Glides Harmonize, Too: Evidence from Akan Dialects[1]

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The language Akan exhibits the typologically rare occurrence of *labio-palatalization,* the formation of a secondary glide articulation that is characterized by simultaneous labial rounding and palatal constriction (de Jong & Obeng 2000). Labio-palatalization occurs in complementary distribution with *labialization*, the formation of a secondary glide articulation with labial rounding but without palatal constriction (Abakah 2004a). The distribution of these two glides varies between two major dialects: Akuapem Twi and Asante Twi, and the conditioning factors on the distribution of this surface articulation are not the same. For a given CVV sequence the factors that determine the place of the glide articulation may include the consonant's place of articulation, both vowel's places of articulation, and/or the initial vowel's specification for harmony according to Advanced Tongue Root (ATR). The analysis shows that the occurrence and distribution of labial and labio-palatal glides can be largely accounted for with alternate rankings of feature-specific OCP and AGREE constraints, including the positing of a new constraint for segment-internal place agreement. The results suggest that glides are sensitive to ATR vowel harmony conditions. Evidence for consonant harmony presents a potential challenge to the notion of underspecification and neutral segments in harmony processes.

1 Introduction

Akan[2] is well known for having vowel harmony according to the feature Advanced Tongue Root (±ATR) (Stewart 1967; Stewart 1971; Dolphyne 1988:14; O'Keefe 2003). In this paper I argue for the participation of glides in Akan vowel harmony as well. My evidence comes from an analysis of dialect-specific glide formation strategies for CVV sequences. The formation of secondary glide articulations on consonants in CVV sequences is a common feature of Kwa languages (see Welmers 1973:61; Leben 1999). *Labio-palatalization* (or *labial palatalization*, Abakah 2004a:142) refers to the formation of a glide with both labial rounding and palatal constriction (Westermann & Ward 1933/1957:106; Eshun 1993:180; de Jong & Obeng 2000). Labio-palatalization is the creation of a particularly strong "consonant-vowel overlap" such that the formant values of the vowel immediately following the consonant are measurable *before* the consonant closure (de Jong & Obeng 2000:689). In addition to glide

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[2] Akan is a Niger-Congo language of the Volta-Comoe group and the Tano subgroup (Stewart 1966; Stewart 1989; Williamson & Blench 2000), created by official language policy combining several related language varieties that now comprise dialects and 'subdialects' of Akan (Wolff 2000:340). It is spoken by approximately 10 million speakers, primarily in Ghana, Eastern Côte d'Ivoire, and Western Togo.

formation, Akan dialects differ depending on the phonological contexts in which labio-palatalization occurs. This difference provides evidence for the participation of glides in the vowel harmony system.

Two Akan dialect groups – Akuapem Twi and Fante (Akuapem) and Asante Twi (henceforth, Asante) – regularly differ in what contexts the *labio-palatal* glide, /ɥ/, is formed and in what contexts the *labial* glide, /w/, is formed (*i.e.*, *labialization*).[3] Together, labialization and labio-palatalization are often referred to jointly as the 'CUe/CUa' process (see Abakah 2004a), since both occur when, for any underlying CVV sequence:

i. consonant (C) is any unspecified consonant,
ii. first vowel (V_1) is always either /u/ or /ʊ/, and
iii. the second vowel (V_2) is always either /e/ or /a/.

Examples are given in (1), where the labio-palatal forms are highlighted in grey. A third Akan dialect, Elder Brong (a sociolect of the Brong dialect of Akan spoken by elderly people in the Brong-Ahafo region), displays no known glide formation in CVV contexts.

(1)

ELDER BRONG	AKUAPEM & FANTE	ASANTE	ENGLISH GLOSS
dua	dᶣia	dᶣia	'tree'
tue	tʷue	tᶣie	'to puncture'
tʊa	tᶣɪa	tʷʊa	'to join'
bʊa	bʷʊa	bʷʊa	'to help'

In Asante, the labio-palatal glide, [ɥ], occurs in CVV sequences where the underlying initial vowel (V_1) is [+ATR], *i.e.* /u/, whereas the labial glide, [w], occurs when the underlying V_1 is [-ATR], *i.e.* /ʊ/.[4] But in Akuapem, the labio-palatal glide targets *coronal consonants*, regardless of the ATR specification of V_1, and *only* when the *second* vowel (V_2) is equivalent to /a/ (the labial glide therefore occurs as the elsewhere glide).

According to this analysis, Asante assigns a glide's place feature just according to the ATR specification of the initial vowel, whereas Akuapem makes that assignment based on the place of the initial consonant and the place specification of the second vowel in the CVV

[3] There is a long-standing difficulty in phonological studies of the Kwa language in determining whether sequences are truly CVV or, rather, CWVV, because the evidence is not always clear (see Leben, 1999; cf. Welmers 1973). For the purposes of this analysis, I am relying on the data from Abakah (2004a), who does not address this potential variation in output forms in his analysis or discussion.
[4] See Appendix A for a complete description of the Akan vowel inventory.

sequence. In Asante, the glides appear to harmonize with vowels in terms of ATR agreement, and in Akuapem, glides appear to be subject to place constraints. Elder Brong is subject to high-ranked faithfulness. In the present paper, all three dialects are accounted for by different rankings of one constraint set.

2 Data

The complete data set of the distribution of labial and labial-palatal glides in 'CUe/CUa' contexts for the Elder Brong, Fante, Akuapem, and Asante dialects of Akan is given in Appendix B. The data for Fante, Akuapem, and Asante are taken, with only a few minor modifications, from Abakah (2004a:142-143; see also 2003 for Fante). The data for Elder Brong are based on an analysis by Dolphyne (1979), who shows that *all* Brong speakers at the time produced diachronically prior pronunciations of CVV sequences related to 'CUe/CUa.' Bota (p.c., 2006), supports Dolphyne's (1979) observation, but only among elderly speakers of the Brong dialect. The Elder Brong pronunciations also correspond to most early descriptions of Akan (Christaller 1875/1964; Christaller 1881/1933; Koelle 1854/1963).

A summary of the Akan dialect-specific labialization and labio-palatalization patterns, based on segmental features within a CVV environment, is given in (2). Forms with the secondary labio-palatal glide are highlighted in grey, and those with the secondary labial glide are left in white. The feature ±COR(ONAL) indicates whether or not the place of the underlying initial consonant, C(PL), is coronal, since this is one of the predictors for Fante and Akuapem glide formation. The column for V_1V_2 gives the underlying values of the first and second adjacent vowels, and ±ATR refers to the ATR specification of the first vowel, since this is the relevant predictor for Asante. The V_1V_2 candidate /ʊɛ/ does not occur in the data under consideration, for independent reasons. Finally, the V_1V_2 candidate /ʊe/ is not considered because the sequence is disharmonic for [ATR] and would never occur in any output form.

(2) Summary of Labialization and Labio-palatalization patterns in Akan[5]

C(PL)	V_1V_2 & ATR	E. BRONG	FANTE	AKUAPEM	ASANTE
+COR	-ue (+ATR)	-ue	-wei	-ʷue	-ᶣie
-COR	-ue (+ATR)	-ue	-wei	-ʷue	-ᶣie
+COR	-ua (+ATR)	-ua	-ᶣia	-ᶣia	-ᶣia
-COR	-ua (+ATR)	-ua	-ʷu(w)a	-ʷua	-ᶣia
+COR	-ʊa (-ATR)	-ʊa	-ᶣɪa	-ᶣɪa	-ʷʊa
-COR	-ʊa (-ATR)	-ʊa	-ʷʊ(w)a	-ʷʊa	-ʷʊa

A summary of the place of articulation conditions is given in (3). Features in bold are those relevant for determining the formation of the labio-palatal glide. Since Fante only differs from Akuapem in terms of vowel sequence resolution, the present paper will compare Akuapem to Asante, where Akuapem refers to both Fante and Akuapem.[6]

(3) Underlying Segmental Environments Correlating with Place of Glide

DIALECT GROUP	GLIDE FORMED	CVV ENVIRONMENT
Akuapem	**ɥ**	**C = coronal** V_1 = high, back, ±ATR **V_2 = /a/**
	w	*Elsewhere*
Asante	**ɥ**	C = any **V_1 = high, back, +ATR** V_2 = any
	w	*Elsewhere*

Clearly, the place of articulation of the glide, whether labial or labio-palatal, is not transparently predictable across all dialects by simply considering the places of articulation of the initial consonant and the initial vowel. The two dialect groups appear to refer to

[5] There are two sites of dialect variation given in (2): the place of articulation of the glide, which is the primary focus of this analysis, and the resolution of the V_1V_2 sequence after glide formation, which is a secondary consideration; the vowel sequence differences that appear for the /e/-final sequences in Fante will not be addressed in the present analysis.

[6] In previous studies, the difference between full glide epenthesis on the one hand (e.g., Abakah 2003) and the formation of a secondary glide articulation on the initial consonant (e.g., Dolphyne, 1988) is only a difference in transcription. No difference in their phonological status has been proposed. Phonetically, the more accurate representation is of a secondary articulation on the initial consonant, so the transcription given here (of a raised glide character) represents this fact.

different segmental features to determine the place of articulation for the glide. The central goal of this paper is to account for this variation as summarized in (3).

3 Analysis

To give an OT account of the Akan glide formation dialect data, the constraint ranking for Akuapem must be different from the ranking for Asante. This analysis aims to account for the following two puzzles: First, what constraints motivate Akan glide formation in the first place? And second, what constraint rankings capture the differences in glide formation between the Asante and Akuapem dialects? I argue that the first question is best answered by paying close attention to the phonetic detail of glide formation, and that the second question is resolved by recognizing that secondary glide articulations are either sensitive to ATR harmony, or to consonant position and OCP-place restrictions.

3.1 Motivating Glide Formation

I propose that the constraint that motivates glide formation should be based on the phonetic realization of labio-palatalization given by de Jong and Obeng (2000; see also Westermann & Ward 1933/1957). Articulatory evidence (from palatography) and acoustic evidence (from formant analyses) of native Akan speakers showed greater-than-typical coarticulation between initial consonants and vowels, with particularly increased coarticulation for coronal consonants and their following vowels. In other words, labio-palatalization in Akan correlates with the creation of a particularly strong "consonant-vowel overlap" (de Jong & Obeng 2000:689), such that the formant values of the vowel immediately following the consonant were measurable even *before* the consonant closure (when the consonant had the labio-palatal secondary articulation and when the following vowel was high). Therefore, "labialization and palatalization are an integrated unit in the synchronic system, and not just a chance temporal convergence of two independent articulations" (de Jong & Obeng 2000:692). This early timing overlap from the following vowel onto the preceding consonant is seen as responsible for the secondary labio-palatal articulation. Phonetically speaking, the motivation for glide formation appears to be a markedness constraint that selects for candidates with increased coarticulation in certain environments. In Articulatory

Phonology, labio-palatalization could be described as a prime example of gestural overlap (Browman & Goldstein 1992).

De Jong and Obeng (2000) provide ample evidence for a historical development whereby certain vowel place features become a part of the place features of the preceding consonant. Historically, "[e]xactly why languages might differ in general timing of consonantal and vocalic gestures is not very well understood at present, and is a pressing direction for future research" (de Jong & Obeng 2000:698). But synchronically, an analysis of labialization and labio-palatalization need only state the generalization for why glide formation might happen. Since glide formation has been shown to occur as the result of shared timing slots between the consonant and the vowel, the motivation for glide formation can be expressed as an AGREE constraint (Bakovic 2000), with consonantal and vocalic features motivated to agree in some given feature.

As typologically expected, secondary glide articulations form on stops, fricatives, or nasals, but never on another glide. By acquiring this secondary articulation, the consonant undergoes a change in manner, acquiring the feature [+VOCALIC].[7] Since vowels are always [+VOCALIC], I propose that some aspect of Akan phonology motivates glide formation by the constraint AGREEVOCALIC, given in (4a).[8] AGREEVOCALIC interacts with the faithfulness constraints IDENTCONSONANT (IDC), given in (4b), and potentially with IDENTVOWEL (IDV), given in (4c), in that both constraints preserve underlying forms for the features [consonantal] and [vocalic].[9] IDC is always dominated by AGREEVOCALIC in Asante and Akuapem while IDV is a high-ranking, undominated constraint in all Akan dialects.

(4a)	AGREEVOCALIC (AGRVOC):	Any adjacent segments must agree in the feature [±VOCALIC]
(b)	IDENTCONSONANT (IDC):	Output correspondents of an input plain consonant are also plain consonants
(c)	IDENTVOWEL (IDV):	Output correspondents of an input vowel are also vowels

[7] Clearly, the articulated consonant does not actually become a full glide, but only acquires a glide-like feature.
[8] This agreement of the feature [Vocalic] is similar to the spreading of the feature [Continuant] as discussed for palatalization by Jacobs (1989) and argued against by Lahiri and Evers (1991:91). However, the feature [Vocalic] captures the change from a plain stop to a stop with a glide articulation; the feature [Continuant] could be satisfied by a change from a plain stop to an affricate. This fact may be important for the analysis of palatalization discussed in the Future Directions section given in §5.
[9] Based on the IDENT(F) constraint family; McCarthy & Prince 1995:16

(5) <u>Asante & Akuapem Ranking: IDV, AGRVOC >> IDC</u>

	IDV	AGRVOC	IDC
tue, 'to puncture'			
1. tue		*!	
2. twe	*!	*	
3. ☞ t^wue			*

As shown in (5), AGREEVOCALIC will render fatal all candidates with plain consonants. Since the Elder Brong dialect does *not* form secondary glide articulation, AGREEVOCALIC must be a constraint subject to dialect-specific rankings.

So, why is AGREEVOCALIC the right constraint for glide formation in CVV sequences? Abakah (2003:57) states that the environment for glide formation is just "when two nonidentical vowels occur in a sequence." The implication is that there is some specific difference between adjacent vowels that motivates glide formation, but Abakah (1993; 2003; 2004a) does not specify the nature of this difference. It is not a difference in ATR specification, since ATR vowel harmony always exists in all CVV sequences, and glide formation could not improve on ATR specification. Nor is it a height difference between the two vowels, because output forms with labio-palatal glides always remain faithful to the height difference between V_1 and V_2 that was in the underlying representation (in the dialects examined here). Any constraint like AGREEHEIGHT or *HEIGHTDIFF would always rule out both the fully faithful candidate as well as the winning candidate.

One regular feature of the labio-palatalization process is that initial vowels, while staying [+high], front and become unrounded, perhaps transferring the quality of roundness (or labiality) to the resultant labio-palatal glide. So, perhaps the motivation for glide formation is due to a difference in roundedness between an initial rounded vowel and the following unrounded vowel. A markedness constraint capturing this intuition would be AGREEROUND or *ROUNDDIFF. But while this constraint seems to hold for the labial-palatalization process, where the formation of /ɥ/ results in the production of /u/ as the unrounded /i/, there are a few problems with its application to the process of glide formation in general. First, in the process of labialization a labial glide articulation, /w/, is always formed while leaving the roundness of the initial vowel intact, /u/, i.e., without resolving the underlying difference in roundedness between the two vowels. Second, there is a process unique to the Fante dialect whereby the palatal glide, /j/, is formed in a CVV context where both vowels are underlyingly unrounded (e.g., /fiew/ → [f^{j}iew]). It seems that CVV glide formation cannot be motivated by the roundness or labiality difference between the two vowels.

Rather than a difference between the two vowels, AGREEVOCALIC motivates glide formation based on a difference between the consonant and the initial vowel. In fact, Abakah (1993) formulates a rule for labialization (and labio-palatalization) in a very similar way. Rather than the consonant acquiring the feature [Vocalic], he states a rule for a process whereby a consonant acquires the roundness of a following vowel if that vowel is specified as [+Round] (Abakah, 1993:148). So, perhaps AGREEROUND *is* a more appropriate constraint than AGREEVOCALIC to motivate glide formation. However, while implementing the constraint AGREEROUND obtains the winning candidate for labialization, the application is problematic for labio-palatalization, as shown in (6).

(6) The failure of AGRRND to select the winning candidate, [t^{ɥ}ia]

	IDV	AGRRND	IDC
tua, 'to apply suppository'			
1. tua		*!	
2. 💣 t^{ɥ}ua			*
3. (☞) t^{ɥ}ia		*!	*

While the process of labialization creates a rounded consonant followed by a round vowel, the process of labio-palatalization creates a rounded consonant followed by an *unrounded* vowel, /i/ (according to Abakah 2004a). My analysis of these facts is given in the analysis in §3.2.1. For now, the point is that the facts for labio-palatalization would never be captured by AGREEROUND. Abakah's (1993; 2004a) ordered-rule analyses can account for this problem by positing a rule that applies *after* the labialization rule (*i.e.*, AGREEROUND) and fronts and un-rounds the vowel. This analysis will be discussed further in §4, but the bottom line is that a sequential explanation is not possible in a parallel OT analysis. Therefore, AGREEVOCALIC must be the relevant constraint to motivate glide formation.

Once glide formation is motivated, a couple other constraints are needed to select the correct output form across both glide-forming Akan dialects. In both Asante and

Akuapem, a round vowel in the input never co-occurs with an unrounded glide in the output, *i.e.,* *[tʲia] is an impossible output of an input, /tua/, even though the similar form, [tᶣia], is possible. The constraint IDENT[ROUND] given in (7) eliminates any candidates that change in their specification for [±Round].

(7) IDENT[ROUND] (ID[RND]): Output correspondents of an input specified for roundedness will maintain the same roundedness specification.

But although labiality is always preserved, it is not necessarily preserved on the underlying labial vowel, as the winning candidate [tᶣia] shows. In fact, in the process of labio-palatalization, the initial vowel categorically loses its labiality; /u/ always unrounds to [i] and /ʊ/ always unrounds to [ɪ]. [10] Consequently, the labio-palatal glide /ɥ/ only co-occurs with front, unrounded vowels. In other words, in both Asante and Akuapem, output forms like *[tᶣue] are never optimal, and [tᶣie] always wins. IDENT[ROUND] must be dominated by a markedness constraint that captures that fact.

(8) AGREEPLACE$_{\text{ONSET-NUCLEUS}}$ (AGRPL$_{\text{ON}}$): Any syllable onset must agree with the place assignment of that syllable's nucleus vowel

In (8) I propose another AGREE constraint, AGREEPLACE$_{\text{ONSET-NUCLEUS}}$ (AGRPL$_{\text{ON}}$). AGRPL$_{\text{ON}}$ simply enforces place agreement between onset consonants and their syllabic nuclei. AGRPL$_{\text{ON}}$ captures the fact that Akan places different demands for agreement on onset-nucleus pairs than nucleus-nucleus pairs. In other words, to posit a general AGREEPLACE constraint applying to all adjacent segments would not only select for the incorrect output candidate but would misrepresent the patterns in the language, since there is no evidence for nucleus-nucleus place agreement. Further support for a constraint like AGRPL$_{\text{ON}}$ is that it is a more general way to capture the process of Akan *palatalization,* analyzed in McCarthy and Prince (1995). To analyze data where underlying velar stops preceding front vowels (*e.g.,* [ki]) palatalize (*e.g.*, [tçi]), McCarthy and Prince posit a constraint,

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[10] This fact is controversial (Leben, p.c.), and should be subject to phonetic confirmation from empirical evidence, *e.g.*, from a close analysis of the vowel formant values between the glide and the low /a/. For the present paper, I assume Abakah's (2004a; p.c.) phonetic description of the initial vowel fronted to /i/.

PAL, which enforces palatalization. AGRPL$_{ON}$ does the same work as PAL but is more a general statement of the constraint.

The feature PLACE in AGRPL$_{ON}$ refers to the Articulator Theory of place that makes a three way distinction between LABIAL, CORONAL, and DORSAL where CORONAL subsumes both [+coronal] and [+palatal] features (see Clements & Hume 1995). CORONAL basically correlates with the feature [-grave], and DORSAL with [+grave] (Jakobson, Fant, & Halle 1963). CORONAL segments include plain coronal consonants, all consonants with labio-palatal glide articulations, and front vowels.[11] Crucially, labial glides are not coronal, even if they appear as secondary articulations on otherwise coronal consonants. So, coronal consonants with labial glides ([t^{w}]) are evaluated as –CORONAL, and agree in place with vowels that are LABIAL and DORSAL, *i.e.*, round, back vowels.

(9) Asante & Akuapem Ranking: AGRPL$_{ON}$ >> ID[RND] >> IDC

	AGRPL$_{ON}$	ID[RND]	IDC
tua, 'to apply suppository'			
1. $t^{ɥ}$ua	*!		*
2. t^{j}ia		*!	*
3. ☞ $t^{ɥ}$ia			*

The constraint ranking in (9) selects the correct candidate in both Asante and Akuapem dialects. Although the winning candidate violates ID[RND], a higher ranked AGRPL$_{ON}$ constraint eliminates the losing candidate that retains labiality on the initial vowel. In other words, AGRPL$_{ON}$ enforces that [ɥ] co-occurs with [i] and [ɪ] and that [w] co-occurs with [u] and [ʊ], as claimed by Akabah (2004a; but questioned by Leben, p.c.).

One remaining question about Akan glide formation generally speaking is how the two standard faithfulness constraints, MAX (no phonological deletion) and DEP (no phonological epenthesis; McCarthy & Prince 1995:16) are ranked vis-à-vis AGRVOC. A common description of 'CUe/CUa' is that a glide is *epenthesized* in between the initial consonant, 'C' and the initial vowel, 'U'. Under this interpretation, AGRVOC would dominate DEP (and MAX would presumably dominate both constraints). But under a

[11] This interpretation is in contrast to Shaw (1991) who argues that the feature [Coronal] applies exclusively to consonants.

phonetic description of 'CUe/CUa,' a glide articulation is shared with the initial consonant: the gesture of that consonant changes, but there is no – strictly speaking – epenthetic glide.[12] Thus, under a phonetic interpretation, MAX and DEP are both high-ranking, undominated constraints. And according to a third description (Schachter & Fromkin 1968), a glide forms and the initial vowel *deletes*, thereby indicating the need for AGRVOC to dominate MAX, and leaving the ranking of DEP unclear. The point is that the rankings of MAX and DEP are dependent on one's theory of representation. For present purposes, I treat glide-formation as a change in consonant gesture, and therefore rank MAX and DEP high and undominated.

Finally, are all of these constraints specific to CVV sequences, or does glide formation occur in CV contexts as well? All Akan dialects have been commonly described as having CV sequences where glide articulations do *not* form (see Dolphyne 1988). Yet the presence of a secondary articulation on initial consonants in CV contexts is still an empirical question, and the need for a constraint to account for differences between CVV and CV contexts stands to be empirically motivated with evidence beyond the scope of the present paper. The facts for CV sequences are especially relevant for future research on glide formation because of copious evidence that velar consonants in CV contexts generally undergo other processes of secondary articulation, such as palatalization before high front vowels (Schachter & Fromkin 1968; McCarthy & Prince 1995; Silverman 2002; Abakah 2004b; Dolphyne p.c.). For present purposes I will assume that there is some secondary articulation of the consonant's gesture even in CV sequences, and that there is, at present, no need to posit constraints that are unique to CVV sequences.

3.2 Accounting for the Dialect Differences

The additional facts about the 'CUe/CUa' process that need to be accounted for are the dialect-specific differences between realizing the labial glide articulation, /w/, and the labio-palatal glide articulation, /ɥ/. As stated in §1, in Asante, /ɥ/ occurs with +ATR initial vowels (V_1) and /w/ occurs with –ATR V_1. In Akuapem, /ɥ/ occurs with [+Coronal] consonants, regardless of the ATR specification of V_1, and *only* when the second vowel (V_2) is equal to /a/. Phonetically, there is a gesture shared between [+Coronal] consonants,

[12] It has been argued (Abakah, p.c.) that the Fante dialect has a full epenthetic glide where the Twi dialects have secondary glide articulations.

+ATR vowels, and labio-palatal glides: a raised and fronted tongue body. Any analysis for determining glide choice phonetically would benefit from accounting for this articulatory fact. But phonologically, the dialects rely on either the consonant's place of articulation or the vowel's ATR specification, and not both. The goal of this section is to account for this difference in predictors by positing two dialect-specific rankings for the same subset of universal constraints.

3.2.1 Asante Twi

Since a vowel's ATR specification is the only conditioning factor for the choice of the labio-palatal glide in Asante, the constraint accounting for this correlation must be framed in terms of ATR.[13] +ATR vowels and palatal consonants have in common some kind of generally advanced tongue position, and an ideal constraint should model this articulatory dependency (McCarthy & Taub 1992; Flemming 2003). Additionally, when /ɥ/ occurs as a full glide (rather than as a secondary articulation, here) it always co-occurs with vowels that are underlying specified as [+ATR]. Since glides are essentially considered weightless vowels, I propose that glides can participate in Akan vowel harmony, and that /ɥ/ is a glide that is specified as +ATR. Based on the fact that Akan has robust ATR vowel harmony within and between morphemes (Stewart 1967; Dolphyne 1967; Stewart 1983; Dolphyne 1988; O'Keefe 1993), positing ATR harmony between glides and vowels – or onsets and nuclei – seems reasonable. However, while the ranking of a constraint that imposes harmony between onsets and nuclei will vary between dialects (dominating in Asante, dominated in Akuapem), vowel harmony – harmony between two syllable nuclei – is always undominated in all Akan dialects. Therefore, I propose here a weaker notion of harmony, in that there are two kinds, given in (10).

(10a) AGREE[ATR]$_{\text{ONSET-NUCLEUS}}$ (AGR[ATR]$_{\text{ON}}$): Any syllable onset must agree with that syllable's nucleus in the feature [±ATR]

(b) AGREE[ATR]$_{\text{NUCLEUS-NUCLEUS}}$ (AGR[ATR]$_{\text{NN}}$): Any syllable nucleus must agree with any adjacent syllable nucleus in the feature [±ATR]

[13] The ATR value of an underlying segment is one potential conditioning factor; another is the value [±labial] of the output segment; which feature conditions labio-palatalization is an open question. My analysis assumes that it is necessary to motivate output forms based on underlying representations, but a different approach could motivate agreement between segments in an output form (see Future Directions discussion, §5).

(c) IDENT[ATR] (ID[ATR]): Output correspondents of an input specified for the feature ATR will maintain the same ATR specification.[14]

The evaluation of these constraints in Asante is shown in the tableaux in (11); only candidates that exemplify the constraints under discussion are included. The vowel /a/ is considered neutral with regard to [±ATR].[15]

(11) Asante Ranking: AGR[ATR]$_{NN}$, AGR[ATR]$_{ON}$ >> ID[ATR]

	AGR[ATR]$_{NN}$	AGR[ATR]$_{ON}$	ID[ATR]
tue, 'to puncture'			
1. t^{w}ʊe	*!		*
2. $t^{\text{ɥ}}$ɪe	*!		*
3. t^{w}ue		*!	
4. ☞ $t^{\text{ɥ}}$ie			
tua, 'to apply suppository'			
5. t^{w}ʊa			*!
6. $t^{\text{ɥ}}$ɪa		*!	
7. t^{w}ua		*!	
8. ☞ $t^{\text{ɥ}}$ia			
tʊa, 'to join'			
9. ☞ t^{w}ʊa			
10. $t^{\text{ɥ}}$ɪa		*!	
11. t^{w}ua		*!	
12. $t^{\text{ɥ}}$ia			*!

In Asante, the constraint that selects for labio-palatalization vis-à-vis labialization is formulated as the crucially high-ranked AGREE constraint AGR[ATR]$_{ON}$. The corresponding constraint that selects for candidates with ATR harmony between vowel nuclei, AGR[ATR]$_{NN}$, is evaluated in the same way as the AGR[ATR] constraint proposed by Bakovic (2003). The constraint that would militate against either or both of the constraints in (10a) and (10b) is IDENT[ATR], given in (10c), which states that every segment should

[14] A different formulation of IDENT[ATR] is the set of constraints suggested by Casali 2003:316, MAX[-ATR] and MAX [+ATR], based on cross-linguistic evidence. The difference is not relevant for the present analysis, but may constitute a better implementation.
[15] To understand the tableaux, the reader may find it useful to consult Appendix A for a complete listing of [+ATR] and [-ATR] vowels. Crucially, /a/ is considered unspecified for the feature [±ATR].

maintain its underlying ATR specification. My evaluation of IDENT[ATR] is identical to Bakovic's (2003) IO-IDENT[ATR].

Since vowel harmony always resolves and is never trumped by the underlying ATR identity of the segment (in other words, since there is never a disharmonic output), IDENT[ATR] is always dominated by $AGR[ATR]_{NN}$, even in the fully faithful Elder Brong dialect. Since the place assignment in Asante glide formation is completely determined by harmony between the glide and the following vowel, $AGR[ATR]_{ON}$ also must outrank IDENT[ATR] in Asante. But as the data in §3.2.2 shows, the ranking of IDENT[ATR] is equal to that of $AGR[ATR]_{ON}$ in Akuapem; both constraints are low-ranked.

Considering an input sequence that has a non-harmonic vowel sequence illustrates the need for positing separate AGR[ATR] constraints. There are no CVV output sequences in Akan of the form /-ʊe/, since /ʊ/ is always –ATR and /e/ is always +ATR, and two adjacent vowels must agree in [±ATR]. But, /-ʊe/ must exist in the input if we assume a universal set of possible inputs. The tableaux for its evaluation are given in Appendix C for both Asante and Akuapem dialects. Bringing the undominated constraint $AGR[ATR]_{NN}$ into the tableaux accounts for the selection of the winning output candidate. This hypothetical example highlights the need for positing two separate harmony constraints: a strong constraint for harmony between nuclei, and a weaker constraint for harmony between onset and nucleus.

3.2.2 Akuapem Twi

Although Akuapem shares virtually identical ATR vowel harmony patterns with Asante, Akuapem does not rely on any ATR-based constraint to determine the place of articulation of the glide. Instead, the labio-palatal glide articulation forms according to the place feature of the initial consonant, targeting only coronal consonants. To account for this difference, I posit that there is a general constraint that accounts for the agreement of place features between underlying consonants and their secondary glide articulations. This constraint, given in (12), enforces harmony *within* the components of any complex consonant.

(12) $AGREEPLACE_{SEGMENT}$ ($AGRPL_{SEG}$): Any distinct articulations internal to a single segment must agree in place.

(13) Akuapem Ranking: ID[RND], AGRPL$_{SEG}$ >> AGR[ATR]$_{ON}$

	ID[RND]	AGRPL$_{SEG}$	AGR[ATR]$_{ON}$
tʊa, 'to join'			
1. tʲɪa	*!		
2. tʷʊa		*!	*
3. ☞ tᶣɪa			*

Like AGRPL$_{ON}$, given earlier to account for a general Akan requirement for place agreement between onsets and nuclei, AGRPL$_{SEG}$ refers to another general place agreement that captures a critical fact about the Akuapem dialect. AGRPL$_{SEG}$ is also motivated by evidence from the general phonotactics of complex segments in Akan. Aside from consonants with secondary glide articulations, the only other complex segments in Akan, across dialects, are pre-nasalized voiceless stops. The secondary nasal articulation on these stops always shares (indeed, assimilates to) the place feature of the stop consonant. This fact supports the idea that complex segments in Akan are prone to sharing PLACE features between the primary and secondary articulations of a complex segment.

Although the constraint AGRPL$_{SEG}$ is motivated by general Akan phonotactics, it is subject to dialect-specific rankings. In Asante, the output [tʷʊa] is the winning candidate even though the segment [tʷ] violates AGRPL$_{SEG}$ (the candidate nonetheless wins because glide formation in Asante only looks at the ATR value of the first vowel). So in Asante, AGRPL$_{SEG}$ is dominated by AGR[ATR]$_{ON}$, but in Akuapem, the ranking is reversed.

However, the place of articulation of the consonant is a motivation of Akuapem glide formation that is evaluated conjointly with the place of articulation of the second vowel. So, since labio-palatalization does not apply categorically in the context of initial coronals in Akuapem, AGRPL$_{SEG}$ is still dominated even in Akuapem by another markedness constraint that disallows labio-palatalization in CVV contexts where the second vowel is /e/. In other words, we need a constraint that insures that /ɥ/ does *not* occur in post-coronal environments in 'CUa/CUe' sequences that are 'CUe'. This distant interaction across segments implicates a constraint on some feature shared by the elements in sequence. To capture this, I refer to a place-specific OBLIGATORY CONTOUR PRINCIPLE (OCP) constraint that militates against the co-occurrence of coronal segments in successive syllables.[16] This is stated in (14).

(14) OCP(+cor): Co-occurrence of coronals in successive syllables is prohibited.

McCarthy and Prince (1995:94) first posit OCP(+cor) to account for exceptions to the somewhat different process of Akan palatalization in the environment of velar stops followed by high vowels. Although OCP constraints commonly apply to single constituents, such as feet or syllables, McCarthy and Prince apply OCP(+cor) between constituents. I share this interpretation for the analysis of labio-palatalization, shown in (15).

(15) Labio-Palatalization and the OCP

(a) t^{w}*ue* vs. *$t^{ɥ}$*ie*

```
i. AGRPL_SEG violated          ii. OCP(+cor) violated
☞ tʷ   u     e                 * tᶣ   i      e
             |                     \  /       |
           +cor                    +cor     +cor
            -ant                    -ant     -ant
```

(b) *t^{w}*ua* vs. $t^{ɥ}$*ia*

```
i. AGRPL_SEG violated          ii. OCP(+cor) obeyed
* tʷ   u     a                 ☞      tᶣ   i    a
                                        \  /
                                        +cor
                                         -ant
```

In Akuapem sequences with final /e/, OCP(+cor) is violated and blocks labio-palatalization. [–Coronal] segments, such as /a/, do not participate in the evaluation of OCP(+cor). Note that the evaluation of OCP(+cor) contrasts with the evaluation of AGRPL$_{ON}$, which looks at the coronality of adjacent segments. For this reason, AGRPL$_{ON}$ and OCP(+cor) are not crucially ranked against one another. This is shown in (16).

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[16] Coronality is not necessarily the crucial factor that differentiates /e/ from /a/, here. In §5, in the discussion of future directions, I entertain alternative analyses.

(16) Akuapem Ranking: AGRPL$_{ON}$, OCP(+COR) >> AGRPL$_{SEG}$

	AGRPL$_{ON}$	OCP(+cor)	AGRPL$_{SEG}$
tue, 'to puncture'			
1. tᶣue	*!		
2. tᶣie		*!	
3. ☞ tʷue			*
tua, 'to apply suppository'			
4. tᶣua	*!		
5. ☞ tᶣia			
6. tʷua			*!

For the Akuapem data, AGRPL$_{ON}$ and OCP(+cor) both crucially outrank AGRPL$_{SEG}$ to allow for winning candidates of the form [tʷue]. This constraint ranking captures the generalization that the presence of a final [+coronal] vowel, *i.e.* /e/, prevents the formation of the [+coronal] glide, /ɥ/, despite the presence of an initial coronal consonant. The generalization about labio-palatal glide distribution in Akuapem is achieved by reference to a general property of Akan phonology whereby two articulations of a single consonant must have the same PLACE specification, and restrictions are placed on the occurrence of dissimilar, adjacent constituents both marked as [+coronal].

The OCP(+cor) constraint raises questions about the unmarked status of the feature [Coronal] (Paradis & Prunet 1991; Kiparsky 1994), suggesting instead that coronals may need to be specified for tongue-body features (see Flemming 2003). Fix (2003) in fact argues that the OCP cannot be specified for the feature [coronal] because of the prohibition on applying OCP to adjacent unmarked segments (Itô & Mester 1998). McCarthy and Prince (1995) appear to circumvent this potential contradiction by assigning violations to adjacent dissimilar constituents, rather than segments. The application of OCP(+cor) to both their palatalization data and the labio-palatalization data presented here may call into question the unmarked status of coronal segments, as raised by Lombardi (2002). On the other hand, perhaps OCP-Coronal is standing in for a more general constraint that will emerge from further analyses of additional CVV data (see §5).

3.3.3 Elder Brong

In addition to Akuapem, Asante, and Fante, another dialect of Akan is the *Brong*, or *Bono* dialect, spoken in the Brong-Ahafo region in the northernmost part of the Akan-speaking region of Ghana. Dolphyne (1979) gives a very brief discussion of the Brong phonological system, and presents no data on 'CUe/CUa' sequences. However, Dolphyne does show the lack of palatalization in CVV sequences where V_1 is a high front vowel. Based on this evidence, and the data from Stewart (1966; see also Koelle 1854/1963), Dolphyne concludes that "as far as /h/ in these examples is concerned the Brong dialects have retained an older form of the Akan language" because they do not undergo palatalization before high front vowels as found in all other Akan dialects (1979:90). Since palatalization is closely related to labio-palatalization and labialization, I infer that Brong also retains initial plain contexts in other CVV sequences. This is supported by Bota (p.c. 2006), but only for the speech of *elderly* Brong speakers.[17] So, in the sociolect I'll call Elder Brong, the output production of any CVV sequence is equivalent to the fully faithful candidate: glide formation does not occur. No additional constraints are needed to account for Elder Brong, only the promotion of IDENTCONSONANT, shown in the next section.

3.3 Summary of Constraint Rankings

The constraints given to account for Akan glide formation and that glide's place of articulation are restated in (17).

(17) Summary of Constraints

<u>*Markedness Constraints*</u>

AGRVOC	Any adjacent segments must agree in the feature [±VOCALIC]
AGRPL_{ON}	Any syllable onset must agree with the place assignment of that syllable's nucleus vowel
AGR[ATR]_{ON}	Any syllable onset must agree with that syllable's nucleus in the feature [±ATR]
AGR[ATR]_{NN}	Any syllable nucleus must agree with any adjacent syllable nucleus in the feature [±ATR]
AGRPL_{SEG}	Any distinct articulations internal to a single segment must agree in place.
OCP(+cor)	Co-occurrence of coronals in successive syllables is prohibited.

[17] Data on middle-aged and young Brong speakers is, at present, only available in Ghana. One future direction of research is to obtain these analyses and data for integration into the present analysis.

Faithfulness Constraints

IDC	Output correspondents of an input with a plain consonant are also plain consonants
IDV	Output correspondents of an input vowel are also vowels
ID[RND]	Output correspondents of an input specified for roundedness will have the same roundedness specification
ID[ATR]	Output correspondents of an input specified for the feature ATR will have the same ATR specification

Among the markedness constraints, AGR[ATR]$_{NN}$ (the stronger of the two harmony constraints) is always ranked high and is always undominated. Among the faithfulness constraints, IDV is also always undominated. All the other constraints given here participate in crucially different rankings that determine the dialect-specific facts. The dialect-specific constraint rankings are given in (18-20), and the full tableaux are given in Appendix C.

(18a) Asante Twi Ranking for 'CUe/CUa'

AGR[ATR]$_{NN}$, IDV, AGRVOC, AGR[ATR]$_{ON}$, AGRPL$_{ON}$, ID[RND]
>> ID[ATR], AGRPL$_{SEG}$, OCP(+cor), IDC

(b) Crucial Constraint Ranking: Asante

	AGR[ATR]$_{ON}$	AGRPL$_{SEG}$	OCP(+cor)
tʊa, 'to join'			
1. ☞ tʷʊa		*	
2. tᶣɪa	*!		
tue, 'to puncture'			
1. ☞ tᶣie			*
2. tʷue	*!	*	

Taken as a single class, the three high-ranked AGREE constraints and ID[RND] account for the formation and distribution of labial and labio-palatal glides in Asante, eliminating all undesired candidates. ID[ATR], AGRPL$_{SEG}$, OCP(+cor), and IDC are all crucially low-ranked in Asante.

The constraint ranking in (19) gives an account for glide formation in Akuapem Twi. In contrast to Asante, AGRPL$_{SEG}$, and OCP(+cor) are promoted and crucially outrank AGR[ATR]$_{ON}$. In addition, these promoted constraints are crucially ranked against one another. Although AGRPL$_{SEG}$ captures the fact that labio-palatal glides target coronal consonants, their assignment can be trumped by an evaluation of OCP(+cor), so the latter dominates AGRPL$_{SEG}$.

(19a) Akuapem Twi Ranking for 'CUe/CUa'

AGR[ATR]$_{NN}$, IDV, AGRVOC, AGRPL$_{ON}$, ID[RND], OCP(+cor)
>> AGRPL$_{SEG}$
>> ID[ATR], AGR[ATR]$_{ON}$, IDC

(b) Crucial Constraint Ranking: Akuapem

	OCP(+cor)	AGRPL$_{SEG}$	AGR[ATR]$_{ON}$
tʊa, 'to join'			
1. tʷʊa		*!	
2. ☞ tᶣɪa			*
tue, 'to puncture'			
1. tᶣie	*!		
2. ☞ tʷue		*	*

While some of the constraints for Asante are important for the Akuapem phonology, the dialect differences are achieved by the promotion of two constraints and the demotion of one. AGR[ATR]$_{ON}$ is now dominated by all the other markedness constraints, which now crucially includes OCP(+cor) and AGRPL$_{SEG}$. The promotion of the two markedness constraints accounts for the fact that Akuapem has an entirely different set of predictors than does Asante. Since OCP(+cor) checks the power of AGRPL$_{SEG}$, the latter is dominated by the former, even though both are active in the selection of the Akuapem candidates.

(20) Elder Brong Ranking for 'CUe/CUa'

IDENTCONSONANT & IDENTVOWEL
>> ALL MARKEDNESS CONSTRAINTS

For Elder Brong productions of CVV sequences, IDC is promoted over all the markedness constraints that were active in the Asante and Akuapem grammars. In addition, IDV becomes necessary for selecting [tua] over [twa], although that constraint is not subject to any new or different ranking vis-à-vis its ranking in the Asante and Akuapem grammars. Interestingly, the analysis of Elder Brong basically amounts to an analysis of Proto-Akan, accounting for the existence of plain consonants in CVV sequences prior to the historical change of secondary glide formation. The modern-day presence of a fully-faithful sociolect such as Elder Brong is a useful tool for understanding how constraint rankings in OT may be able to account for historical changes from one grammar to a slightly newer grammar. This change appears to be brought about by a promotion of a few crucial markedness constraints. A future analysis of Brong phonology across age groups may be one research site for studying labio-palatalization as it develops.

In summary, Asante Twi and Akuapem Twi both have a high-ranked AGREEVOCALIC constraint that is dominated by IDC in Brong. Asante and Akuapem are differentiated from one another by the position of AGR[ATR]$_{ON}$, AGRPL$_{SEG}$, and OCP(+cor). All Akan dialects have the undominated constraint for vowel-to-vowel harmony, AGR[ATR]$_{NN}$, as well as the IDENTVOWEL constraint maintaining that input vowels remain vowels in the output. Ultimately, these constraints and their rankings differentiate between the dialect that relies on vowel harmony constraints for glide formation (Asante) and the dialect that relies on place-specific predictors instead (Akuapem).

4 Alternate Analyses

Two rule-ordered accounts of CVV glide epenthesis in 'CUe/CUa' sequences have been given in the literature: Schachter and Fromkin (1968:17) and Abakah (1993; 2004a). This section outlines those analyses and argues that the OT analysis presented in §3 gives an improved account of the general facts for labialization and labio-palatalization.

4.1 Schachter & Fromkin 1968

Schachter & Fromkin (1968) present the earliest analysis of CVV glide epenthesis. Interestingly, they account for a different output form than the form given in my analysis or the analysis of Abakah (2004a). Because of this, Schachter and Fromkin's (1968) description accounts for rather different data; crucially, the initial vowel is deleted, whereas in Abakah's (and my) analysis, the initial vowel is retained (and fronted, in the context of labio-palatalization). Schachter and Fromkin (1968:17) state:

> A /ʊ/ which occurs as the first vowel of a diphthong in a lexical matrix is always deleted. This deletion, however, must occur after the /ʊ/ has labialized the preceding non-vowel. For example, the underlying representation of the word hwɛ [çɥɛ́] 'look at' is /huɛ́/. By the labialization rule the /h/ becomes labialized before /ʊ/. The /ʊ/ is then deleted, and the consonant becomes palatalized before /ɛ/.

(21) Schachter & Fromkin's (1968) Analysis of Labio-palatalization

Underlying form	/hʊ́ɛ/
Labialization rule	[hwʊ́ɛ]
[ʊ]-deletion rule	[hẃɛ]
Palatalization rule	[ɔɥɛ́]

It is difficult to reconcile the analysis in (21) with the analysis presented in §3, because the winning output forms are different from the output forms attested by Abakah (2004a; given here in Appendix B). Phonetically, Abakah (p.c.) states that the only dialect in which the initial vowel is evidenced to actually delete is the Boka sub-dialect of Fante, which is not the one under consideration by Schachter and Fromkin (1968; they focus primarily on standard Akuapem Twi and Asante Twi dialects).[18] Because of this discrepancy, it is impossible to directly compare Schachter and Fromkin's account with the one I give in §3, or the one given by Abakah (1993; 2004a). The question of appropriate output representation, and the corresponding phonological analysis of that representation, is an open question for now.

4.2 Abakah 1993 & 2004a

Abakah (2004a:144; see also 1993:149) analyzes labialization and labio-palatalization in Fante, Akuapem Twi and Asante Twi in terms of ordered rules. The analysis is replicated almost exactly in (22). Each numbered rule is ordered sequentially. Although only two of all possible CVV forms are illustrated here, these rules are applicable to all processes of labialization and labio-palatalization in CVV contexts, *i.e.*, the data in Appendix B.[19] Each rule feeds to the next and there is no opacity, implying that these rules are easily translatable into a parallel OT analysis.

[18] From an email communication, February 5, 2006: "this Boka pronunciation … is different from the other dialectal pronunciations."
[19] This applicability is inferred.

(22) Abakah 2004a: An Analysis of Labio-palatalization

Rule	FANTE	AKUAPEM TWI	ASANTE TWI
1. *Underlying Rep.*	#pue# #hue#	#pue# #hue#	#pue# #hue#
2. *Labialization*	#p^{w}ue# #h^{w}ue#	#p^{w}ue# #h^{w}ue#	#p^{w}ue# #h^{w}ue#
3. *Velarization*	#____# #ʍue#	#____# #____#	#____# #____#
4. *VH (V coronality)*	#p^{w}ie# #ʍie#	#____# #____#	#p^{w}ie# #h^{w}ie#
5. *Metathesis*	#p^{w}ei# #ʍei#	#____# #____#	#____# #____#
6. *Palatalization*	#____# #____#	#____# #____#	#p^{ɥ}ie# #____#
7. *Coronalization*	#____# #____#	#____# #____#	#____# #ç^{ɥ}ie#
8. *Derived Output*	[pwei] [ʍei]	[p^{w}ue] [h^{w}ue]	[p^{ɥ}ie] [ç^{ɥ}ie]
English Gloss	'go out' 'pour'	'go out' 'pour'	'go out' 'pour'

In Abakah's (2004a) analysis, labialization applies to all forms initially, obligatorily, and crucially prior to a separate process of palatalization. Palatalization then only applies in Asante either because it is blocked by a process of metathesis (occurring only in Fante) or because no rules subsequent to labialization apply (in Akuapem). Important for this analysis is that labio-palatalization is a combinative result of these labialization and palatalization rules. Separating out the two rules is regularly assumed in earlier works on labio-palatalization (see also Stewart 1971:200; Eshun 1993:30-61), and is supported by independent evidence in Akan for both labialization and palatalization processes.

Positing an independent rule for palatalization is supported by copious evidence of palatalization in the language in general; for example, /k/ regularly palatalizes to /tç/ in such environments (see Schachter & Fromkin 1968; also McCarthy & Prince 1995). The change that Abakah terms *coronalization*, whereby /h/ goes to /ç/ when followed by a high front vowel, is a related process. The rule of *velarization* is necessary just to account for the variable pronunciation of /h/ in Fante (between /h/ and the voiceless dorsal glide /ʍ/).

4.2.1 Potential Problems with the Ordered Rule Analysis

Abakah's third rule, *VH (V coronality)*, requires a bit more explanation. Abakah (2004a) argues that a change from [p^{w}ue] to [p^{w}ie] is motivated by vowel harmony. Yet rather than ATR harmony or labial (rounding) harmony, both of which are well-attested forms of vowel harmony in Akan (see Schachter and Fromkin 1968; also O'Keefe 2003), Abakah's rule harmonizes vowels for the feature [+Coronal]. Abakah's coronal vowel harmony is essentially the same thing as labial harmony among non-labial vowels; in fact, Abakah later rephrases coronal harmony as "unroundness VH" (2004a:144). According to Abakah's application of unroundness harmony, harmony applies regressively, as has been argued (not without debate; see O'Keefe 2003) for Akan ATR harmony. So, [p^wue] is changed to [p^wie] because the [+Coronal] feature of /e/ spreads regressively to /u/ and (maintaining the features [+ATR] and [+High]) changes /u/ to /i/. Crucial to Abakah's analysis is that 'unroundness harmony' not only applies after labialization, but is motivated by it. Glide formation results from the initial vowel losing its feature [+Labial] to the preceding consonant, therefore making the initial vowel unspecified for place, and therefore open to the spreading of coronality.

But what about when the second vowel is /a/, not /e/? Like most Akan phonologists, Abakah (2004a) does not assign a place feature to /a/, so /a/ cannot be [+Coronal]. Yet, *[$t^ɥ$ua] does not obtain, while [$t^ɥ$ia] does, at least according to Abakah's own data. Akabah's analysis applies to /a/ in terms of rounding, since /a/ is not round, and therefore unroundness harmony may still take place (confirmed by Abakah p.c.). Thus, harmony is crucially based on the feature [-Labial], not [+Coronal]. In §3, I proposed that [$t^ɥ$ia] wins and *[$t^ɥ$ua] loses because of the constraint AGRPL$_{ON}$. AGRPL$_{ON}$ motivates agreement between the glide and the initial vowel, whereas 'unroundness VH' motivates agreement between the two vowels. Since /a/ is not a coronal vowel, I argue that AGRPL$_{ON}$ is a better motivation for back vowel fronting.

Finally, Abakah's (2004a) rule-based analysis accounts for initial vowels are that [+ATR] but does not explicitly account for initial vowels that are [–ATR]. When the initial vowel is /ʊ/, Fante and Akuapem may form the labio-palatal glide /ɥ/, but Asante always forms /w/. Abakah (2004a:144-45) discusses these ATR differences in detail in-text but does not propose a rule-ordered analysis to account for them. My OT analysis, given in §3, eliminates the need for proposing a separate analysis for –ATR initial vowels, accounting for all possible 'CUe/CUa' vowel sequence combinations.

5 Future Directions

As in earlier accounts of the 'CUe/CUa' process, the analysis of underlying initial high back vowels given here is kept separate from any analyses of high *front* vowels or *mid-back* vowels (Schachter & Fromkin 1968; Abakah 1993; Abakah 2004a; Abakah 2004b; but see Abakah 2003). However, an integration of glide formation in these different CVV contexts would greatly improve upon the analysis for future work. For example, the mid-back vowels /o/, [+ATR], or /ɔ/, [-ATR], also occur as initial vowels in underlying CVV sequences that condition labial and labio-palatal glide formation, just not as consistently or as often as is found for high back vowels. In mid-vowel contexts, the labio-palatal glide /ɥ/ only forms in the Fante and Akuapem dialects, and then only sometimes, but never for the Asante dialect (see Dolphyne 1988:145-46; Abakah 2003). Just as underlying high, back vowels front in contexts of labio-palatalization (*e.g.,* from /u/ to /i/), mid-vowels also front (*e.g*, from /o/ to /e/). Although the evidence is suggestive that labio-palatalization again targets coronal stops in these dialects, the simple fact is that the data are sparse and more data on mid-vowel glide formation are needed to properly analyze mid-vowel contexts.

Another site of glide formation in CVV contexts that is relevant to future analyses is when the first vowel is a high, front vowel. When the initial vowel in a CVV sequence is underlyingly a high front vowel, such as /i/, it often co-occurs with *palatal glide formation*, but only in the Fante dialect (not in Akuapem or Asante; see Schachter & Fromkin 1968:90; Eshun 1993:173-180; Abakah 2003; Abakah 2004b). In Fante, a palatal glide forms on the consonant of CVV only when the consonant is not a coronal or velar stop. For example, /fiew/, 'to suck,' is realized as [fʲiew] (Abakah 2003:57; the role of final labial rounding, if any, is not clear). When the consonant is a coronal or velar stop, the following /i/ triggers *palatalization* of the consonant, rather than palatal glide formation. This palatalization process results in the affrication of coronals, as in /tia/, 'short,' realized as [tsia], or the palatalization of velars, as in /kia/, 'to greet,' realized as [tɕia]. Of these, the only process that occurs in Asante and Akuapem dialects is the palatalization of initial velars; neither palatal glide formation nor coronal affrication occur. An analysis of palatal glide formation would then need to postulate separate constraint rankings for Fante and Akuapem dialects, as opposed to the combined-dialect analysis given in §3 of this paper. In addition, palatal glide formation would need to be distinguished from palatalization.

Finally, accounting for the place assignment of secondary glide articulations may not be the best way to approach these data. Since labio-palatal glides must co-occur with /i/ or /ɪ/, another direction to take is to provide an account for the fronting and un-rounding of the initial vowel and to show that the glide's place of articulation is assigned based on the features of that vowel. There are a couple good reasons for this approach. First, the co-occurrence of the labio-palatal glide and the front, unrounded vowel is exceptionless, implying that glide formation is a completely predictable process contingent on the occurrence of vowel fronting. This approach thus necessitates a new analysis that motivates vowel fronting. The table in (2) is reformulated here in (23) with this new approach to the data. The pattern for Asante is highlighted in grey and the pattern for Akuapem is in bold.

(23) Reframing the analysis as an account of vowel fronting patterns:

C(PL)	*V_1 & ATR*	*V_2 & ATR*	*AKUAPEM*	*ASANTE*
+COR	u (+ATR)	e (+ATR)	FAITH	u → i
-COR	u (+ATR)	e (+ATR)	FAITH	u → i
+COR	u (+ATR)	**a (±ATR)**	**u → i**	u → i
-COR	u (+ATR)	a (±ATR)	FAITH	u → i
+COR	ʊ (–ATR)	**a (±ATR)**	**ʊ → i**	FAITH
-COR	ʊ (–ATR)	a (±ATR)	FAITH	FAITH

Accounting for Asante glide formation under a vowel-fronting approach is initially puzzling: why would vowels that are [+ATR] undergo fronting, while vowels that are [–ATR] stay back? On reason could be that there is some kind of shared place constraint, in the most general sense: since [+ATR] segments have a more fronted articulation vis-à-vis [–ATR] segments, there may be a natural correlation between advanced tongue root segments and fronted vowels (this fact may indeed be necessary for the constraint AGRPL$_{ON}$ given in my analysis in §3). On the other hand, while most analyses of vowel harmony consider [+ATR] to be the marked, non-assimilating feature and [–ATR] to be the unmarked, assimilating feature (Bakovic 2000; Casali 2003), here [+ATR] vowels are losing their place and labiality, while [–ATR] vowels are not allowing for this loss. Perhaps vowels are reversed for markedness in conditions of vowel fronting.

The facts for Akuapem are a little more straightforward: coronal consonants are known, typologically, to have a fronting effect on following back vowels (Clements 1991, Hume 1992; Flemming 2003; Hall-Lew 2005). Additionally, perhaps the way to look at the difference between V_2 = /e/ and V_2 = /a/ is not based on the feature [±Coronal] (as in OCP(+cor)), but rather the feature [±ATR]. Specifically, perhaps it is the presence of a second vowel that is unspecified for the feature [ATR], *i.e.*, /a/, which allows this fronting effect to obtain in Akan, while having a second vowel underlyingly specified for [±ATR] inhibits the fronting of the first vowel. But since there are no 'CUe/CUa' sequences ending in the [–ATR] vowel, /ɛ/, the question that remains is: does the underspecification of /a/ promote vowel fronting, or does the potential [–ATR] feature of /a/ promote vowel fronting? One might argue for the former and argue for the emergence of the unmarked in unmarked environments. Given a theory that coronal segments are unspecified for place (*e.g.*, Paradis & Prunet 1991a), and assuming that /a/ is unspecified for [ATR], the analysis could claim that the fronting of /u/ to /i/ obtains only in fully unspecified phonological environments. In other words, labio-palatalization – via vowel fronting – would only emerge in the most unmarked segmental environments. Such an analysis has compelling implications for understanding the segmental relations at work in the Akan phonological system, and remains open to future exploration.

6 Conclusion: Glides Participate in Vowel Harmony

A significant body of literature exists on the segmental phonology of Akan, in historical-comparative (Stewart 1967), SPE (Schachter & Fromkin 1968; Stewart 1983) and autosegmental (Abakah 2004a) frameworks. Two approaches in Optimality Theoretic terms are an analysis of velar palatalization 'underapplying' in reduplicative prefixes (McCarthy & Prince 1995) and an analysis of ATR vowel harmony (O'Keefe 2003). The analysis of glide formation given here adds to the growing literature of Akan segmental phonology in OT.

This analysis significantly expands on previous work by including an account of all the Akan data where the initial vowel is underlying specified as [–ATR]. The analysis further adds to an understanding of Akan phonology by extending the application of the

OCP(+coronal) constraint proposed for Akan by McCarthy and Prince (1995). In addition to the OCP, a few general constraints on agreement capture most of the generalizations for Akan glide formation. In particular, the analysis calls for constraints that enforce shared place features between two articulations of a single consonantal segment, and shared place features between an onset and its nucleus. A constraint enforcing agreement in the feature [Vocalic], between a syllable onset and its nucleus, is offered as a new way to motivate CVV glide formation in general.

The most significant contribution of the present analysis of glide formation in Akan is the claim that consonants – in particular, secondary glide articulations – are sensitive to ATR harmony constraints. Furthermore, the analysis predicts that this ability to harmonize is subject to different pressures than is vowel-to-vowel harmony. Key to this observation is that while ATR consonant harmony may be crucial in one dialect (Asante), it can be a low-ranked priority in another dialect (Akuapem). However, the general claim that glides participate in the harmony system significantly adds to a larger body of literature on consonant-vowel and vowel-consonant harmony, *e.g.* for Turkish (Clements & Sezer 1982, cited in Shaw 1991).

Glide formation, and labio-palatalization in particular, is an interesting phonological process in Akan and a rare occurrence typologically. Determining its possible motivations and the constraints on its dialectal distribution sheds new light on the general segmental constraints at work within the synchronic system of Akan.

References

Abakah, Emmanuel Nicholas. 1993. *Some Aspects of the Phonology of the Mfantse Dialect of Akan*. Department of Linguistics, University of Ghana, Legon: Unpublished MPhil Thesis.

—. 1998-1999. On the Question of Standard Fante. *The Journal of West African Languages*. 27:95-115.

—. 2002. Remarks on the Akan Vocalic Inventory. *New Directions in Ghanaian Linguistics: Essays in Honor of the 3Ds*, ed. by Felix Ameka and E. Kweku Osam, 243-63. Accra: Black Mask Ltd.

—. 2003. Syllable Structure Processes in Akan. *Langues et Linguistique (Languages and Linguistics)*. Revue Internationale de Linguistique (An International Refereed Journal of Linguistics). Series: Etudes Linguistiques et Enseignement des Langues (Linguistic Studies and Language Teaching). Editor: Moha Ennaji. Series Editor: Fatima Sadiqi. Vol. 12, pp. 43-63.

—. 2004a. *The Segmental and Tone Melodies of Akan*. Unpublished Ph.D Dissertation. Faculty of Arts, Department of Language and Communication Studies (Linguistic Section), NTNU Trondheim, Norwegian University of Science and Technology.

—. 2004b. Elision in Fante. *Africa & Asia*. 4:181-213.

—. 2004c. Where have all the Consonantal Phonemes of Akan Gone? *Journal of Philosophy and Culture*. 1:21-48.

Bakovic, Eric. 2000. Harmony, Dominance and Control, Department of Linguistics, Rutgers University: PhD dissertation.

Bakovic, Eric. 2003. Vowel harmony and stem identity. ROA-540, Rutgers Optimality Archive. http://roa.rutgers.edu.

Browman, Catherine and Goldstein, Louis. 1992. Articulatory Phonology: An Overview. *Phonetica*, 49.155-80.

Casali, Roderic F. 2003. (ATR) Value Asymmetries and Underlying Vowel Inventory Structure in Niger-Congo and Nilo-Saharan. Linguistic Typology, 7.307-82.

Christaller, Rev. J. G. 1875/1964. *A Grammar of the Asante and Fante Language, Called Tshi (Chee, Twi): Based on the Akuapem Dialect with Reference to the other (Akan and Fante) Dialects*. Basel: Basel Evangelical Missionary Society.

—. 1881/1933. *Dictionary of the Asante and Fante Language Called Tshi (Twi)*. Basel: Basel Evangelical Missionary Society.

Clements, G.N. and Sezer, E. 1982. Vowel and Consonant Disharmony in Turkish. The Structure of Phonological Representations, ed. by Harry van der Hulst and N. Smith, 213-55. Dordrecht: Foris Publications.

Clements, George N. 1986. Compensatory Lengthening and Consonant Gemination in LuGanda. *Studies in Compensatory Lengthening*, ed. by Leo Wetzels and Engin Sezer. Dordrecht-Holland/Riverton: Foris Publications.

Clements, G.N. 1991. Place of articulation in consonants and vowels: a unified theory. Working Papers of the
Cornell Phonetics Laboratory, 5.77-123.

Clements, G.N. and Hume, E.V. 1995. The Internal Organization of Speech Sounds. *The Handbook of Phonological Theory*, ed. by J.A. Goldsmith, 245-306. Oxford: Blackwell.

de Jong, Kenneth and Obeng, Samuel Gyasi. 2000. Labio-Palatalization in Twi: Contrastive, Quantal, and Organizational Factors Producing an Uncommon Sound. *Language*, 76.682-703.

Dolphyne, Florence. 1967. A Phonological Analysis of Vowels. *Journal of West African Languages*. 4.83-89.

—. 1979. The Brong (Bono) Dialect of Akan. A Profile of Brong Kyempim: Essays on the society, history, and politics of the Brong people, ed. by Kwame Arhin. Accra, Ghana: Afram Publications (Ghana) Limited; Institute of African Studies.

—. 1988. *The Akan (Twi-Fante) Language: Its Sound System and Tonal Structure*. Accra: Ghana University Press.

Eshun, Francis Bannerman. 1993. Aspects of Akan Phonology, University of Wisconsin.

Fix, Sonya. 2003. Fixed Segmentism and Consonant Cluster Prohibition in Gbe Reduplication: Implications for Local Conjuction, Department of Linguistics, New York University: Qualifying Paper.

Flemming, Edward. 2003. The relationship between coronal place and vowel backness. Phonology, 20.335-73.

Hall-Lew, Lauren. 2005. One shift, two groups: When fronting alone is not enough. Penn Working Papers in
Linguistics, 10.2.105-16.

Hayes, B., Tesar, B. and Zuraw, K. 2003. OTSoft 2.1, software package. [http://www.linguistics.ucla.edu/people/hayes/otsoft/.]

Hume, E.V. 1991. Front vowels, coronal consonants and their interaction in non-linear phonology, Department of Linguistics, Cornell University: PhD Dissertation.

Itô, Junko and Mester, Armin. 1998. Markedness and word structure: OCP effects in Japanese. Rutgers Optimality Archive. 255-498

Jacobs, H. 1989. Non-linear studies in the Histoirical Phonology of French, Nijmegen University: Doctoral Dissertation.

Jakobson, R., Fant, G. and Halle, M. 1963. Preliminaries to Speech Analysis. Cambridge, Massachusetts: MIT Press.

Keating, Patricia A. 1991. Coronal Places of Articulation. The Special Status of Coronals: Internal and External Evidence, ed. by Carole Paradis and Jean-François Prunet, 29-48. San Diego: Academic Press, Inc.

Kiparsky, Paul. Jan. 22, 1994. Remarks on Markedness. Paper presented at TREND 2.

Koelle, S.W. 1854/1963. *Polyglotta Africana*. London: Church Missionary House.

Ladefoged, Peter. 1964. A phonetic study of West African languages: An auditory-instrumental study. Cambridge: Cambridge University Press.

Lahiri, Aditi and Evers, Vincent. 1991. Palatalization and Coronality. The Special Status of Coronals: Internal and External Evidence, ed. by Carole Paradis and Jean-François Prunet, 79-100. San Diego: Academic Press, Inc.

Leben, William R. 1999. Weak Vowels and Vowel Sequences in Kwa: Sounds that phonology can't handle. *Proceedings of LP '98*, ed. by O. Fujimura, B. D. Joseph and B. Palek. Charles University, Prague: The Karolinum Press. 717-32

Lombardi, Linda. 2002. Coronal epenthesis and markedness. Phonology, 19.219-51.

McCarthy, John and Prince, Alan. 1995. Faithfulness and Reduplicative Identity. *University of Massachusetts Occasional Papers in Linguistics 18: Papers in Optimality Theory*, ed. by J. Beckman, L. Dickey and S. Urbanczyk. Amherst: GLSA, University of Massachusetts. 249-384.

McCarthy, John and Taub, Alison. 1992. Review of C. Paradis and J.-F. Prunet, eds. (1991) The Special Status
of Coronals. Phonology, 9.363–72.

Mensah, E. N. A. 1982. The Feature Lingual and the Akan Consonant System. *The Journal of West African Languages*, 12.24-33.

Nyaggah, Lynette. 1976. Associative Tone and Syllable Structure in Asante. *Studies in African Linguistics*, Supplement 6.191-99.

O'Keefe, Michael. 2003. *Akan vowel harmony*. Department of Linguistics, Swarthmore College: BA Thesis.

Paradis, Carole and Prunet, Jean-François (eds.) 1991a. The Special Status of Coronals: Internal and External Evidence. vol. 2. Phonetics and Phonology. San Diego: Academic Press, Inc.

Paradis, Carole and Prunet, Jean-François. 1991b. Introduction: Asymmetry and Visibility in Consonant Articulations. The Special Status of Coronals: Internal and External Evidence, ed. by Carole Paradis and Jean-François Prunet, 1-28. San Diego: Academic Press, Inc.

Prince, Alan and Smolensky, Paul. 1993/2004. *Optimality Theory: Constraint Interaction in Generative Grammar*. Malden, MA: Blackwell Publishing.

Schachter, Paul and Fromkin, Victoria. 1968. A Phonology of Akan: Akuapem, Asante, Fante. *Working Papers in Phonetics*, No. 9. Los Angeles, CA: University of California.

Shaw, Patricia A. 1991. Consonant Harmony Systems: The Special Status of Coronal Harmony. The Special Status of Coronals: Internal and External Evidence, ed. by Carole Paradis and Jean-François Prunet, 125-58. San Diego: Academic Press, Inc.

Stewart, John M. 1966. Akan History: Some Linguistic Evidence. *Ghana Notes and Queries*, 9.54-58.

—. 1967. A Theory of the Origin of Akan Vowel Harmony. Proceedings of the Sixth International Congress of Phonetic Sciences Held at Prague 7-13 September 1967, ed. by Bohuslav Hala, Milan Romportl and Premysl Janota, 863-64. Prague: Academic Publishing House of the Czech. Academy of Sciences.

—. 1971. Niger-Congo, Kwa. *Current Trends in Linguistics*, 7.179-212.

—. 1983. Akan Vowel Harmony: The Word Structure Conditions and the Floating Vowels. Studies in African Linguistics, 14.111-39.

—. 1989. Kwa. *The Niger-Congo Languages: a classification and description of Africa's largest language family*, ed. by John Bendor-Samuel, 216-45. Lanham, MD: University Press of America, Inc.

Welmers, William E. 1973. *African Language Structures*. Berkeley/Los Angeles/London: University of California Press.

Westermann, D. and Ward, Ida C. 1933/1957. Practical Phonetics for students of African Languages: International African Institute. London: Oxford University Press.

Williamson, Kay and Blench, Roger. 2000. Niger-Congo. *African Languages: An Introduction*, ed. by Bernd Heine and Derek Nurse. Cambridge: Cambridge University Press.

Appendix A: The Segment Inventory

Consonants

The Akan consonant inventory given below is adapted from Dolphyne (1988). It includes all surface phonemes. The segments designated with (FA) are only present in the Fante dialect; the segment designated with (AK) only occurs in the Akuapem dialect. All labial consonants are specified as [+Round], while all other places of articulations have both [+Round] and [-Round] segments, although not for the alveolar plosive and affricate classes.

	LABIAL	ALVEOLAR		PALATAL		VELAR		GLOTTAL	
		-RND	+RND	-RND	+RND	-RND	+RND	-RND	+RND
Plosive	p b	t d				k g	k^w g^w		
Fricative	f	s s^j	s^w	ç	ʃɥ			h	h^w
Affricate		ts (FA) dz (FA)		tç dʒ	tçɥ dʒɥ				
Nasal	m	n		ɳ	ɳɥ	ŋ	ŋw		
Lateral		l							
Trill		r (AK)							
Approx-imant		ɹ			ɥ		w		

Akan has three underlying glides: palatal, [-Round] /j/; palatal, [+Round] /ɥ/; and velar /w/. Although /ɥ/ usually emerges from surface constraints such as those discussed in the analysis in §3, it does exist, albeit rarely, as an underlying segment. Examples include the word /ɥie/, 'to finish,' and /oɥie/, 'sun' (Dolphyne 1988:31; Abakah 2004a:106). Dolphyne (1988:46) notes that /ɥ/ only occurs before front vowels except for the one word in Asante, /ɥɔ/, 'to do'.

Vowels

The representation of the Akan vowel system given in the table below (adapted from Schachter & Fromkin 1967:30) gives the entire vowel inventory, including ATR and nasalization. 'ATR' refers to the advancement of the tongue root, which has been shown to best correlate with the distinctions between these vowel sets, as opposed to a tense/lax distinction (Ladefoged 1964; Stewart 1967). Akan has either a 10-vowel system or a 9-vowel system, depending on the dialect or the particular phonological analysis. The 10-vowel system is divided into two groups of five, one group of advanced (+ATR) vowels, {i, u, e, o, æ}, and the other group of non-advanced (-ATR) vowels, {ɪ, ʊ, ɛ, ɔ, a}. The 9-vowel system is the same as the 10-vowel system minus the [æ] vowel. For the 9-vowel system, [a] is a default vowel that occurs in both +ATR and –ATR environments. The existence of underlying [æ] (or [ə] or [ʌ], which have also been given as corresponding to the +ATR variant of [a]) is highly debated (see Abakah 2004a), and figures largely in discussions of Akan vowel harmony. Regardless of the analysis, the low vowels /æ/ and /a/ are typically unspecified for backness. The 9-vowel system is argued for the Standard/Iguae Fante and Anee Fante dialects, while the 10-vowel system is attributed to the Asante, Akuapem, and Boka Fante dialects (see Stewart 1983); but some authors claim that all Akan dialects only have the 9-vowel system, which is the point of view taken in the present paper.

	-Back		+Back		
	+ATR	-ATR	+ATR	-ATR	
+High, -Low	ĩ	ɪ̃	ũ	ʊ̃	+Nasal
	i	ɪ	u	ʊ	-Nasal
-High, -Low	e	ɛ	o	ɔ	-Nasal
-High, +Low	æ̃, ã				+Nasal
	æ, a				-Nasal

Syllable Structure

According to Schachter and Fromkin (1968:49-51), the Akan root syllable is of the form C(V)V(C). The first segment is a consonant or a glide; the second segment is a vowel. The second segment of a syllable may also be a glide, in some dialects. The presence of a syllable-final consonant is debatable (see Dolphyne 1988:53). Schachter and Fromkin (1968) note that both vowel segments in a CVV(C) sequence must agree in tone, nasality, and ATR specification. But while Schachter and Fromkin (1968) allow for vowel sequences within one syllable, Dolphyne argues: "each vowel in a vowel sequence belongs to a different syllable" (1988:53). Evidence from tone supports this, in that a single syllable cannot be specified for more than one tone, so that the presence of a tonal contour on a single vowel is analyzed as two adjacent vowels with the same place features. In the CVV sequences analyzed in the present paper, all vowels are considered independent nuclei.

Appendix B: The Data

Forms with the secondary labio-palatal glide are in grey and those with the secondary labial glide are left in white. The data are organized according to the place of articulation of the (initial) consonant and the ATR specification of the V_1V_2 sequence. One modification made to the dataset below concerns the data for Akuapem in (iiia-d). In Abakah (2004a:143), these data are written with the glide /w/. However, from the prose description of his data, the data are actually supposed to have the glide /ɥ/. This fact was confirmed by personal communication (Emmanuel N. Abakah, August 2005; see also Dolphyne (1988:145-146) for some slight differences in representation that may be due to changes in real time). Furthermore, Abakah (2000:143) analyzes the labio-palatal pronunciation of the first token, /d^{ɥ}ie/ (an 'expression of condolence'), to be an exceptional pronunciation in Fante and Akuapem that is due to a borrowing from the Asante pronunciation. Since this is the only example in the literature of Fante or Akuapem labio-palatalization in this particular phonological environment, I see no reason to disagree.

The data are given on the following page. Labio-palatal forms are highlighted in grey.

	Elder Brong	Fante	Akuapem	Asante	Gloss
i. (CVV = C + [+ATR] + /e/)					
a.	due	d^{ɥ}ie	d^{ɥ}ie	d^{ɥ}ie	*expression of condolence*
b.	tue	twei	t^{w}ue	t^{ɥ}ie	‘to puncture’
c.	bue	bwei	b^{w}ue	b^{ɥ}ie	‘to open’
d.	pue	pwei	p^{w}ue	p^{ɥ}ie	‘to go out’
e.	hue	ʍei	h^{w}ue	ç^{ɥ}ie	‘to pour’
ii. (CVV = C + [+ATR] + /a/)					
a.	nua	n$^{\tilde{ɥ}}$ĩã	n$^{\tilde{ɥ}}$ĩã	n$^{\tilde{ɥ}}$ĩã	‘sibling’
b.	dua	d^{ɥ}ia	d^{ɥ}ia	d^{ɥ}ia	‘tree’
c.	tua	t^{ɥ}ia	t^{ɥ}ia	t^{ɥ}ia	‘to apply suppository’
d.	sũã	s$^{\tilde{ɥ}}$ĩã	s$^{\tilde{ɥ}}$ĩã	s$^{\tilde{ɥ}}$ĩã	‘to learn’
e.	afua	ef^{w}u(w)a	ɛfwua	ɛf^{ɥ}ia	*proper name*
f.	kua	k^{w}u(w)a	k^{w}ua	k^{ɥ}ia	‘farming’
g.	hũã	ʍ̃ũ(w̃)ã	h^{w}ũã	ç$^{\tilde{ɥ}}$ĩã	‘scent’
h.	mũã	m^{w}ũ(w̃)ã	m^{w}ua	m^{ɥ}ia	‘shut (mouth)’
i.	pua	p^{w}ũ(w̃)ã	p^{w}ua	p^{ɥ}ia	*type of haircut*
iii. (CVV = C + [-ATR] + /a/)					
a.	nʊa	n$^{\tilde{ɥ}}$ĩã	n$^{\tilde{ɥ}}$ĩã	n^{w}ʊ̃ã	‘to cook’
b.	dʊa	d^{ɥ}ɪa	d^{ɥ}ɪa	d^{w}ʊa	‘to arrest’
c.	tʊa	t^{ɥ}ɪa	t^{ɥ}ɪa	t^{w}ʊa	‘to join’
d.	sʊa	s^{ɥ}ɪa	s^{ɥ}ɪa	s^{w}ʊa	‘to carry’
e.	fʊa	f^{w}ʊ̃(w̃)ã	f^{w}ʊa	f^{w}ʊa	‘to add’
f.	akʊa	ak^{w}ʊ̃(w̃)ã	ak^{w}ʊa	ak^{w}ʊa	‘servant’
g.	hʊa	ʍʊ(w)a	h^{w}ʊa	h^{w}ʊa	‘to fade’
h.	mʊ̃ã	m^{w}ʊ̃(w̃)ã	m^{w}ʊ̃ã	m^{w}ʊ̃ã	‘to dent’
i.	bʊa	b^{w}ʊ̃(w̃)ã	b^{w}ʊa	b^{w}ʊa	‘to help’

Appendix C: Dialect Tableaux

Akuapem Twi

	AGRATR$_{NN}$	AGRVOC	AGRPL$_{ON}$	IDRND	OCP(+cor)	AGRPL$_{SEG}$	IDATR	AGRATR$_{ON}$	ID-C
tue, 'to puncture'									
1. tue		*!							
2. twe		*!							
3. t^{ɥ}ue			*!						*
4. t^{j}ie				*!	*				*
5. t^{ɥ}ie					*!				*
6.☞t^{w}ue						*		*	*
tua, 'to apply suppository'									
7. tua		*!							
8. twa		*!							
9. t^{ɥ}ua			*!					*	*
10. t^{j}ia				*!					*
11. ☞ t^{ɥ}ia									*
12. t^{w}ua						*!			*
tʊa, 'to join'									
13. tʊa		*!							
14. twa		*!							
15. t^{ɥ}ʊa			*!						*
16. t^{j}ɪa				*!				*	*
17. ☞ t^{ɥ}ɪa								*	*
18. t^{w}ʊa						*!		*	*
tʊe, *hypothetical non-harmonic candidate*									
19.tʊe	*!	*							
20.twe		*!							
21.t^{w}ʊe	*!					*			*
22. t^{ɥ}ɪe	*!				*			*	*
23. tue		*!					*		
24. ☞t^{w}ue						*	*	*	*
25. t^{ɥ}ie					*!		*		*

Asante Twi

	AGRATR$_{NN}$	AGRVOC	AGRATR$_{ON}$	AGRPL$_{ON}$	IDRND	IDATR	AGRPL$_{SEG}$	OCP(+cor)	ID-C
tua, 'to apply suppository' (also relevant for **tue**, 'to puncture')									
1. tua		*!							
2. twa		*!							
3. t^wua			*!				*		*
4. $t^ɥ$ua				*!					*
5. ☞ $t^ɥ$ia									*
6. t^jia					*!				*
tʊa, 'to join'									
7. tʊa		*!							
8. twa		*!							
9. ☞ t^wʊa							*		
10. $t^ɥ$ʊa			*!	*					*
11. $t^ɥ$ɪa			*!						*
12. t^jɪa			*!		*				*
tʊe, *hypothetical non-harmonic candidate*									
13. tʊe	*!	*							
14. twe	*!	*							
15. t^wʊe	*!						*		*
16. $t^ɥ$ɪe	*!							*	*
17. tue		*!		*		*			
18. t^wue			*!			*	*		*
19. ☞ $t^ɥ$ie						*		*	*

Elder Brong

	IDC	IDV	ALL OTHER CONSTRAINTS
tua, 'to apply suppository'			
1. ☞tua			*
2. twa		*!	*
3. t^wua	*!		*
4. $t^ɥ$ua	*!		*
5. $t^ɥ$ia	*!	*	*
6. t^jia	*!	*	*