Going the Distance: Synchronic Chain Shifts in Optimality Theory

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Synchronic chain shifts, whereby certain sounds are promoted (or demoted) stepwise along some phonetic scale in some context, are one of the classic cases of opaque rule interactions (see, e.g., Kenstowicz and Kisseberth 1977). If, for example, /a/ raises to [e], and /e/ raises to [i], it would appear that the /e/ → [i] raising must precede /a/ → [e] raising in the derivation, otherwise /a/ and /e/ would both neutralize to [i].[1] These cases therefore pose a challenge for non-derivational theories of phonology, including standard (strongly parallel) Optimality Theory (henceforth OT).[2] McCarthy (1993) and Orgun (1995) have given OT analyses of a particular chain shift, namely a→i→Ø reduction in Hijazi Bedouin Arabic; however, both these solutions are limited to chain shifts which involve no more than two "links," where one of the links involves deletion. I examine synchronic vowel raising alternations in Basque (Kenstowicz and Kisseberth 1979, Hualde 1991) and Nzebi (Guthrie 1968). Neither of these chain shifts involves deletion; and the Nzebi case involves a three-link chain shift. Employing the notion of *distantial faithfulness*, i.e. minimization of distance between underlying and surface values along the phonetic scale, I show that an OT analysis is not only capable of handling these sorts of alternations, but is the only approach which can formally characterize such shifts in a unified manner. Constraints enforcing distantial faithfulness can in turn be derived from ordinary featural faithfulness constraints by the operation of local conjunction (Green 1993, Smolensky 1995).

Let us begin with the previous treatments of vowel reduction in the Ḥarb dialect of Bedouin Hijazi Arabic (BHA) (Al-Mozainy 1981). In non-final open syllables, short /a/ raises to a high vowel (transcribed [i], realized as [i], [u], or [ɨ] depending on adjacent consonants), while short /i/ syncopates (short /u/ is marginal, and in any case behaves like /i/):

(1)	a→i	/ʕarif-at/	ʕarfat	'she knew'
		/kitil/	ktil	'he was killed'
		/kitil-at/	kitlat	'she was killed'
		/kitil-na/	ktilna	'we were killed'
		/yaskin-uun/	yasknuun	'they (m.) dwell'
		/yaskin-in/	yasknin	'they (f.) dwell'

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[1]This property obviously is not problematic in *diachronic* chain shifts, where the ordering of sound changes presumably reflects distinct historical stages.

[2]Prince and Smolensky (1993) are careful not to identify Optimality Theory as necessarily non-derivational, distinguishing between serial and parallel deployments of OT. Nevertheless, the overwhelming success of constraint ranking in capturing effects once attributed to rule ordering naturally leads one to view OT as an alternative to derivational models; moreover, the parallel version of OT makes stronger empirical claims. For these reasons, I believe, the non-derivational view of OT has become predominant.

i→Ø	/katab/	kitab	'he wrote'
	/samiʕ/	simiʕ	'he heard'
	/rafaagah/	rifaagah	'companions'

In classic rule-based theories, such cases were handled by breaking the chain shift into distinct rules, one rule for each link, and imposing a counterfeeding order on the rule set.

(2)

Rule 1:	a	→	i	/ __ σ	Rule 2 precedes Rule 1
Rule 2:	i	→	Ø	/ __ σ	

In the absence of counterfeeding, the application of these rules will result in a neutralization rather than a chain shift.

(3)

	/kitil/	/katab/		/kitil/	/katab/
Rule 1:	--	kitab	Rule 2:	ktil	--
Rule 2:	ktil	*ktab	Rule 1:		kitab

However, this approach fails to capture two crucial aspects of the chain shift (not to mention the formal arbitrariness of the rewrite rules themselves). First, as McCarthy (1993) observes, this shift constitutes a unified phenomenon of vowel reduction. It should therefore not be decomposed into a set of formally unrelated rules. Second, within rule-based frameworks, feeding (and certain cases of counterbleeding) are generally taken to be the unmarked rule interactions (Kiparsky 1968, Kenstowicz and Kisseberth 1977). The counterfeeding order which characterizes chain shifts therefore appears to be aberrant, when in fact it has obvious functional motivation which the derivational formalism fails to express, namely the avoidance of massive neutralization (cf. Kaye 1974).

McCarthy attributes the vowel reduction to a constraint prohibiting place feature specifications in a short vowel in an open syllable, NO-V-PLACE. He further assumes the following faithfulness constraints:

(4) PARSE$_{hi}$: The feature [high] is parsed (by a vocalic root node).
PARSE$_{low}$: The feature [low] is parsed (by a vocalic root node).
PARSE$_{V}$: A vocalic root node is parsed (by a mora).

In this view of faithfulness, stray elements are automatically deleted post-phonologically, therefore failure to parse (indicated by angle brackets below) amounts to deletion.

(5)

			NO-V-PLACE	PARSE$_{hi}$	PARSE$_{V}$	PARSE$_{low}$
a.		/{V,low}/ → V (= a) │ low	*!			
		/{V,low}/ → <V> (= Ø) │ low			*!	
	☞	/{V,low}/ → V (= i) <low>				*
b.		/{V,hi}/ → V (= i) │ hi	*!			
	☞	/{V,hi}/ → <V> (= Ø) │ hi			*	
		/{V,hi}/ → V (= i) <hi>		*!		

(The restriction to non-final syllables is the result of interaction with alignment constraints, which are not relevant to this discussion.) Note that in the winner in (5b), PARSE$_{hi}$ is satisfied by linking the [high] feature to the root node, even though the root node itself is unparsed. As Orgun (1995) notes, this interpretation of featural faithfulness is problematic with respect to the phenomenon of autosegmental stability, e.g. Rotuman umlaut under deletion of a front vowel:

(6) <u>Complete</u> <u>Incomplete</u>

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f u t i        f  ü  t  < i >        'to pull'
    |             |
  -back         -back
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If PARSE$_{back}$ can be satisfied by linking the [-back] feature to the unparsed root node, it is unclear why [-back] reassociates to the preceding (parsed) vowel.

Orgun instead handles the BHA facts by splitting the faithfulness constraints into two distinct families: the CORRESPONDENCE constraints, which require the presence of corresponding segments in the input and output; and the MATCH constraints, which require corresponding input and output segments to be featurally identical.

(7) CORR(/a/): Every input /a/ has an output correspondent.
NO [a]: No [a] in open syllables.
NO V: No V in open syllables.
MATCH(V): Output correspondents of input V are featurally identical to it.

(8)

		CORR(/a/)	NO [a]	NO V	MATCH(V)
	/a/ → a		*!	*	
	/a/ → Ø	*!			
☞	/a/ → i			*	*
	/i/ → i	*!		*	
☞	/i/ → Ø				

Orgun's analysis, however, shares certain shortcomings with McCarthy's. First, both approaches predict unattested vowel reductions, e.g. /a/→ Ø, /i/→ [i]. For McCarthy's analysis, this outcome obtains under the following ranking:

(9)

		NO-V-PLACE	$\text{PARSE}_{\text{low}}$	PARSE_{V}	PARSE_{hi}
	/a/ → a	*!			
☞	/a/ → Ø			*	
	/a/ → placeless V (= i)		*!		
	/i/ → i	*!			
	/i/ → Ø			*!	
☞	/i/ → placeless V (= i)				*

In Orgun's approach, this outcome obtains by reranking the constraints and invoking a CORRESPONDENCE constraint for /i/:

(10)

		CORR(/i/)	MATCH(V)	NO [a]	NO V	CORR(/a/)
	/a/ → a			*!	*	
☞	/a/ → Ø					*
	/a/ → i		*!		*	
☞	/i/ → i				*	
	/i/ → Ø	*!				

More seriously, neither McCarthy's nor Orgun's approach can be extended to chain shifts with more than two links, or where none of the links involve deletion. The fact that the BHA chain shift has only two links, a → i and i → Ø, allows McCarthy and Orgun to exploit the distinction between failure to parse a feature and failure to parse a segment. McCarthy does this by treating the top-ranked faithfulness constraint, PARSE_{hi}, as satisfied in an unparsed segment. Orgun does so by distinguishing a violation of CORRESPONDENCE from a violation of MATCH.

Non-deletional vowel raising chain shifts occur in a number of Basque dialects. Kenstowicz and Kisseberth (1979), citing de Rijk (1970), present the following data for Western (Bizcayan) Basque:

(11)

	Indefinite	Definite	
a → e	alaba bat	alabea	‘daughter’
	neska bat	neskea	‘girl’
	gona bat	gonea	‘skirt’
e → i	seme bat	semie	‘son’
	ate bat	atie	‘door’
o → u	asto bat	astue	‘donkey’
	baso bat	basue	
i → i^y	erri bet	erriye	‘village’
	ari bet	ariye	‘thread’
u → u^w	buru bet	buruwe	‘head’
	iku bet	ikuwe	‘fig’

According to Jose Ignacio Hualde (p.c.), these data conflate several distinct Western Basque dialects (see generally Hualde 1991). Nevertheless, Kenstowicz and Kisseberth's data, with the exception of the a→e raising (shaded in (11)), are substantially representative of the Etxarri dialect of Navarrese Basque;[3] and it is this dialect that I analyze here.

2.2. A unified raising analysis. I attribute the Etxarri Basque raising to the following constraint:

(12) HIATUS RAISING: In V_1V_2, maximize height of V_1.

The phonetic characterization of these alternations as vowel raising seems plausible, even in the case of /i,u/ → /i^y,u^w/: the high vowel in [i^y] and [u^w] will inevitably be somewhat higher than plain [i] and [u], due to coarticulation with the off-glide. Raising of V_1 under hiatus is well-attested cross-linguistically: Ilokano, [more languages and references to be filled in].[4] Hiatus raising may ultimately be related to the general dispreference for onsetless syllables: the more V_1 is raised, the more glide-like the transitions between V_1 and V_2 become, hence the more the second syllable satisfies its onset requirement.[5] However, for present purposes, namely accounting for the chain shift application of this raising, the formulation of the constraint in (12) suffices. I further posit feature-specific faithfulness constraints, of the following form:

(13) PARSE$_F$: For all $\alpha \in \{+,-\}$, if feature F is specified α in the input, it is specified α in the output.

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[3]Jose Ignacio Hualde (p.c.). In Etxarri Basque, /a+a/ → [a]; moreover, the raising of the suffix and clitic vowel to [e] (not discussed here) is conditioned by a preceding surface high vowel, rather than an underlyingly high vowel as in Kenstowicz and Kisseberth's data.

[4]A related phenomenon is the blocking of elision or coalescence just in case V_1 is high, e.g. Igbo (Emananjo, n.d.).

[5]Rod Casali (p.c.)

I make no crucial assumptions concerning the featural representation of vowel height, provided that the feature system can express the four-way height distinction observed in Etxarri Basque, and provided that we can evaluate the relation “higher than” over the values of the height features, so that violations of HIATUS RAISING can be assessed in a scalar manner. For the sake of concreteness, I posit the following features:

(14)

	low	high	raised
i^y, u^w	-	+	+
i, u	-	+	-
e, o	-	-	-
a	+	-	-

“>“ = higher than

+raised > -raised
+high > -high
-low > +low

We can rank PARSE$_{low}$ above HIATUS RAISING to rule out the raising of /a/ in V_1 position. However, there appears to be no way to rank HIATUS RAISING relative to PARSE$_{hi}$ and PARSE$_{raised}$ to permit raising of /e/ and /i/ without allowing /e/ to raise all the way to [i^y]:

(15) HIATUS RAISING » PARSE$_{hi}$ (otherwise no /e/ → [i] raising)
HIATUS RAISING » PARSE$_{raised}$ (otherwise no /i/ → [i^y] raising)
∴ /e/ → [i^y] raising is not ruled out:

		PARSE$_{low}$	HIATUS RAISING	PARSE$_{hi}$	PARSE$_{raised}$
	e → a	*!	***		
	e → e		**!		
	e → i		*!	*	
☞	e → i^y			*	*

An alternative approach is to build the stepwise nature of the shift into the raising constraint itself, by allowing the constraint to refer to the underlying height of the vowel.

(16) STEPWISE HIATUS RAISING (not adopted): In V_1V_2, raise V_1 one step from its underlying height value.

However, this approach violates the implicit restriction that all OT constraints, modulo faithfulness, are surface well-formedness constraints. Permitting constraints to refer to underlying as well as surface properties vastly increases the descriptive power of the formal system (cf. Lakoff 1993, showing that a system of constraints which may refer to both input and output properties is, like the SPE framework, capable of describing *any* input-output pairing). Moreover, this approach would require at least two types of raising constraints: the stepwise constraint (16) for chain shifts, as in Western Basque; and the "maximal" raising constraint (12) for raisings which result in neutralization. The latter case in fact occurs in the Lekeitio dialect of Basque (Hualde 1991, Hualde and Elordieta 1992):

(17) Neutralizing hiatus vowel raising in Lekeitio Basque[6]

/buru-a/	→	burua	'the head'
/baso-a/	→	basua	'the forest'
/ume-a/	→	umia	'the child'
/neska-a/	→	neskia	'the head'

In fact, even this primarily neutralizing vowel raising has elements of a chain shift, since /i+a/ → [iya], e.g. [mendiya] ('the mountain'). But this merely strengthens the argument: to account for Lekeitio Basque with this approach, we would require a hiatus raising constraint which is neutralizing with respect to /a/ ~ /e/ and /o/ ~/u/, but stepwise with respect to the unrounded non-high and high vowels. Thus, the variety of hiatus raising constraints required is potentially quite large. A unified approach to hiatus raising is clearly preferable.

To capture the stepwise restriction in chain shifts generally, I propose constraints which enforce *distantial faithfulness*. That is, assuming some phonetic scale, the output may not be more than a certain "distance" from its input value along that scale. For Etxarri Basque, let us assume that each link in the chain shift represents a distance of 1 along the vowel height scale. We can now posit the following distantial faithfulness constraint:

(18) V-HEIGHT DISTANCE ≤ 1 (initial formulation): The output may not be a distance > 1 from the input value with respect to vowel height.

(19)

		PARSE$_{low}$	V-HEIGHT DIST ≤ 1	HIATUS RAISING	PARSE$_{hi}$	PARSE$_{raised}$
☞	a → a			***		
	a → e	*!		**		
	a → i		*!	*		
	a → i^y	*!	*		*	*
	e → a	*!		***		
	e → e			**!		
☞	e → i			*	*	
	e → i^y		*!		*	*
	i → a	*!	*	***	*	
	i → e			*!*	*	
	i → i			*!		
☞	i → i^y					*

This approach captures the vowel raising in a unified manner, while directly expressing the faithfulness factor that makes this a chain shift rather than a neutralization, namely the requirement that surface values not be too distant from the underlying values.

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[6]In this dialect, V_2 optionally totally assimilates to (raised) V_1, e.g. [basua]~ [basuu].

Note, however, that the effect of the distantial faithfulness constraint is simply to penalize double violations of PARSE$_{hi}$ and PARSE$_{raised}$ within a single vowel; that is, no vowel may have more than one of its height features changed. This assessment of an extra penalty for compounded violations of a single constraint (or a set of closely related constraints) in a single domain (in this case, within a given vowel), is not unique to this problem. To handle such constraint interactions, Green (1993) posits an operation on the constraint set, local conjunction, whereby two or more related constraints may be conjoined to form a derived constraint, which is violated just in case all the conjoined constraints are violated within the relevant domain (see also Suzuki 1995, Smolensky 1995). Since the distantial faithfulness effect can apparently be captured either in terms of atomic distantial faithfulness constraints, or in terms of local conjunction of PARSE$_{F}$ constraints, appeal to local conjunction here is not crucial. In any case, for Etxarri Basque, the correct distantial faithfulness effect can be obtained by conjoining faithfulness constraints as follows:

(20) PARSE$_{hi}$ ∨ PARSE$_{raised}$ (satisfied iff PARSE$_{hi}$ or PARSE$_{raised}$ are satisfied w.r.t. a given vowel)

(21)

		PARSE$_{low}$	PARSE$_{hi}$ ∨ PARSE$_{raised}$	HIATUS RAISING
☞	a → a			***
	a → e	*!		**
	a → i	*!		*
	a → i^y	*!	*	
	e → a	*!		***
	e → e			**!
☞	e → i			*
	e → i^y		*!	
	i → a	*!		***
	i → e			*!*
	i → i			*!
☞	i → i^y			

The somewhat more complicated Lekeitio Basque pattern can be accounted for by demotion of PARSE$_{low}$, and introduction of a constraint prohibiting [w].[7]

[7]Labial continuants appear to be generally disfavored in Western Basque dialects. Hualde (1991:11) gives the example of the name *Fernando* becoming [pernando] in Western and Central Basque.

(22)

		*[w]	PARSE_{hi} ∨ PARSE_{raised}	HIATUS RAISING	PARSE_{low}
	a → a			**!*	
	a → e			**!	*
☞	a → i			*	*
	a → i^y		*!		*
	e → a			**!*	*
	e → e			**!	
☞	e → i			*	
	e → i^y		*!		
	i → a			*!**	*
	i → e			*!*	
	i → i			*!	
☞	i → i^y				
	o → a			**!*	*
	o → o			**!	*
☞	o → u			*	*
	o → u^w		*!		*
	u → a			**!*	*
	u → o			**!	
☞	u → u			*	
	o → u^w	*!			

This approach can readily be extended to handle the BHA facts as well. I posit the following vowel reduction constraint:

(23) REDUCE: Minimize duration of a vowel in open syllable.

High vowels are phonetically shorter than low vowels (Lehiste 1970), and of course Ø is shorter than anything.[8] Therefore [a] incurs a greater violation of REDUCE than [i], and so on. Failure to reduce long vowels may be attributed to high ranking of PARSE_{long} (i.e. preservation of the distinction between long and short vowels, however represented). The following faithfulness constraints may be conjoined to yield the correct pattern:

(24) PARSE_{+low}: Preserve an underlying [+low] specification.
PARSE_{cons}: Preserve the underlying value of [consonantal] (i.e. do not delete the vowel).

[8]For arguments that sub-phonemic durational properties are phonologically relevant and must be represented, see Kirchner (1995), Steriade (1995).

(25)

		PARSE$_{long}$	PARSE$_{+low}$ ∨ PARSE$_{cons}$	REDUCE
	a → a			**!
☞	a → i			*
	a → Ø		*!	
	i → a			*!*
	i → i			*!
☞	i → Ø			
☞	a: → a:			***
	a: → i	*!		*

Note, however, that if we permit distinct reference to PARSE$_{+low}$ (and therefore PARSE$_{-low}$ as well) we are, like McCarthy and Orgun, unable to rule out unattested vowel reductions such as /a/ → Ø, /i/ → [i].

(26)

		PARSE$_{-low}$	REDUCE
	a → a		*!*
	a → i		*!
☞	a → Ø		
	i → a	*!	**
☞	i → i		*
	i → Ø	*!	

It therefore seems necessary to prohibit distinct PARSE$_{+F}$ and PARSE$_{-F}$ constraints, and to identify the relevant dimension for distantial faithfulness in the BHA chain shift as durational. That is, we could posit features such as [duration > 100 msec] and [duration > 0 msec]. Assuming Ø = [-dur>0,-dur>100], [i] = [+dur>0,-dur>100], and [a] = [+dur>0,+dur>100], the correct distantial faithfulness effect can be obtained by conjoining PARSE$_{dur>0}$ and PARSE$_{dur>100}$.

(27)

		PARSE$_{long}$	PARSE$_{dur>0}$ ∨ PARSE$_{dur>100}$	REDUCE
	a → a			**!
☞	a → i			*
	a → Ø		*!	
	i → a			*!*
	i → i			*!
☞	i → Ø			
☞	a: → a:			***
	a: → i	*!		*

No ranking of these faithfulness constraints, conjoined or otherwise, can give rise to the /a/ → Ø, /i/ → [i] chain shift. For any reduction of /a/ to Ø necessarily violates both $\text{P}_{\text{ARSE}}$$_{dur>0}$ and PARSE$_{dur>100}$; and if this is permitted, then /i/ must reduce to Ø as well.

Recall that an additional limitation of McCarthy's and Orgun's approaches is the inability to handle chain shifts involving more than two links. A three-link chain shift in fact occurs in Nzebi (Guthrie 1968):[9]

(28)

	raised	unraised	
i → i	bis(-i)	bis	'to refuse'
u → u	suem(-i)	suɛm	'to hide self'
o → u, ə → i	kulin(-i)	kolən	'to go down'
e → i	bit(-i)	bet	'to carry'
ɛ → e	βeed(-i)	βɛɛd	'to give'
ɔ → o	tood(-i)	tɔɔd	'to arrive'
a → ɛ	sɛl(-i)	sal	'to work'

The raised form of the verb appears to be selected by certain tense and aspect affixes. The suffix /-i/ in the raised form is omitted except in extremely careful speech, nor is there a general synchronic rule of vowel raising before a high vowel; therefore the raising is most plausibly analyzed as being morphologically conditioned:

(29) MORPHOLOGICAL RAISING: Maximize vowel height in verbs when occurring with certain tense and aspect affixes.

The stepwise restriction on raising can readily be captured using local conjunction of faithfulness constraints, as follows:[10]

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[9]Flemming (1995) gives an alternative OT analysis of Nzebi, relying on constraints which refer directly to the preservation of contrasts within a given phonetic dimension. That is, the raising is constrained by the need to maintain at least two vowel height contrasts. However, the MAINTAIN CONTRAST constraints say nothing about the mapping between particular vowels in the unraised and raised forms. To rule out mappings such as i→ɛ, {a,e}→i, ɛ→e, constraints enforcing distantial faithfulness are required. But as shown throughout this article, the distantial faithfulness constraints alone are sufficient to account for chain shifts, whether or not the MAINTAIN CONTRAST constraints are required to account for other phonological phenomena.

[10]Note that vowel raising in Basaa (Guthrie 1953), identical to Nzebi except that /a/ and /ɛ/ both raise to [e], can be handled straightforwardly in this framework, *pace* Schmidt (1994), by ranking PARSE$_{low}$ (and any conjoined constraints containing PARSE$_{low}$) below RAISING.

(30)

		PARSE$_{low}$ ∨ PARSE$_{ATR}$	PARSE$_{ATR}$ ∨ PARSE$_{hi}$	RAISING
	a → a			***!
☞	a → ε			**
	a → e	*!		*
	a → i	*!	*	
	ε → a			**!*
	ε → ε			**!
☞	ε → e			*
	ε → i		*!	
	e → a	*!		***
	e → ε			*!*
	e → e			*!
☞	e → i			
	i → a	*!		***
	i → ε		*!	**
	i → e			*!
☞	i → i			

The two conjoined constraints could, alternatively, be replaced by an atomic distantial faithfulness constraint, V-HEIGHT DISTANCE ≤ 1, provided that the "distance" is now understood to include the height distinction between -ATR and +ATR vowels.

It is unlikely that the notions introduced here will be sufficient for the reanalysis of all phenomena previously characterized as opaque rule interactions. Cole and Kisseberth (1995), for example, account for the counterbleeding interaction of Yawelmani vowel lowering and harmony in terms of the notion of feature domains, and the distinction between existence of a domain and its featural expression. Other cases of opacity may require yet other treatments, assuming they can be handled within strongly parallel OT at all. I have shown, however, that a substantial class of opaque rule interactions, namely synchronic chain shifts, can be handled insightfully within a non-derivational theory of phonology, using the notion of distantial faithfulness. The effect of distantial faithfulness may, in turn, be derived from simple featural faithfulness constraints, by the operation of local conjunction.

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