Vowel contours in ABC+Q: the role of q

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The participation of diphthongs in vowel harmony and disharmony parallels that of complex consonants (e.g. ⁿd or tˢ) and contour tones (e.g. HL) in many respects: diphthongs act like units in some processes, but like sequences of independent elements in others. This paper applies ABC+Q to the analysis of diphthongs. ABC+Q is the marriage of Agreement by Correspondence (Hansson 2001, Rose & Walker 2004) and Q theory, the proposal by Inkelas & Shih (2013a,b) and Shih & Inkelas (2014) that subdivides each vowel and consonant into three quantized 'q' subsegments (1). The 'q' subsegments are roughly phonetically grounded, such that q^2 corresponds to a target of a constriction, with q^1 the transition into and q^3 the transition away from that target. q^1, q^2 and q^3 correspond loosely to the 'landmarks' of Gafos 2002:271. In subdividing complex segments, Q theory has elements in common with Aperture theory (Steriade 1993).

(1) Q(q^1 q^2 q^3), where Q varies over V, C and each 'q' is a uniform feature bundle

(2) [a]: V(a a a)
[ai]: V(a a i)
[ia]: V(i a a)

The novel contribution of ABC+Q is that correspondence among similar entities can be stated either at the Q level (CORR-QQ, IDENT-QQ) or at the q level (CORR-qq, IDENT-qq). This paper focuses on the ability of q-level correspondence to capture the behavior of diphthongs in harmony and disharmony patterns, focusing on two areas: the common 'invisibility' of the margins of diphthongs to vowel harmony patterns, and the creation of diphthongs as the result of vowel-consonant correspondences across segment boundaries. By drawing on featural and structural similarity, a design feature of ABC, and the segment-internal decomposition of ABC+Q, we are able to offer a unified account of the behavior of diphthongs which brings out their parallels with tonal contours and other complex segments.

1. Vowel harmony at the q level. In many languages, the high portion of a diphthong acts transparent to palatal, labial, or ATR harmony, neither triggering, undergoing, or interfering with the harmony process even though monophthongs of the same quality participate fully in the pattern (see Rhodes 2012 for a recent survey of such effects). In Turkish, for example, only the first component of a [Vj] diphthong is relevant in progressive labial and palatal harmony, which in (3) governs the surface form of the associative (*-li* ~ *-lɯ* ~ *-ly* ~ *-lu*) and past (*-di* ~ *-dɯ* ~ etc.) suffixes. Note that all of the diphthongs in the 'back' column are internally disharmonic for [back] and, in some cases, also for [round]. Dots indicate syllable boundaries; diphthongs are bolded:

(3)

	front		back	
i/ɯ	e.ri.-di g**ij**.-di	'melt-PAST' 'put on-PAST'	kɯz.-lɯ k**ɯj**.-dɯ	'girl-ASSOC' 'mince-PAST'
e/a	an.ne.-li b**ej**.-li	'mother-ASSOC' 'sir-ASSOC'	el.ma.-lɯ sa.r**aj**.-lɯ	'apple-ASSOC' 'palace-ASSOC'
y/u	ør.ty.-ly t**yj**.-ly	'cloth cover-ASSOC' 'feather-ASSOC'	ku.ju.-lu h**uj**.-lu	'well-ASSOC' 'temperament-ASSOC'
ø/o	jøn.-ly k**øj**.-ly	'aspect-ASSOC' 'village-ASSOC'	bal.kon.-lu k**oj**.-lu	'balcony-ASSOC' 'cove-PL'

As seen in the second example in each cell, the high front portion of a diphthong, transcribed per Turkish tradition as [j] but phonetically indistinguishable from [i], permits [+back] and [+round] to pass through it to the following suffix vowel, even though as a [-back, -round] vowel, monophthongal [i] root normally triggers [-back, -round] suffix harmony.

The nonparticipation of certain diphthong portions (q^e, in Turkish) in harmony is challenging both in autosegmental and in standard ABC approaches. The latter portion of [aj] in Turkish is featurally comparable to short [i], so from an autosegmental standpoint, why should its features not spread or block spreading just as those of monopthongal /i/ do? One answer might be that the high vocoid in Turkish [aj] is phonologically a consonant, and that the harmony rule is stated over vowels.

However, being a consonant does not preclude participation in harmony. In Turkish, palatal root-final laterals trigger harmony on suffixes (e.g. *sol, sol-u* 'left(-ACC)' but *sol̯, sol̯-y* 'note 'sol' (-ACC)'), though other palatalized consonants do not (e.g. *kʲar* 'profit'). Structural position, rather than segment type, appears to be the more important factor. In Pasiego, for example, where stressed vowels trigger anticipatory height harmony on non-low vowels, the first part of a rising diphthong is also a harmony trigger, but the last part of a falling diphthong, or a simple intervocalic glide, is not (McCarthy 1984, Rhomieux ms.).

(4)	a.	molér	'to grind'	muljénda	'grinding'
		bebér	'to drink'	bibjéndu	'drinking'
	b.	krej̯ér	'to believe'	*krij̯ér	
		koxájs	'take_2p.pl.subj'	*kuxájs	

The demonstrated sensitivity of harmony patterns to segment-internal position can be addressed by incorporating Q theory into an ABC approach to harmony. In a system like that of Turkish, correspondence is stated over q^2 subsegments. q^3 is irrelevant to harmony, which affects only segment 'centers'. (Separate constraints, not given here, ensure that Turkish diphthongs are always of the form $V(v_i\ v_i\ i)$; Turkish lacks rising sonority diphthongs, or triphthongs.)

(5)	CORR-v^2v^2	Central (q^2) vocalic subsegments correspond (correspondence is local and pairwise (Hansson 2007), enforced between the closest two elements in the corresondence set)
	IDENT-qq-[F]	Corresponding subsegments agree in feature [F].

And in Pasiego, either v^1 or v^2 (but not v^3) in a stressed vowel can enter into correspondence with a preceding unstressed vowel.

A similar analysis can be given to facts like those in (6) from Tohono O'Odham, in which under partial reduplication, only the first half of a light (monomoraic) diphthong is preserved (Miyashita 2011; see also Fitzgerald 2000):

(6)	a.	kais	'rich'	ka-kais	'rich (pl. subj.)'
	b.	piast	'party'	pi-piast	'parties'

While this might be analyzed as a TETU effect (McCarthy & Prince 1994) in which a reduplicated diphthong is monophthongized due to markedness constraints, the pattern is arguably more amenable to a CORR-v^1v^1 analysis. A TETU account would predict both diphthongs to monophthongize to the same unmarked target (presumably [i], or perhaps [a]), while the position-senstive CORR-q^1q^1 account correctly predicts that the copy vowel will match v^1 of the base in quality.

In Oroch (Tolskaya 2008), RTR harmony provides evidence for unrestricted CORR-qq, in which any pair of adjacent q segments is compelled to correspond and agree. Oroch contains many diphthongs. The two that consist solely of two non-neutral vowels (/əu/, /aʊ/) agree internally in their values for

[RTR] and participate fully in [RTR] harmony. The monophthongs /i/ and /æ/ are neutral (transparent) with respect to RTR harmony; not surprisingly, the [i] and [æ] components of diphthongs like /iu/ are also transparent to [RTR] harmony. This is a feature-driven transparency, unlike what is seen in Turkish, where transparency is a result of structural position.

(7)

Oroch vowel inventory

Neutral	-RTR	+RTR
i/ii	u/uu	ʊ/ʊʊ
		ɔ/ɔɔ
æ	ə/əə	a/aa

Setting aside the separate question of front vowel neutrality, all q components of vowels in Oroch are equally subject to harmony: CORR-vv is the operative correspondence constraint.

2. Diphthongization as repair for unstable qq correspondence. Above we discussed the behavior of existing diphthongs in harmony systems. The creation of diphthongs also provides a useful window into the internal structure of vowels.

Diphthongization often arises in a context-free manner (particularly affected stressed tense vowels), but can also be triggered by assimilation to a nearby consonant or vowel. In Old English, for example, the short vowels /i, e, æ/ assimilated in [back] to a following unstressed back vowel (/u/ or /a/), resulting in the short diphthongs /ĭo, ĕo, æ̆a/ (e.g. Hogg 2011:149). Hogg notes that back umlaut is restricted to applying when “only a single consonant intervenes. In all dialects that consonant must not be a palatal and in [West Saxon] only labials and liquids permit the change.” (p. 150):

(8) Back umlaut in Old English (Hogg 2011:152)

s**eo**fon	‘seven’,
eorðb**eo**fung	‘earthquake’
t**eo**lað	‘he strives for’
bīl**eo**fa	‘food’

Diphthongization is not a straightforward concept in standard, segment-based approaches like SPE, classical ABC, or for that matter most implementations of Optimality Theory (none of which were developed with contour segments as a central focus). Hogg, in his description of diphthongization, characterizes it as back vowel epenthesis, using SPE-style rules. Conceptually similar accounts are found in the OT and ABC era. Bakovic (2000) and Miglio & Morén (2003) treat vowel diphthongization as epenthesis and vowel fission, respectively, in both cases converting one segment into two. But the internally harmonic diphthongs which arise from partial assimilation, as in Back Umlaut, are not clearly bisegmental, any more than a short vowel with a contour tone is bisegmental. Rather, the segment epenthesis analysis is motivated only by the inability of the theory to represent capture segment-internal contours.

Autosegmental approaches might seem to have an advantage in representing diphthongs, since a hallmark of autosegmental theory is the many-to-one and one-to-many linkage between melodic elements and timing units. A diphthong like [ei] or Old English [æ̆a] could be represented as in (9a), below. But in autosegmental theory, the *process* of diphthongization is not always straightforward to accomplish, as Hayes (1990) points out. Hayes discusses the example of Old French Diphthongization (/eː, oː/ → [ei, ou]). If a standard autosegmental representation (as in (9b)) is the starting point, changing the value of /e/ to [+high] would incorrectly raise the entire vowel, as in (9c). Delinking the original vowel from the second V position and inserting [+high] (9d) would fail to capture the fact that roundness is preserved in that position, incorrectly predicting /eː oː/ → *[ei, oi] (9d,e). Partial diphthongization is not what these representations were designed to capture, leading Hayes to essentially abandon autosegmental theory altogether in favor of a coindexation approach that could be seen as a forerunner of ABC.

(9)

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     (a)          (b)      (c)        (d)              (e)
      V           V V      V V      V      V         V      V
      /\           \/       \/      |      |         |      |
  Root  Root      Root     Root    Root   Root      Root   Root
   |     |         |        |       |      |         |      |
  [e]   [a]       [e]      [i]     [e]    [i]       [o]    [i]
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ABC+Q is a hybrid approach which can capture both the segmental and the subsegmental behavior of diphthongs. In ABC+Q, diphthongization consists in the redistribution of features across the (monophthongal) v subsegments of a V(v v v) segment. The representations of Q theory make it easy to describe partial diphthongization, as in Old French, in which v^3 changes in just one feature, leaving v^1 and v^2 unaffected.

By incorporating the correspondence constraints of ABC, ABC+Q theory can also easily describe assimilatory diphthongizations like Old English back umlaut, in which CORR-v-σ-v compels structurally adjacent v subsegments to correspond across a syllable boundary. The effect is v^3-v^1 correspondence. Thus an input like *sefon*, with V(e e e)CV(o o o), becomes V(e e o_i)C(o_i o o) through v^3-v^1 correspondence and enforcement of [back] identity. Note that highly analogous behavior occurs in tone languages, where tonal contours arise from partial assimilation across a syllable boundary of one tone to another, e.g. Yoruba /rárà/ → [rárâ] 'elegy' (Akinlabi & Liberman 2001). Shih & Inkelas (2014) analyze this as V(á á á)CV(à à à) → V(á á $á_i$)CV($á_i$ à à). It is a virtue of ABC+Q that it can capture parallels of this kind between tonal contours and diphthongs.

In many languages, diphthongization arises from assimilation between adjacent v and c subsegments, under the conditions of featural similarity which are a prerequisite for correspondence in ABC. Huave is a particularly illuminating case study. As closely analyzed by Kim (2008), Huave diphthongization is a repair for two different phonotactic constraints involving local vc subsegment pairs.

Huave has a five vowel system (i e a o u). While consonants palatalize allophonically before front vowels in onset position, root-final consonants exhibit contrastive underlying palatality, which is realized in two ways. One, termed 'Vowel Breaking' by Kim (2008), is diphthongization of a preceding tautosyllabic root vowel. When a root-final C is syllabified as a coda, diphthongization can result under the circumstances that Kim characterizes as a mismatch in palatality. As seen in (10), 'plain' root-final consonants, whether coronal, labial or velar, cause a preceding tautosyllabic front vowel to diphthongize.

(10)

	Cor	NonCor
u, o, a	got	sap
i, e	et → iat in → ion	mik → miok chip → chiop

In ABC+Q terms, v^3 corresponds and therefore must be identical in [back] to the following (tautosyllabic) c^1. (The restriction to the syllable rime can be captured either in this constraint or by a separate 'limiter' constraint of the kind in Bennett 2012.) The analysis is sketched below:

(11) ABC+Q analysis of diphthongization:

CORR-v[-bk]c	A front vocalic q must correspond to a following consonantal q
Ident-qq-[pal]	Corresponding q's are identical in palatality

/ V(i i i)C(t t t) /	CORR-[q-S-q]$_{rime}$	Ident-qq-[pal]	IDENT-IO-C	IDENT-IO-V	
a. V(i i i_x)C(t_x t t)		W1			*q corr, faithful*
b. V(i i i_x)C(t_y t t)	W1				*No corr, faithful*
c. V(i i i_x)C(t^j_x t t)			W1		*q corr, assimilation*
☞d. V(i i a_x)C(t_y t t)				1	*No q corr, dissimilation*

Above, we noted the parallels between diphthongizing partial V-to-V assimilation and the kind of tonal spreading that can create tone contours. Tonal parallels also exist with the partial V-to-C assimilation seen in Huave. In Nupe (George 1970; Yip 2002:143–144), a H tone will assimilate to a preceding L, producing a LH rising contour, only if the intervening consonant is voiced.

(12)	a.	Spreading:	èdǔ			'taxes'
			/è-lé/	→	[èlě]	'past'
			/è-mí/	→	[èmǐ]	'I' or 'me' (Kpada dialect)
	b.	No spreading:	ètú			'parasite'

Building on proposals by Shih (ms.), Inkelas & Shih (2014) model this effect using strictly local, q-level correspondence, in which a crucial component is a c-v correspondence between c^3 of a voiced consonant and v1 of the following vowel. For an input like *èlé*, the L tone propagates through local pairwise qq correspondence from the first vowel through the consonant, and onto v^1 of the second vowel. The c^3-v^1 correspondence needed to achieve tonal contour formation in Nupe is directly parallel to the v-c correspondence that produces diphthongization in Huave.

Summary. The role of diphthongs in harmony systems clearly motivates a representation in which the components of a diphthong are independent of one another. Strictly segmental theories, such as SPE or standard ABC, lack the ability to refer to subsegments. Autosegmental theory, with its many-to-one associations between feature bundles and timing units, was a step in the right direction, but its formalism had limits (Hayes 1990). This problem is solved by Q theory, which eliminates many-to-one associations in favor of spitting segments into subsegments which can but need not agree with one another featurally. ABC+Q, the marriage of Q theory and ABC, has the descriptive power to model subsegmental behavior and thus to capture the parallels in behavior among diphthongs, contour tones, and other contour segments.

3. Predictions and implications. A potential flaw of ABC+Q is that, because correspondence can be stated either at the Q or the q level, Q-level vowel harmony is predicted to duplicate diphthongs. We have not as yet found a case of this kind. However, its counterpart in tone does seem to exist, partially supporting this prediction of the theory. As documented by Yip 1989, Bao 1990, Duanmu 1994, Changzhi exhibits whole-contour tone assimilation. The diminutive suffix acquires exactly the same complex tonal contour as the preceding syllable:

(13)	a.	/kuə$_{213}$ -tə$^{ʔ}_{535}$/	→	[kuə$_{213}$ -tə$^{ʔ}_{213}$]	‘pan-DIM’
	b.	/səŋ$_{24}$ -tə$^{ʔ}_{535}$/	→	[səŋ$_{24}$ -tə$^{ʔ}_{24}$]	‘rope-DIM’
	c.	/ti$_{535}$ -tə$^{ʔ}_{535}$/	→	[ti$_{535}$ -tə$^{ʔ}_{535}$]	‘bottom-DIM’
	d.	/kʰu$_{44}$ -tə$^{ʔ}_{535}$/	→	[kʰu$_{44}$ -tə$^{ʔ}_{44}$]	‘pants-DIM’
	e.	/təu$_{53}$ -tə$^{ʔ}_{535}$/	→	[təu$_{53}$ -tə$^{ʔ}_{53}$]	‘bean-DIM’

Shih & Inkelas (2014) provide an ABC+Q account of Changzhi tone assimilation in which CORR and IDENT constraints target the Q level, causing the entire tonal specification of a vowel to be duplicated exactly on its correspondent. Applied to diphthongs, this analysis would predict the possibility of a vowel harmony process in which a diphthong in a root is duplicated exactly on a suffix vowel, via CORR-QQ and IDENT-QQ. Whole diphthong duplication certainly occurs in outright reduplication, as in Kikuyu (Peng 1993:18):

(14)	a.	tɛrɛm-a	tɛr-a+tɛrɛm-a	‘trample (a little)’
		tɛɛhór-a	tɛɛh-a+tɛɛhór-a	‘tear (a little)’
	b.	β**oi**k-a	β**oi**k-a+β**oi**k-a	‘march (a little)’,
		t**ɛi**θí-a	t**ɛi**θ-a+t**ɛi**θí-a	‘help (a little)’

While outright consonant harmony itself is rare, consonant copy in partial reduplication duplicates complex consonants with no issue. In Q theory, a complex consonant like the affricate /ʧ/ is a contour: C(t t ʃ). The Koasati example in (15), while unusual in some respects, is completely typical of consonant copy in that the affricate “c” ([ʧ]) is copied wholesale, just as the simplex consonants are. This is Q-level correspondence:

(15) Koasati punctual reduplication (infix *Có:*) (Kimball 1991:325; data cited from Yu 2007)

‘to be narrow’	lapátkin	→	lapát-l̲ó:-kin	
‘to be circular’	taháspin	→	tahas-tó:-pin	
‘to be angled’	copóksin	→	copok-có:-sin	*copok-ʃó:-sin, *copok-tó:-sin
‘to be a hill’	cofóknan	→	cofok-có:-nan	*cofok-ʃó:-nan, cofok-tó:-nan

Clearly, correspondence theory needs to be able to duplicate contour segments. Whether the prediction of full contour assimilation (i.e. wholesale diphthong ‘spreading’) is correct for vowel harmony per se remains to be seen.

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