Working Papers of the Cornell Phonetics Laboratory
2000, vol. 13, pp. 105–124

Vowel Harmony and Vowel-to-Vowel Coarticulation in Three Dialects of Yorùbá*

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I explore the similarities between phonological vowel harmony and phonetic vowel-to-vowel coarticulation by examining the vowels in three dialects of Yorùbá: Standard Yoruba, Moba, and Akure. While they all exhibit some degree of ATR vowel harmony, only Akure exhibits a vowel harmony in the high vowels. I compare the acoustic characteristics of the vowel harmony in the high vowels of Akure, with the coarticulatory properties in parallel environments in the non-harmonizing dialects. In Akure, the high vowel pairs exhibit a large difference in F1 between the +ATR and –ATR vowels as expected; in SY and Mọ̀bà, where there is no phonological split, the high vowel pairs also exhibit a split in F1 in the same direction as the contrast found in Àkùrẹ́, though crucially much smaller and less distinct. These findings support the conclusion that vowel harmony has its origins in vowel-to-vowel coarticulation.

1 Introduction

I examine the parallels between vowel harmony and vowel-to-vowel coarticulation in three dialects of Yorùbá (Benue-Congo, Niger-Congo): Standard Yorùbá (SY), Mọ̀bà Yorùbá, and Àkùrẹ́ Yorùbá. In Àkùrẹ́, high vowels harmonize to successive vowels, while in the other dialects, the high vowels do not harmonize. I show how the phonetic patterns of coarticulation in high vowels where there is no harmony, resemble the phonological patterns of harmony in Àkùrẹ́. I have found that the acoustic effects of coarticulation are in the same direction, though with a much smaller magnitude, as the acoustic effects of the phonological harmony; the phonetic effects are found in the same group of vowels that undergoes vowel harmony; and, both the coarticulatory effects and the vowel harmony occur across consonants. These findings are consistent with the view that vowel harmony emerges from coarticulation.

After sketching the vowel harmony systems of the three dialects in §2, I describe the experiment designed to determine the patterns of coarticulation in the three dialects (§3). The results are described in §4, followed by a discussion in §5.

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* This material is based on work supported under a National Science Foundation Graduate Fellowship. Additional support was provided by a Research Travel Grant from the Mario Einaudi Center for International Studies, Cornell University. I would like to thank audiences at ACAL 28, NLSC 1999, and the Cornell University Phonetics Lab, as well as Abigail Cohn, Eungyeong Kang, and Akinbiyi Akinlabi for helpful comments.

2 Yorùbá Vowel Harmony

Àkùrẹ́ and Mọ̀bà Yorùbá are in the Central Èdè branch of Yoruboid along with Ìjèṣà, Èkìtì, Ìfẹ̀, and others; Standard Yorùbá is in the North West Èdè branch, with Ọ̀yọ́, Ẹ̀gbá, and Ọ̀shùn (Capo 1989). Àkùrẹ́ is spoken in Àkùrẹ́, Òndó state; Mọ̀bà, in Ọ̀tụ̀n-Èkìtì, Èkìtì state; and SY, in Ìbàdàn, and increasingly throughout Yorùbáland in Nigeria.

There are seven underlying oral vowels in each of the three dialects, as shown in (1).

(1)

high	i	u[1]	
mid	e	o	+ATR
	ẹ	ọ	–ATR
low	a		

The vowels may be split into two sets based on the feature Advanced Tongue Root (ATR): +ATR (i, u, e, o) and –ATR (ẹ, ọ, a). In ATR languages such as Akan and Igbo, +ATR vowels have expanded pharyngeal volume compared to their –ATR counterparts (see Stewart 1967, Ladefoged 1968, Lindau 1979, among others). Some degree of vowel cooccurence restrictions typifies these languages. Because the characteristics of Yorùbá vowel harmony (especially in Àkùrẹ́ Yorùbá) resemble those of ATR languages, I follow Akinlabi (forthcoming) and Archangeli and Pulleyblank (1989) in using the labels [+ATR] and [–ATR]; however, it has not been established whether the articulatory characteristics typically associated with ±ATR are present in some or all dialects of Yorùbá, since the articulation of Yorùbá vowels has not been instrumentally investigated.

I will describe the relevant features of vowel harmony in the three dialects, first describing harmony to prefix clitics, and then, cooccurence restrictions within the word. In the acoustic experiment presented here, I am concerned only with patterns within the word; however, the general harmony patterns help to illustrate the word level patterns. For further discussion of Yorùbá vowel harmony, see Bamgbọṣe (1967), Awobuluyi

[1] Using the standard Yorùbá orthography, I mark [–ATR] midvowels with an underdot. I also mark with an underdot the high vowels that are [–ATR] on the surface.

(1967), Archangeli and Pulleyblank (1989), Akinlabi (forthcoming), and references found therein.

2.1 Àkùrẹ́

Of the three dialects I examine, Àkùrẹ́ exhibits the most robust harmony. Singular subject pronouns harmonize with vowels in the following word, as we see for the third person singular, *ó/ọ́*, in (2). Before +ATR vowels (i, u, e, o) the pronoun is realized as *ó*; before –ATR vowels (ẹ, ọ, a), the pronoun is realized as *ọ́*.

(2) **ó** dé 's/he arrived' **ó** jó 's/he danced' **ó** kí 's/he greeted'
ọ́ jẹ 's/he eats' **ọ́** lọ 's/he went' **ọ́** á 's/he came'

The harmony involves both mid vowels and high vowels, as we see in (3) and (4). Like mid vowels, high vowels not only undergo harmony by surfacing as distinct allophones (4a, b), but they also trigger harmony to their left (4a, b).

(3) **ó** r'oko 's/he saw the farm.'
ọ́ r'ọkọ̀ 's/he saw the car.'

(4) (a) **ó** r'ulé 's/he saw the house.'
ọ́ r'ụgbá 's/he saw the calabash.'

(b) **ó tú** ti jó 'it has burnt again' from Bamgbose (1967)
ọ́ tú tị bẹ́ 'it has burst again' from Bamgbose (1967)

Note that what we see above in (4a, b) is cross height harmony, which typifies ATR harmony systems. In this case, a high vowel [ụ] lowers a mid vowel /o/ to a phonetically lower mid vowel [ọ]; that is, a high vowel acts as a trigger to lower a vowel that is already lower than itself.

2.2 Mọ̀bà

Like Àkùrẹ́, Mọ̀bà has right-to-left harmony to prefix clitics:

(5) **é** dé 's/he arrived' **é** jó 's/he danced' **é** kí 's/he greeted'
ẹ́ jẹ 's/he eats' **ẹ́** lọ 's/he went' **ẹ́** á 's/he came'

Mid vowels participate in vowel harmony as shown in (6). However, unlike Àkùrẹ́, high vowels do not participate in harmony—they are opaque to it, neither undergoing nor triggering vowel harmony. The high vowels do not have –ATR allophones (as will be phonetically verified later). Both high vowels, /i/ and /u/, are preceded by +ATR allophones to their left (7).

(6) **é** r'oko 's/he saw the farm.'
ẹ́ r'ọkọ̀ 's/he saw the car.'

(7) **é** r'ulé 's/he saw the house.'
é r'ugbá 's/he saw the calabash.'
é tú ti jé 'it has burnt again' from Bamgbose (1967)
é tú ti bẹ́ 'it has burst again' from Bamgbose (1967)

2.3 Standard Yorùbá

Although Standard Yorùbá is often said to exhibit vowel harmony, it has no harmony to prefix clitics (8), (9).[2]

(8) **ó** dé 's/he arrived' **ó** jó 's/he danced' **ó** kí 's/he greeted'
ó jẹ 's/he eats' **ó** lọ 's/he went' **ó** wá 's/he came'

(9) **ó** r'oko 's/he saw the farm.'
ó r'ọkọ̀ 's/he saw the car.'
ó r'ilé 's/he saw the house.'
ó r'igbá 's/he saw the calabash.'

SY does exhibit coocurrence restrictions within the word, as described in the next section. As in Mọ̀bà, there is no evidence of high vowel participation in vowel harmony.

2.4 Lexical Cooccurence

Yorùbá exhibits cooccurrence restrictions for adjacent syllables within the lexical word, as shown in Table 1, where the words shown are indicative of robust patterns in the languages.

	Àkùrẹ́	Mọ̀bà	SY	gloss
(a)	[ekpo]	[ekpo]	[ekpo]	oil
(b)	[ọbẹ̀]	[ọbẹ̀]	[ọbẹ̀]	soup
(c)	[ulé]	[ulé]	[ilé]	house
(d)	[ịjọ̀]	[ịjọ̀]	[ịjọ̀]	salt
(e)	[ụsẹ́]	[iʃẹ́]	[iʃẹ́]	work
(f)	[ụgbá]	[ugbá]	[igbá]	calabash
(g)[3]	[ẹ́ụ́rẹ́]	[ewúrẹ́]	[ewúrẹ́]	goat
(h)	[etu]	[ẹtu]	[ẹtu]	deer

Table 1. Lexical Cooccurence patterns (from Bamgbose 1967, Fresco 1970)

In all three dialects, we see cooccurrence restrictions in the mid-vowels in (a) and (b): adjacent mid vowels must agree in their ATR values. In (c) through (f) we see that only Àkùrẹ́ has harmony extending to the high vowels. For example, in (d), the /i/ is realized as a –ATR phone [ị] only for Àkùrẹ́. All cooccurrence restrictions can be seen as applying from right-to-left; for example, in all dialects, mid vowels before /a/'s are always –ATR, while mid vowels after /a/ may be either +ATR or –ATR, as shown in (10) for Mọ̀bà.

(10)	ẹja, 'fish'	ọba, 'king'	*oCa,	*eCa
	apẹ, 'type of pot'	aṣọ, 'clothing'	apó, 'quiver'	agbe, 'type of bird'

2.5 Summary of Vowel Harmony Characteristics

In Àkùrẹ́ and Mọ̀bà, the distributional pattern found within the lexical word is the same as that found in harmony to the prefix clitics; this comparison cannot be made for SY since it lacks harmony to the prefix clitics. The high (and mid) vowels in Àkùrẹ́ participate in vowel harmony: they have ±ATR allophones, which trigger ATR harmony

[2] Note, there are no initial /u/s in SY—initial /u/s in other dialects have become /i/s in SY.

[3] (g) and (h) are here for the reader's interest; they are not directly relevant to this paper. In (g), for Mọ̀bà and SY, the –ATR of the rightmost vowel does not spread to the high vowel, so the word may contain a +ATR mid vowel. But in Àkùrẹ́, the –ATR spreads through the high vowel, and to the preceding mid vowel. (h) shows that only in Àkùrẹ́ does a high vowel trigger ATR harmony.

to the left. In the other two dialects, only mid vowels have ±ATR allophones, the high vowels do not trigger ±ATR allophones to their left. So crucially, the high vowels participate in harmony only in Àkùrẹ́. Finally, the low vowel /a/ always triggers –ATR harmony in environments where harmony is typically found.[4] A summary of the characteristics is shown in Table 2.

	Distributional constraints on ATR	Harmony to Prefix Clitics	Mid-vowel Split [e, o, ẹ, ọ]	**High-vowel Split [i, u, ị, ụ]**	Right-to-left ATR Spread
Àkùré	✓	✓	✓	✓	✓
Mọ̀bà	✓	✓	✓	**no**	✓
SY	✓	no	✓	**no**	✓

Table 2. Summary of vowel harmony characteristics for Àkùrẹ́, Mọ̀bà, and Standard Yorùbá.

3 Experiment

If phonological vowel harmony emerges from phonetic effects, then we should find that the phonological patterns resemble phonetic ones. A vowel's articulatory realization, and thus its acoustic realization, is influenced by, among other things, the realization of adjacent vowels—this is vowel-to-vowel coarticulation (see Ohman 1966, Manual 1990, and others). Both harmony and coarticulation involve an influence of characteristics from one vowel onto a neighboring vowel. The effect is larger and generally more perceptable with harmony than with coarticulation. In this experiment, I examined both effects to determine to what extent they are similar. My hypothesis is that coarticulation should look like vowel harmony, though the phonetic effects should be much smaller and less robust than the phonological ones.

I investigated the acoustics of vowel harmony and coarticulation in VCV tokens (words and non-words) in the three Yorùbá dialects. Of interest in this paper are the high vowels—in Àkùrẹ́ the high vowels have ±ATR allophones, but in Mọ̀bà and SY, they do

[4] The behavior of [a] in Yorùbá is typical for ATR languages; even in languages such as Akan, where /a/ has allophones, both variants trigger –ATR harmony.

not (as noted above). I expected to find that in Mòbà and SY, the effects of coarticulation resembled the harmony found in Àkùré, as exemplified for /i/ in Figure 1.

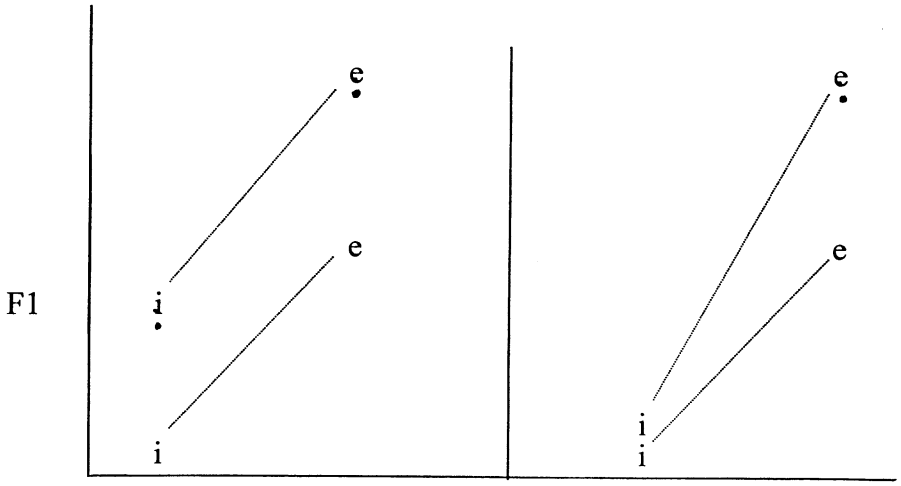

Figure 1. Schematic of Predicted F1 value for vowels in Àkùré's *ike* and *ikẹ*, and in Mòbà and SY's *ike* and *ikẹ*.

On the left side, we see a schematic illustration of predicted F1 values for the vowels in *ike* and *ikẹ* in Àkùré: the F1s for each vowel pair are very different. On the right side, we see the expected F1 values for the vowels of *ike* and *ikẹ* for Mòbà and SY. While the [e]/[ẹ] pair should resemble its Àkùré counterpart, the high vowel pair was expected to show only a small difference, with the [i] having a higher F1 before –ATR [ẹ] than before +ATR [e]. The difference in the articulation of [i] before –ATR vowels versus before +ATR vowels is not neccesarily part of a speaker's knowledge, rather it is in some way the result of anticipating the articulation of the following vowel.

3.1 Methodology

10 native speakers for each of the three dialects were recorded. Here, I report on two speakers per dialect. The speakers read a list of words with the form VCV, which included all allowable vowel combinations in their dialect. The words had the general shape in (11).

(11)	V1	–	C	–	V2
	{i, e, ẹ, a, ọ, o, u}	–	{k, b}	–	{ i, e, ẹ, a, ọ, o, u }

Some combinations, such as eCẹ, ẹCe, oC ẹ, and ẹCo (where C is /k/ or /b/), are not allowed in any of these dialects, and so these combinations were not included in the list. Other combinations are present in some dialects but not others. For example, Mọ̀bà and SY speakers were given forms of the shape eCu and ẹCu, both allowable forms in those dialects; Àkùrẹ́ speakers were given only the former, since words of shape ẹCu are not found in Àkùrẹ́. I controlled for tone and intervocalic consonant: the words all had mid tones on the first and second syllable; the intervocalic consonants used were /b/ and /k/. Due to the difficulty of finding minimal sets with the same tone and intervocalic consonants, I included nonsense words as well as real words; indeed, most of the words on the list are not real words.

The words were pronounced in the carrier phrase listed in (12).

(12)	Standard Yorùbá:	ó	f'	ike	s'ókè.[5]
	Mọ̀bà:	é/ẹ́	f'	ike	s'ókè.
	Àkùrẹ́:	ó/ọ́	f'	ike	s'okè.
		3sg	put	word	on top
		'S/he put *ike* on top.'			

The carrier phrase differs minimally from dialect to dialect, as shown. (Note the pronouns and the tone of *oke* differ.) The sentences were written in Yorùbá orthography. Four repetitions of each target word and carrier phrase were recorded, of which three were measured.

The recordings were made in Nigeria with a Sony WM-D6C Professional Walkman and a Shure SM10A head-mounted microphone, and were digitized on a Sun SparcStation at a sampling rate of 11,025 kHz. Measurements were made using the Entropic Signal Processing Systems (ESPS) Waves+® speech analysis software system. Formants and bandwidths were measured using the xspectrum feature of Xwaves using

an LPC spectra, with a 20 ms. window and an order of 14. Other measurements were taken using FFT spectra, LPC spectra, spectrograms, and pitch tracking programs, using scripts developed by Eric Evans and me.

3.2 Acoustics of ATR Vowels

ATR vowel pairs typically differ in the first formant (F1), with a +ATR vowel having a lower F1 than its –ATR counterpart (Halle and Stevens 1969, Lindau 1978, Hess 1992, Fulop 1996, and others). F1 Bandwidth has also been associated with ±ATR in some languages, with a +ATR vowel having a lower F1 Bandwidth than its –ATR counterpart (Hess 1992, Maddieson and Gordon 1996). Hess (1992) tested five acoustic properties of the vowels from one speaker of Akan to determine which was the most reliable correlate with the phonological ATR distinction. She considered F1, F1 bandwidth, vowel duration, as well as two spectral measures: difference in peak amplitude of F1 and F2, and the difference in amplitude between the second and first harmonic. Although she found that the F1 Bandwidth was correlated with ATR, she found that F1 was a more reliable correlate. The other three measures were not correlated with ATR.

Following Hess (1992), as well as Watkins (1998), I made these measurements for the midpoint of each V1:

- F1, F2, F3
- F1, F2, and F3 Bandwidths
- F0
- Vowel Duration
- Various Spectral Measures (from Watkins (1998))
  - Amp(H1) – Amp(H2)
  - Spectral Tilt: Max Amplitude between 0-1000 Hz minus Max Amplitude between 2500-3500 Hz.
  - Amp(F1) – Amp(H1)

[5] Tone is marked in Yorùbá orthography— ´ indicates a high tone; `, a low tone; and mid tones are unmarked.

4 Results

Consistent with other studies discussed above, I found F1 to be the most reliable phonetic correlate to ±ATR distinctions, and so I report only on this measurement here. Each chart below (Figure 2-Figure 7) represents one speaker, comparing each vowel before +ATR versus –ATR mid vowels. I limit the comparison to vowels before mid vowels, since mid vowels differ only in one feature, ATR. The first bar (labeled small 'i') represents the F1 average for /i/ when followed by the +ATR mid vowels, /e/ and /o/. The capital 'I' shows the average F1 for /i/ before the –ATR midvowels, /ẹ/ and /ọ/. The same is true for the other vowels, so that the small [a], for example, is the a of *ake*, *ako*, *abe*, *abo*, and the capital [A] is for a in *akẹ*, *akọ*, *abẹ* and *abọ*.

4.1 Àkùrẹ́

Looking at the results from the Àkùrẹ́ speakers, in Figure 2 and Figure 3, first note that the two mid vowel pairs are clearly distinct; the differences between [e] and [ẹ], and [o] and [ọ], are large and statistically significant for both speakers. For speaker Ak2, the differences were 204 Hz and 174 Hz for front and back vowels, respectively [$p < .001$ for both]. For speaker Ak6, the differences were 115 Hz and 131 Hz for front and back vowels, respectively [$p < .001$ for both]. These differences were expected, since these phones are distinct phonemes.

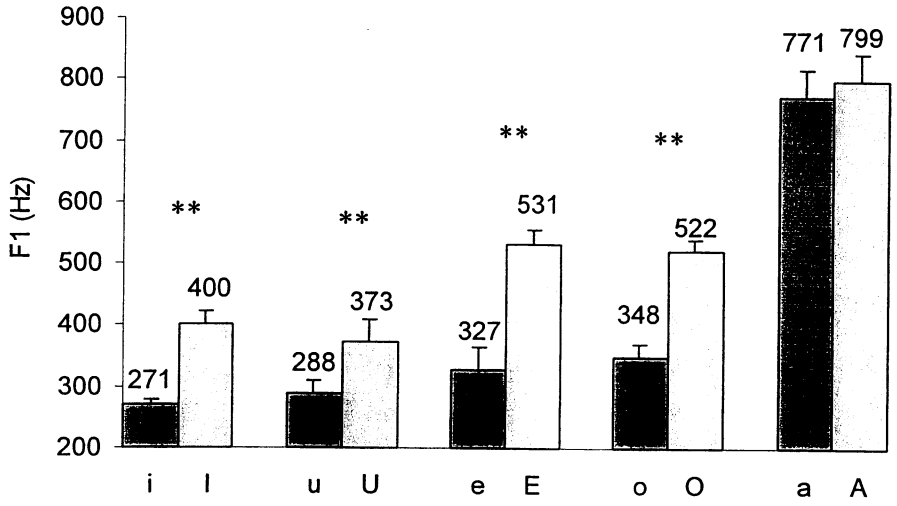

Figure 2. F1 Averages at V1 midpoint for Àkùré speaker "Ak2"; the small letters show the average of the vowels before +ATR /e/ and /o/; the capital letters show the average before –ATR /e̩/ and /o̩/. (Bars mark one standard deviation. ** indicates a statistical significance of $p < .01$ using a t-test; * indicates $p < .05$.)

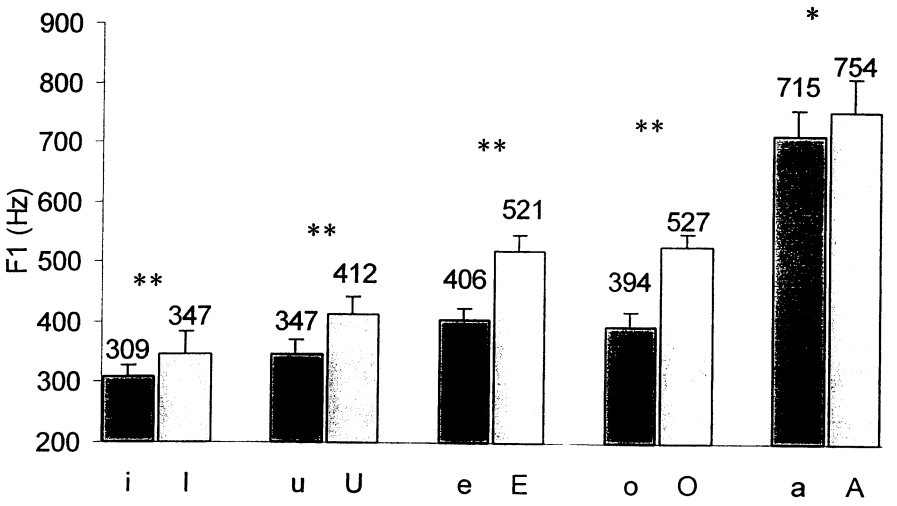

Figure 3. F1 Averages at V1 midpoint for Àkùré speaker "Ak6"; the small letters show the average of the vowels before +ATR /e/ and /o/; the capital letters show the average before –ATR /e̩/ and /o̩/. (Bars mark one standard deviation. ** indicates a statistical significance of $p < .01$ using a t-test; * indicates $p < .05$.)

For the Àkùré high vowels, +ATR and –ATR variants also have significantly different F1 averages. For speaker Ak2, we find a difference of 129 Hz for the front vowels and 85 Hz for the back vowels, both significant [$p < .001$ for both]. For Ak6, the difference is smaller: 39 Hz for the front vowels and 65 Hz for the back vowels; still,

t-tests show significance differences [$p < .01$, for front vowels, $p < .001$ for back vowels]. These findings show that there are categorical differences between these phones in Àkùré, consistent with phonological generalizations, since we know that high vowels participate in the vowel harmony as triggers, as well as targets. For the Àkùré low vowel, the difference between [a] before E and O versus [a] before e and o is small [not significant for Ak2, with $p > .05$; slightly signficant for Ak6, with $p < .05$). In summary, in Àkùré we see distinct differences in the vowel pairs described to be phonologically distinct, either as phonemes (in the mid vowels) or as allophones (in the high vowels).

4.2 Mòbà

For Mòbà mid vowel pairs, shown in Figure 4 and Figure 5, the results are similar to Àkùré: the differences between e and E, and o and O, are large for both speakers and statistically significant [$p < .001$ for both speakers, both vowel pairs].

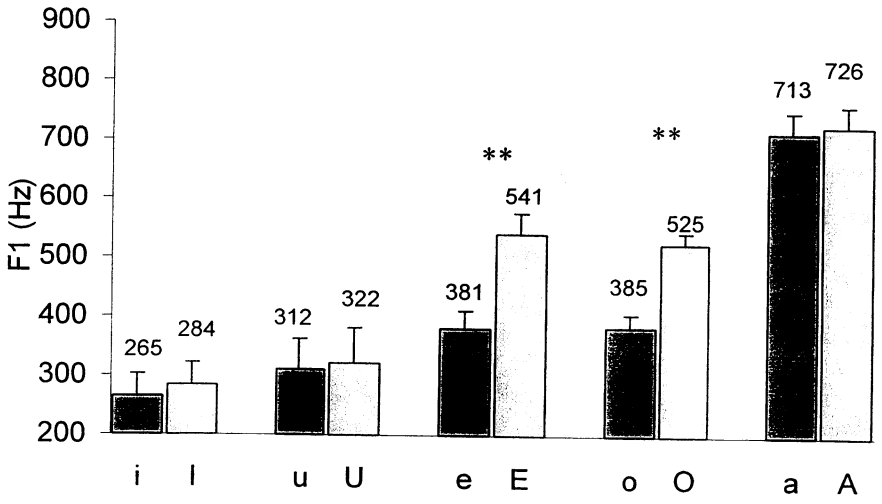

Figure 4. F1 Averages at V1 midpoint for Mòbà speaker "Mb8"; the small letters show the average of the vowels before +ATR /e/ and /o/; the capital letters show the average before –ATR /E/ and /O/. (Bars mark one standard deviation. ** indicates a statistical significance of $p < .01$ using a t-test; * indicates $p < .05$.)

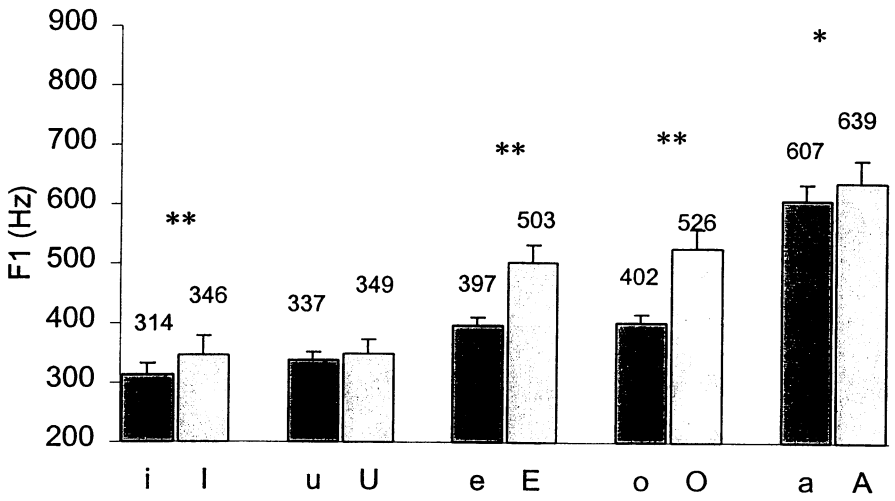

Figure 5. F1 Averages at V1 midpoint for Mọ̀bà speaker "Mb9"; the small letters show the average of the vowels before +ATR /e/ and /o/; the capital letters show the average –ATR /E/ and /O/. (Bars mark one standard deviation. ** indicates a statistical significance of $p < .01$ using a t-test; * indicates $p < .05$.)

As in Àkùrẹ́, these differences are expected for distinct phonemes. In the Mọ̀bà high vowels, we do not expect a large difference since there is no ±ATR phonological split in high vowels, and in fact the observed difference is smaller than for Àkùrẹ́. For speaker Mb8, the differences were 19 Hz and 2 Hz for front and back vowels respectively [$p > .05$ for both]. For speaker Mb9, the differences were 32 Hz for front vowels [significant, $p < .01$] and 5 Hz for back vowels [not significant, $p > .05$]. In each high vowel pair, for each speaker, the direction of the difference is the same as for the Àkùrẹ́ allophonic pairs. For the low vowel /a/, the difference is 13 Hz for speaker Mb8 [not significant, $p > .05$], and 22 Hz for speaker Mb9 [slightly signficant, $p < .05$].

4.3 Standard Yorùbá

SY mid vowels pattern like Mọ̀bà and Àkùrẹ́, with large differences and statistical significance [$p < .001$ for both speakers, both vowel pairs]. For the single high vowel /i/, SY speakers, like Mọ̀bà speakers, show a small difference in the same direction as found for the Àkùrẹ́ allophonic pairs. For speaker SY1, the difference was 20 Hz; for speaker SY8, the difference was 5 Hz [both not significant with $p > .05$]. For the low vowel /a/,

the difference is 22 Hz for speaker SY1 and 8 Hz for speaker SY8 [both not significant with $p > .05$].

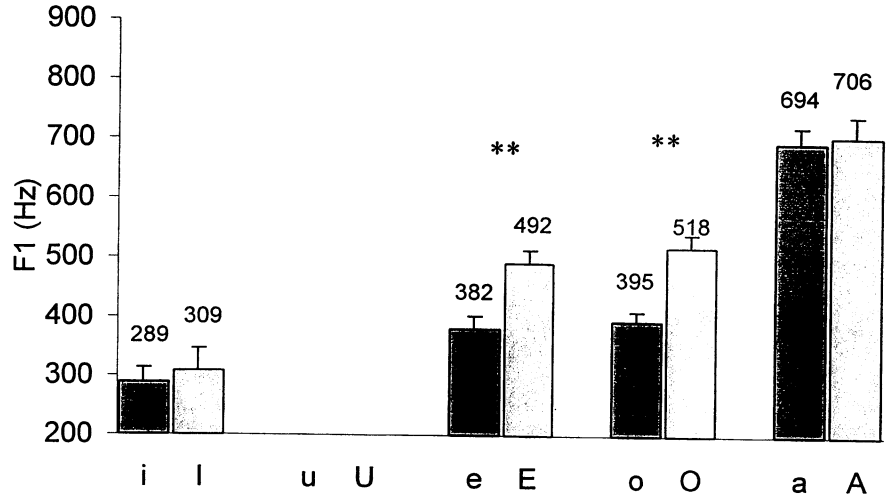

Figure 6. F1 Averages at V1 midpoint for SY speaker "SY1"; the small letters show the average of the vowels before +ATR /e/ and /o/; the capital letters show the average before –ATR /E/ and /O/. (Bars mark one standard deviation. ** indicates a statistical significance of $p < .01$ using a t-test; * indicates $p < .05$.)

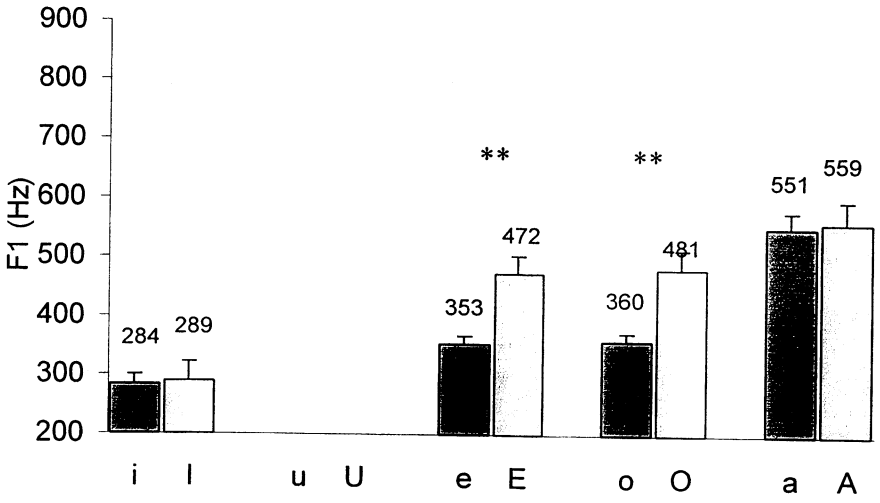

Figure 7. F1 Averages at V1 midpoint for SY speaker "SY8"; the small letters show the average of the vowels before +ATR /e/ and /o/; the capital letters show the average before –ATR /E/ and /O/. (Bars mark one standard deviation. ** indicates a statistical significance of $p < .01$ using a t-test; * indicates $p < .05$.)

4.4 Comparison of Average Values

Mid vowels patterned similarly in all speakers of three dialects. In the high vowels, Àkùrẹ́ showed the large robust differences we expected of allophones. In the high vowels for speakers of Mọ̀bà and SY, the differences found are much smaller, but in the same direction as those found for Àkùrẹ́. With the exception of Mọ̀bà speaker Mb9's /i/, none of the differences for Mọ̀bà and SY were statistically significant. In order to ascertain that the direction of the differences is statistically significant, I pooled together the data for the four speakers of the Mọ̀bà and SY dialects. Using an ANOVA to measure statistical significance (with two-factors, subject and ATR of V2), I found that for the F1 of V1 of /i/ in i̱Ceo versus i̱CEO showed a highly significant effect for ±ATR of V2 [$F(1, 20)$, $p < .01$]. /i/ and /u/ together also showed a significant effect for ±ATR of V2 [$F(1, 5)$, $p < .05$].[6] So although t-tests for individual speakers show that the direction of the coarticulation in high vowels for Mọ̀bà and SY is in general not significant, the results of the ANOVA show that it is significant when all the speakers are pooled, indicating that the coarticulation pattern we have observed is a general pattern of these speakers.

4.5 Individual Token Values

Until now, we have been looking at averages of F1. In the next few figures, we will look at F1 values for individual tokens. Figure 8 shows the F1 values for the first vowel midpoint for individual tokens of *ikẹ* (shown as *ikE*) and *ike* for the six speakers of the three dialects. Each mark indicates a single token.

[6] Because SY does not have initial /u/, and there were only two speakers of Mọ̀bà at this point in the study, an ANOVA for /u/ was not performed.

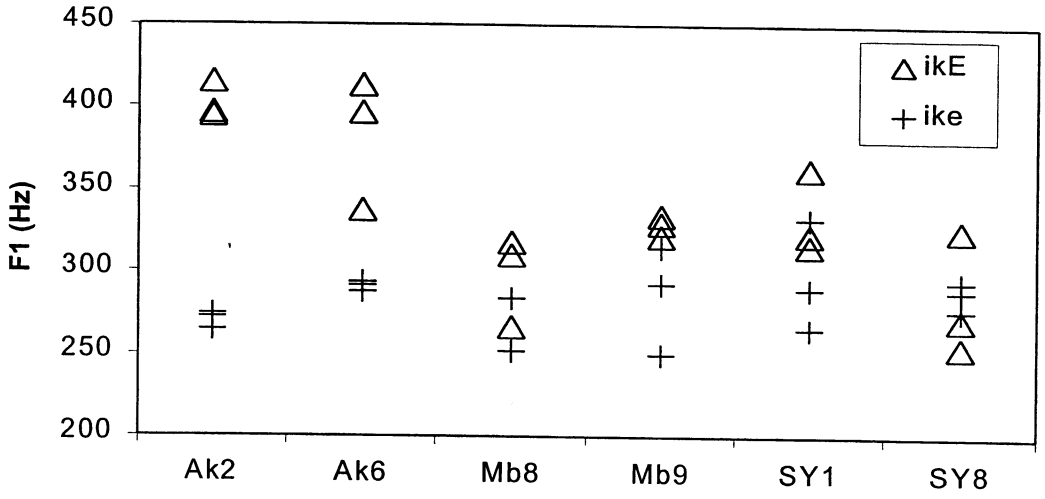

Figure 8. F1 values of individual tokens at the midpoint of V1 for *ikẹ* (*ikE*) and *ike* for speakers of Àkùrẹ́ (Ak2, Ak6), Mọ̀bà (Mb8, Mb9), and Standard Yorùbá (SY1, SY8).

From these charts, two clear generalizations emerge. First, for the Àkùrẹ́ speakers (Ak2 and Ak6), we can see that, as expected, +ATR [i] and –ATR [i] are categorically different, with no overlap between them; this contrasts with the Mọ̀bà and SY speakers, who show considerable overlap in the two types of tokens shown. That is, the high vowels of Àkùrẹ́ exhibit a qualitatively different pattern than those of Mọ̀bà and SY; Àkùrẹ́ high vowels are clearly distinct, enough to be considered as different phones—consistent with their description as allophonic variants—while Mọ̀bà and SY are not. Second, the high vowels of Mọ̀bà and SY, do exhibit a trend in the same direction as the Àkùrẹ́ vowels, with vowels preceding +ATR vowels having lower F1s than vowels preceding –ATR vowels. The ANOVA results from above (Section 4.4) corroborate this pattern. This same general pattern is also seen (with a few exceptions[7]) in Figure 9 for *iko* versus *ikọ*, and in Figure 10 for *uke* versus *ukẹ*.

[7] The exceptions seen here will be considered further in future work when more speakers have been investigated.

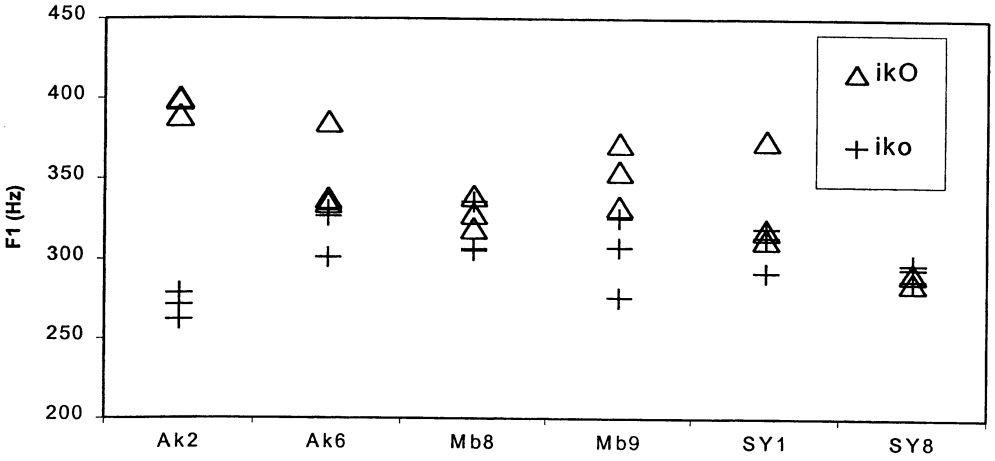

Figure 9. F1 values of individual tokens at the midpoint of V1 for *ikọ* (*ikO*) and *iko* for speakers of Àkùrẹ́ (Ak2, Ak6), Mọ̀bà (Mb8, Mb9), and Standard Yorùbá (SY1, SY8).

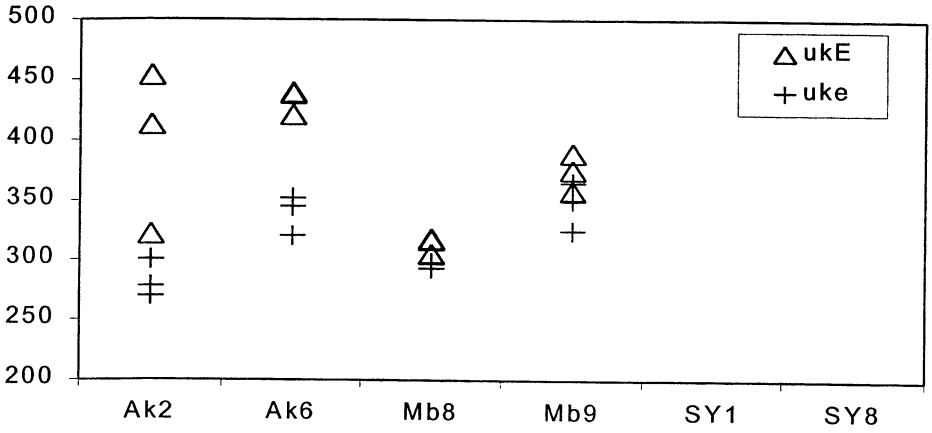

Figure 10. F1 values of individual tokens at the midpoint of V1 for *ukẹ* (*ukE*) and *uke* for speakers of Àkùrẹ́ (Ak2, Ak6), Mọ̀bà (Mb8, Mb9), and Standard Yorùbá (SY1, SY8). SY words can not start with /u/.

5 Discussion of findings

By examining the acoustics of high vowels in three dialects of Yorùbá, I have shown that while Àkùrẹ́ has phonological vowel harmony in the high vowels, Mọ̀bà and SY do not—the patterns of phonology and phonetics differ in terms of degree (amount of F1 difference) and robustness. However, the patterns of coarticulation in Mọ̀bà and SY resemble in direction the patterms of harmony in Àkùrẹ́. The phonological patterns must

be part of a speaker's grammar; however the coarticulatory patterns, at least in part, are not. While vowel-to-vowel coarticulation is certainly rooted in the physical interaction between the articulations of neighboring vowels, part of this coarticulation may be under the control of the speaker. In fact, in the data presented here, we observe a difference between the coarticulation of vowels in Mọ̀bà versus SY, with Mọ̀bà exhibiting greater coarticulation, suggesting that the degree of coarticulation is language specific, and thus under speaker control.[8]

The findings presented here suggest that ATR vowel harmony, like other phonological phenomena, has its origin in extra-grammatical phonetic effects (see Hyman 1976, Ohala 1995 and elsewhere, and Myers 1997); in this case, the vowel harmony in Àkùrẹ́ may have emerged from coarticulation in an earlier stage of Yorùbá.

In further studies, I will address these open questions: to what extent coarticulation occurs across word boundaries; how does progressive coarticulation compare with anticipatory coarticulation; and to what extent dialects differ in their degree of coarticulation.

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[8] Interestingly, the coarticulatory patterns shown for high vowels in Mọ̀bà and SY, are also found for the low vowel /a/ in all three dialects. All else being equal, we might expect that /a/ would exhibit phonological properties such as those found with high vowels. Future studies will examine this vowel closely.

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