also

[15]The input-output pair (xyz, xz) violates I-CONTIG once, MAX-CONTIG twice, and DEP-CONTIG once. The input-output pair (xyz, xy) violates I-CONTIG zero times, MAX-CONTIG once, and DEP-CONTIG zero times. The input-output pair (xz, xyz) violates O-CONTIG once, DEP-CONTIG twice, and MAX-CONTIG once. The input-output pair (xy, xyz) violates O-CONTIG zero times, DEP-CONTIG once, and MAX-CONTIG zero times.

[16]A challenge for Candidate Chain Theory will be synchronic long distance r-metathesis in Sardinian (Chiara Frigeni p.c.). The current approach can naturally handle such cases.

identifies three relevant properties of CV metathesis in Kwara'ae, namely that underlying contiguous vowels must be contiguous on the surface, that the order of the vowels may not change, and that the introduction of CV transitions not present in the underlying form is prohibited.

Appendix: Normal Form Vowel Qualities

The following table summarizes how the diphthong in the Normal form is predictably derived from two vowels from the set [i,u,e,o,a].

(1)

V_1V_2		V_2 i	V_2 u	V_2 e	V_2 o	V_2 a
V_1	i	i˞	i̯u	⊘	i̯o	i̯ɛ
	u	u̯i	u˞	u̯ɛ	⊘	u̯ʌ
	e	e̯i	e̯u	ɛ˞	e̯o	e̯a
	o	o̯i	o̯u	o̯e, u̯e	ɔ˞	o̯a
	a	a̯i, e̯i, e˞	a̯u, o˞	æ˞, a̯e	a̯o	a˞

⊘ = *unattested*

Nuclei following a ',' can occur in faster speech

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