Patterns of Glide Formation in Niger-Congo: An Optimality Account

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Many Niger-Congo languages do not permit sequences of adjacent vowels. Where these would arise through morphological or syntactic concatenation, they are typically eliminated through various processes. Among the most common of these are Vowel Elision, Glide Formation, and Vowel Coalescence. These are schematized in (1).

(1)

a. Vowel Elision:	$CV_1\#V_2$ > C V_2(:)		
b. Glide Formation:	$V_1\#V_2$ > CGV_2(:)		
c. Coalescence:	Ca#i > Ce(:)	Ca#u > Co(:)	
	Ce#i > Ce(:)	Ce#u > Co(:)	/ Cyo(:)
	Co#i > Cwe(:)	Co#u > Co(:)	

Here and throughout, I use the number sign to represent a word or morpheme boundary. Although individual languages sometimes resolve hiatus differently at different boundaries, the cross-linguistic generalizations treated here hold true at both word and morpheme boundaries. For simplicity, I hereafter ignore the possibility of compensatory lengthening.

With respect to Glide Formation, Niger-Congo languages exhibit considerable variation. This is summarized in (2).

(2) Glide Formation -- Language-specific variation:

a. Whether or not Glide Formation applies to both front and round V_1's or round V_1's only.

/u/ and /i/ both glide C ___ V:	13/18 languages.
Only /u/ glides (/i/ elided C ___ V):	5/18 languages.

b. Whether Glide Formation applies to both high and mid V_1's or high V_1's only.

/u/ and /o/ both glide C ___ V:	11/18 languages.
Only /u/ glides (/o/ elided C ___ V):	7/18 languages.

c. Whether or not Glide Formation may apply when V_1 and V_2 agree in roundness and/or frontness:

/u/ glides before /o/ (and also non-round V):	8/18 languages.
/u/ glides only before non-round V:	10/18 languages.

N.B. /o/ never glides before a round vowel, and /u/ never glides before /u/.

d. Whether or not Coalescence occurs in addition to Glide Formation (cf. (1c) above).

Coalescence occurs:	8/18 languages.
No Coalescence:	10/18 languages.

While virtually all languages with Glide Formation glide /u/, languages differ as to which other vowels will glide. First, in (2a), some languages glide both front and round vowels whereas others glide round vowels only. Second, in (2b), languages differ as to whether Glide Formation affects both high and mid V_1's or high V_1's only. Languages also differ as to whether Glide Formation may occur when V_1 and V_2 agree in frontness or roundness, as shown in (2c). Finally, in (2d), some languages with Glide Formation also manifest Coalescence while others do not. Despite the variation which exists, however, we shall see that there are a number of logically possible and seemingly very sensible patterns which surprisingly do not seem to occur. The goal of my analysis is to account for the permitted range of variation, while explaining the absence of the unattested patterns. The patterns I treat are based primarily on a sample of 18 Niger-Congo languages which have substantial Glide Formation, listed in (3).

(3) Glide Formation languages looked at:

18 Languages with substantial Glide Formation and reasonably clear source information: Anufɔ, Chumburung, Bemba, Ebira, Edo, Etsako, Gichode, Gonja, Igede, Isoko, Ivie, Krachi, Lamba, LuGanda, Nawuri, Nupe, Sango, Xhosa.

I assume that the resolution of hiatus is determined by the relative ranking of the general constraints in (4).

(4) Major constraints relevant to vocalic hiatus:

ONSET	Avoid onsetless syllables (Prince & Smolensky 1993).
*DIP	Avoid tautosyllabic vowel sequences (diphthongs). (Casali 1994, Rosenthall 1994)
*INS(F)	Avoid feature (and, consequently, segment) insertion (Kirchner 1993).
PARSE(F)	Avoid unincorporated (floating) features (Kirchner 1993).

PARSE(F,i)   Parse features of a word-initial segment (Casali 1994).

Note that in addition to PARSE(F), I posit a more specific constraint PARSE(F,i) that favors the parsing of features in word-initial position. I assume that PARSE(F,i) is universally ranked above ordinary PARSE(F). These assumptions, motivated in Casali (1994) account for a striking generalization concerning Vowel Elision: where two vowels are juxtaposed across a word boundary it is almost always the word-final, rather than the word-initial vowel that deletes.

The vowel features I assume are privative [round], [front], [low], and binary [high]. For simplicity I ignore [ATR] distinctions, which are ordinarily irrelevant to the behavior of Glide Formation. I assume that all vowel features are in general fully specified.

Although languages vary as to which sequences undergo Glide Formation, Glide Formation never applies when V_1 and V_2 agree in frontness or roundness unless V_1 is higher than V_2, as indicated in (5).

(5) a. Attested in some languages:

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Cu#o > Cwo  Ci#e > Cye
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b. Unattested:

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* Cu#u > Cwu      * Ci#i > Cyi
* Co#u > Cwu      * Ce#i > Cyi
* Co#o > Cwo      * Ce#e > Cye
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N.B. Glide Formation is possible in some languages with /Ce#o/, /Ce#u/, /Co#e/, /Co#i/. This shows that the correct generalization involves more than relative sonority or relative height.

Although Glide Formation is possible in some languages with the patterns in (5a), it is not possible with those in (5b). To account for this, I propose a constraint RELATIVE CONSTRICTION given in (6).

(6) Constraint on glide-vowel sequences:

RELATIVE CONSTRICTION (Rel-Cstr): In a GV sequence, G must possess a constriction feature not possessed by V. (Constriction features are [rnd], [+hi], [frt]) This constraint states that the glide in a GV sequence must possess some constriction feature which is lacking in the vowel, where constriction features are [round,], [front], and [+high]. RELATIVE CONSTRICTION will with rare exceptions be ranked above PARSE(F).

Languages with Glide Formation will have the ranking in (7), with PARSE(F) ranked below the other constraints.

(7) {ONSET, *DIP, *INS(F), Rel-Cstr, PARSE(F,i)} >> PARSE(F).

In general, this ranking gives rise to Glide Formation with some sequences and Vowel Elision, or possibly Coalescence, with others. In particular, it will ensure that certain sequences, listed below, are subject to Elision rather than Glide Formation.

(8) Cu#u Ci#i

Co#u Ce#i
Co#o Ce#e

Ca#u Ca#i
Ca#o Ca#e

Essentially, this is because gliding V_1 in these sequences violates highly-ranked RELATIVE CONSTRICTION, as illustrated for a few sequences in(9).

(9) a. Vowel Elision results with /Ca#o/ (A = /a/ in onset):

	/Ca#o/	ONSET	*DIP	*INS(F)	Rel-Cstr	PARSE(F)
	.CAo.				*	
⇒	.C<a>o.					** (-hi,+low)
	.Cao.		*			
	.Ca.o.	*				
	.Ca.Co.	*				
	.Cyo.			** (+hi, frt)		* (-hi)

b. Vowel Elision results with /Cu#u/:

	/Cu#u/	ONSET	*DIP	*INS(F)	Rel-Cstr	PARSE(F)
	Cwu				*	
⇒	C<u>u					* (+hi, rnd)

c. Vowel Elision results with /Co#u/:

	/Co#u/	ONSET	*DIP	*INS(F)	Rel-Cstr	PARSE(F)
	Cwu			* (+hi)	*	
⇒	C<o>u					* (-hi, rnd)

The failure of Glide Formation to apply with these particular sequences is a common trait of virtually all the languages I have looked at. Which of the other input sequences are subject to Glide Formation varies from language to language, and depends on the ranking of other constraints which I must now introduce.

Consider in particular the problem of distinguishing languages which glide both high and mid vowels from those which glide high vowels only. For simplicity, I begin by considering only round vowels in V_1 position. I employ the terminology in (10), referring to a language that glides both /u/ and /o/ as an O-Gliding language and a language that glides /u/ but not /o/ an O-Deleting language. Please keep in mind that both types of languages glide /u/ in V_1 position, at least before non-round vowels.

(10) Terminology:

An O-Gliding language is one in which both /o/ and /u/ glide:

Cu#V. > Cw#V. (for at least some V.)
Co#V > CwV " " " " "

An O-Deleting language is one in which /u/ glides but /o/ does not:

Cu#V₂ > Cw#V₂ (for at least some V_2)
Co#V₂ > CV₂ (*CwV_2)

Crucially, I claim that there are two types of round postconsonantal glides, given in (11):

(11) a. High Glide: (symbolized w) has both lip-rounding and raising of the tongue back.

w = [+hi, rnd] phonetic interpretation: both lip-rounding and velarization.

b. Non-High Glide: (W) involves lip rounding only.

W= [rnd] phonetic interpretation: lip-rounding, tongue-position variable and contextually determined.

The first type, which I refer to as a High Glide, is specified both [+high] and [round]. The second type, which I refer to as a Non-High Glide and symbolize with a capital W, is specified only as [round]. Phonetically, the [+high] specification of the High Glide will be interpreted as requiring a raised tongue body. The absence of a [+high] specification on Non-High Glide on the other hand means that the tongue position in this type is expected to be variable. Also, because the tongue position of the Non-High type lacks a phonetic target, this type of glide is more free to overlap temporally with a preceding coronal or dorsal consonant.

The type of glide that arises through Glide Formation in a given language will depend on the relative ranking of two conflicting constraints given in (12). (Note that here I assume that [-high] glides are universally disallowed.)

(12) Competing constraints:

hi-w Prefer a round glide to be [+hi]. (violated by [W])

*+hi Prefer a vocoid not to be [+hi]. (violated by [w])

The first of these, hi-w, prefers that a round glide should be [+high]. This constraint, which is violated by Non-High Glides, is motivated by the fact that the high type of glide is more salient. The second constraint, *+hi, prefers a vocoid to be non-high. It is satisfied by Non-High Glides but violated by High Glides. It is motivated by articulatory concerns, i.e. the desire to conserve articulatory effort. Crucially, it applies to vowels as well as glides.

Given these constraints, the ranking of hi-w >> PARSE(F) >> *+hi will give rise to an O-Deleting language, as shown in (13).

(13) Results for O-Deleting languages (hi-w >> PARSE(F) >> *+hi):

a.

	/Cu#a/	higher constraints	hi-w	PARSE(F)	*+hi
⇒	Cwa				*
	CWa		*	* (+hi)	
	C<u>a			** (+hi, rnd)	

b.

	/Co#a/	higher constraints	hi-w	PARSE(F)	*+hi
	Cwa	* (*INS(F))		* (-hi)	*
	CWa		*	* (-hi)	
⇒	C<o>a			** (-hi, rnd)	

In (13a), the outcome of gliding /u/ before a non-round vowel such as /a/ is [wa], where the resulting round glide is of the high type. This candidate violates only the lowest ranked constraint, *+hi. In (13b), on the other hand, we see that gliding of /o/ before a non-round vowel must violate either hi-w or *INSERT, both of which are ranked above PARSE(F). The optimal candidate is therefore one in which the features of /o/ are simply not parsed, i.e. we have Vowel Elision.

O-Gliding languages on the other hand will have the ranking in (14):

(14) Results for O-Gliding languages (*+hi >> PARSE(F) >> hi-w):

a.

	/Cu#a/	higher constraints	*+hi	PARSE(F)	hi-w
	Cwa		*		
⇒	CWa			* (+hi)	*
	C<u>a			** (+hi, rnd)	

b.	/Co#a/	higher constraints	*+hi	PARSE(F)	hi-w
	Cwa	*INS(F)	*	* (-hi)	
⇒	CWa			* (-hi)	*
	C<o>a			** (-hi, rnd)	

This ranking will entail that both /u/ and /o/ glide before non-round vowels. What is of particular interest here is that the glides which result from both /u/ and /o/ are predicted to be of the Non-High type. To see why this should be the case with /u/, notice in (14a) that the candidate with the High Glide in the first row of the tableau violates *+hi, which is ranked above PARSE(F). The candidate with the Non-High Glide is therefore to be preferred, since it violates only PARSE(F) and the still lower ranked hi-w. The analysis thus makes the strong empirical prediction that round glides resulting from Glide Formation in O-Deleting languages will always be of the high type, while those in O-Gliding languages will always be of the non-high type, that is the type that involve lip-rounding only.

Recall that the constraint *+hi is violated not only by a high glide but a high vowel as well. A consequence of this is that the ranking *+hi above both PARSE(F) and PARSE(F,i) gives rise to coalescence with sequences like /a/-plus-/i/, as shown in (15).

(15) Ranking *+hi >> PARSE(F) >> PARSE(F,i) gives Coalescence:

	/Ca i/	*+hi	PARSE(F,i)	PARSE(F)
	C<a>i	*		** (-hi, low)
⇒	Cc		* (+hi)	** (+hi, low)
	Ca<i>		** (+hi, frt)	** (+hi, frt)

(Other candidates, e.g. CaCi, Cai are ruled out by undominated *INS(F), *DIP, ONSET.)

Here the candidate in the top row, which involves elision of V_1, incurs a fatal violation of the highly-ranked constraint *+hi, while the candidate in the bottom row, which involves elision of

V_2, incurs two violations of PARSE(F,i). The winning candidate is therefore the one in the middle row, which undergoes Coalescence. This candidate incurs only a single violation of PARSE(F,i) and two of the still-lower-ranked PARSE(F).

The analysis of front glides is formally parallel to that of round glides. I propose that there are two types of front glides, as shown in (16):

(16) Front Glides:

y = [+hi, frt]	Phonetic interpretation: tongue body must be high.
Y= [frt]	Phonetic interpretation: tongue body must be front, but need not be high.

I further propose the competing constraints in (17), analogous to those for round glides in (12).

(17) Competing constraints:

hi-y	Prefer a front glide to be [+hi].
*+hi	Prefer a vocoid not to be [+hi].

Instances of the Non-High front glide, which arise in languages that glide mid front vowels, are comparatively rare, much rarer than the round Non-High Glides that result in languages which glide /o/. I assume that this is because front vowels are not very salient unless they are phonetically high. This suggests a universal, or at least unmarked ranking of hi-y above hi-w, i.e. it is more critical for front glides to be [+high] than it is for round glides to be [+high]. This assumption will have beneficial consequences in ruling out a number of unattested language types, as we shall see below.

The analysis is summarized in (18):

(18) Summary of constraints:

Undominated in languages with Vowel Elision / Glide Formation:

ONSET, *DIP, *INS(F), RELATIVE CONSTRICTION.

Variable relative ranking: PARSE(Fi), PARSE(F), *+hi, hi-w, hi-y.

(Constrained however by universal PARSE(F,i) >> PARSE(F) and near-universal hi-y >> hi-w.)

Languages with Vowel Elision and/or Glide Formation will have undominated ONSET, *DIP, *INSERT, and RELATIVE CONSTRICTION. The variability which results in these languages is due to the variable ranking of the remaining five constraints, PARSE(F,i), PARSE(F), *+hi, hi-w, and hi-y. This variability is constrained however by the universal ranking of PARSE(F,i) above PARSE(F) and the near-universal ranking of hi-y above hi-w. With these restrictions, we predict a total of 30 different possible overall rankings, as shown in (19).

(19) Predicted typology (* indicates unattested type):

Possible Rankings↓ Inputs→	Ca#i	Cu#a	Co#a	Cu#o	Ci#a	Ce#a	Ci#e	Language type
PARSE(F,i)>>PARSE(F)>>*+hi>>hi-y>>hi-w	C a i	Cwa	CWa	Cwo	Cya	CYa	Cye	L1*
PARSE(F,i)>>PARSE(F)>>hi-y>>*+hi>>hi-w	C a i	Cwa	CWa	Cwo	Cya	CYa	Cye	L1*
PARSE(F,i)>>PARSE(F)>>hi-y>>hi-w>>*+hi	C a i	Cwa	CWa	Cwo	Cya	CYa	Cye	L1*
PARSE(F,i)>>*+hi>>PARSE(F)>>hi-y>>hi-w	C a i	CWa	CWa	C u o	CYa	CYa	C i e	L2
PARSE(F,i)>>*+hi>>hi-y>>PARSE(F)>>hi-w	C a i	CWa	CWa	C u o	C i a	C e a	C i e	L3*
PARSE(F,i)>>*+hi>>hi-y>>hi-w>>PARSE(F)	C a i	C u a	C o a	C u o	C i a	C e a	C i e	L4
PARSE(F,i)>>hi-y>>PARSE(F)>>*+hi>>hi-w	C a i	Cwa	CWa	Cwo	Cya	C e a	Cye	L9*
PARSE(F,i)>>hi-y>>PARSE(F)>>hi-w>>*+hi	C a i	Cwa	CWa	Cwo	Cya	C e a	Cye	L9*
PARSE(F,i)>>hi-y>>*+hi>>PARSE(F)>>hi-w	C a i	CWa	CWa	C u o	C i a	C e a	C i e	L3*
PARSE(F,i)>>hi-y>>*+hi>>hi-w>>PARSE(F)	C a i	C u a	C o a	C u o	C i a	C e a	C i e	L4
PARSE(F,i)>>hi-y>>hi-w>>PARSE(F)>>*+hi	C a i	Cwa	C o a	Cwo	Cya	C e a	Cye	L5
PARSE(F,i)>>hi-y>>hi-w>>*+hi>>PARSE(F)	C a i	C u a	C o a	C u o	C i a	C e a	C i e	L4
*+hi>>PARSE(F,i)>>PARSE(F)>>hi-y>>hi-w	Ce	CWa	CWa	C u o	CYa	CYa	C i e	L6*
*+hi>>PARSE(F,i)>>hi-y>>PARSE(F)>>hi-w	Ce	CWa	CWa	C u o	C i a	C e a	C i e	L7
*+hi>>PARSE(F,i)>>hi-y>>hi-w>>PARSE(F)	Ce	C u a	C o a	C u o	C i a	C e a	C i e	L8
*+hi>>hi-y>>PARSE(F,i)>>PARSE(F)>>hi-w	Ce	CWa	CWa	C u o	C i a	C e a	C i e	L7
*+hi>>hi-y>>PARSE(F,i)>>hi-w>>PARSE(F)	Ce	C u a	C o a	C u o	C i a	C e a	C i e	L8
*+hi>>hi-y>>hi-w>>PARSE(F,i)>>PARSE(F)	Ce	C u a	C o a	C u o	C i a	C e a	C i e	L8
hi-y>>PARSE(F,i)>>PARSE(F)>>*+hi>>hi-w	C a i	Cwa	CWa	Cwo	Cya	C e a	Cye	L9*
hi-y>>PARSE(F,i)>>PARSE(F)>>hi-w>>*+hi	C a i	Cwa	CWa	Cwo	Cya	C e a	Cye	L9*
hi-y>>PARSE(F,i)>>*+hi>>PARSE(F)>>hi-w	C a i	CWa	CWa	C u o	C i a	C e a	C i e	L3*
hi-y>>PARSE(F,i)>>*+hi>>hi-w>>PARSE(F)	C a i	C u a	C o a	C u o	C i a	C e a	C i e	L4
hi-y>>PARSE(F,i)>>hi-w>>PARSE(F)>>*+hi	C a i	Cwa	C o a	Cwo	Cya	C e a	Cye	L5
hi-y>>PARSE(F,i)>>hi-w>>*+hi>>PARSE(F)	C a i	C u a	C o a	C u o	C i a	C e a	C i e	L4
hi-y>>*+hi>>PARSE(F,i)>>PARSE(F)>>hi-w	Ce	CWa	CWa	C u o	C i a	C e a	C i e	L7
hi-y>>*+hi>>PARSE(F,i)>>hi-w>>PARSE(F)	Ce	C u a	C o a	C u o	C i a	C e a	C i e	L8
hi-y>>*+hi>>hi-w>>PARSE(F,i)>>PARSE(F)	Ce	C u a	C o a	C u o	C i a	C e a	C i e	L8
hi-y>>hi-w>>PARSE(F,i)>>PARSE(F)>>*+hi	C a i	Cwa	C o a	Cwo	Cya	C e a	Cye	L5
hi-y>>hi-w>>PARSE(F,i)>>*+hi>>PARSE(F)	C a i	C u a	C o a	C u o	C i a	C e a	C i e	L4
hi-y>>hi-w>>*+hi>>PARSE(F,i)>>PARSE(F)	Ce	C u a	C o a	C u o	C i a	C e a	C i e	L8

In this table, the possible rankings are given in the first column, while the middle columns show the results which the rankings generate for various input sequences listed across the top row. In the rightmost column, I classify the resulting languages into types, where two rows belong to the same type if they have identical realizations for each of the seven sequences given in the middle columns. There are nine different types in all. Five of the nine types are attested in my survey, while four, marked with asterisks, are not. The five attested types are ed in (20); the four unattested types are given in (21).

(20) Attested types:

L2: O-Gliding with no coalescence at word boundaries (2 languages).[1]

L4: Vowel Elision across the board (numerous, e.g. Lokəə, Mundani).

L5: O-Deleting (7 languages).

L7: O-Gliding with coalescence and no Glide Formation of front vowels (5 languages).

L8: Coalescence and Vowel Elision only (Owon Afa, possibly Dangme)

(21) Unattested but expected:

L3: Like L2, but with no gliding of front vowels. Expected to occur.

L6: Like L7, but with gliding of front vowels. Expected to occur.

L1, L9: Have [w] / [W] contrast; predicted to be rare.

Two of the unattested types, L3 and L6 are very similar to languages that do occur; and since they do not violate any plausible cross-linguistic generalization, I assume that their absence is accidental. The other unattested patterns, L1 and L9, will be discussed momentarily.

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[1] An interesting property of the ranking PARSE(F,i)>>*+hi>>PARSE(F)>>hi-y>>hi-w that gives rise to L2 is that it predicts that this type will manifest Coalescence at stem-suffix boundaries, since PARSE(F,i) is irrelevant in this context, and *+hi >> PARSE(F). This is exactly the situation that occurs in Nupe: /Ca i.../ is resolved as [Ci], but /Ca+i/ (/i/ = suffix) as [Ce].

The predicted languages types in (19) display all of the observed variation described in (2), which I repeat with slight modifications as (22); note that here I give the language types from (19) that display each kind of variation.

(22) Language-specific variation:

a. Whether or not Glide Formation applies to both front and round V_1's or round V_1's only.

/u/ and /i/ both glide C ___ V: types: L1, L2, L5, L6, L9.	actual languages: 13.
Only /u/ glides (/i/ elided C ___ V): types: L3, L4, L7, L8	actual languages: 5.

b. Whether Glide Formation applies to both high and mid V_1's or high V_1's only.

/u/ and /o/ both glide C ___ V: types: L1, L2, L3, L6, L7,	actual languages: 11.
Only /u/ glides (/o/ elided C ___ V): types: L4, L5, L8	actual languages: 7.

c. Whether or not Glide Formation may apply when V_1 and V_2 agree in roundness and/or frontness:

/u/ glides before /o/ (and also non-round V): types: L1, L5, L9	actual languages: 8.
/u/ glides only before non-round V: types: L2, L3, L4, L6, L7, L8	actual languages: 10.

N.B. /o/ never glides before a round vowel (possible exception: Gonja).

d. Whether or not Coalescence occurs in addition to Glide Formation (cf. (1c) above).

Coalescence occurs:	types: L6, L7, L8	actual languages: 8.
No Coalescence:	types: L1, L2, L3, L4, L5, L9	actual languages: 10.

What is of equally great interest, however, is the fact that the analysis gives rise to a number of surprising yet seemingly correct restrictions on the patterns which may occur. These are given in (23).

(23) Predicted restrictions on Glide Formation:

a. Languages which glide front V_1's also glide round V_1's.

Types that glide front V_1's:	L1	L2		L5	L6		L9
Types that glide round V_1's:	L1	L2	L3	L5	L6	L7	L9

Sole violation: Chagga has Glide Formation with front but not round V_1's. Possible account: Chagga exceptionally has hi-w >> hi-y.

b. O-Deleting language always glide front as well as round V_1's. O-Gliding languages may or may not glide front V_1's.

O-Deleting types:				L5			
Types that glide front V_1's:	L1	L2		L5	L6		L9
O-Gliding types:	L1	L2	L3		L6	L7	L9

This prediction is not violated by any language in the survey.

O-Deleting languages: 7 of 7 have Glide Formation with both front and round V_1's.
O-Gliding languages: 6 of 11 have Glide Formation with both front and round V_1's.
5 of 11 have Glide Formation with round V_1's only.

c. O-Deleting languages never have Coalescence. O-Gliding languages may or may not have Coalescence.

O-Deleting types:				L5				
Types with Coalescence:					L6	L7	L8	
O-Gliding types:	L1	L2	L3		L6	L7		L9

This prediction is not violated by any language in the survey.

O-Deleting languages: 0 of 7 have Coalescence.
O-Gliding languages: 8 of 11 have Coalescence.

d. O-Deleting languages will always glide /u/ before /o/, /i/ before /e/. The single O-Deleting type produced by the analysis, L5, has both /Cu#o/ > Cwo and /Ci#e/ > Cye.

This prediction is not violated by any language in the survey: 7 of 7 O-Deleting languages have both /Cu#o/ > Cwo and /Ci#e/ > Cye.

e. O-Gliding languages that glide /u/ before /o/ and/or /i/ before /e/ are expected to be possible but rare. Reason: The only such types generated by the analysis are L1 and L9. These types have a perceptually difficult contrast between [Cw] (arising from /Cu/) and [CW] (arising from /Co/). The claim is that such a contrast would be easily lost, i.e. these types are diachronically unstable.

10 of 11 O-Gliding languages have /Cu#o/ > [Co] (Gonja has /Cu#o/ > [Cwo]).
8 of 11 O-Gliding languages have /Ci#e/ > [Ce] (Anufɔ, Bemba, Lamba have /Ci#e/ > [Cye]).

There are no languages in the survey that clearly match either L1 or L9 exactly, although Lamba might be an instance of to L9 (not clear) and Bemba comes close to L1 (differing only in that it has /Cu#o/ > [Co], rather than [Cwo]).

First, in (23a), we predict that languages which glide front vowels will also glide round vowels, though not conversely, as seen by the fact that the types which glide front V_1's are a subset of those which glide round V_1's. This prediction is violated by only one language that I know of, Chagga.

The second prediction, in (23b), is that O-Deleting languages always have Glide Formation with both front and round vowels. This is evident from the simple fact that the single O-Deleting type produced by the analysis, L5, is one of the types that glides front V_1's. This prediction is in accordance with the observed facts: all 7 O-Deleting languages in the survey have Glide

Formation with front V_1's. Note that O-Gliding languages, on the other hand, are predicted to be variable with respect to gliding of front vowels. Whereas the O-Gliding types I 1, L2, L6, and L9 glide front V_1's, the O-Gliding types L3 and L7 do not. And in fact, both kinds of O-Gliding languages are attested: 6 O-Gliding languages glide front V_1's, while 5 glide round V_1's only.

In (23c) is the prediction that O-Deleting languages never have Coalescence, while Mid-Gliding languages may or may not have Coalescence. Here again, I have come across no languages that violate this prediction: None of the 7 O-Deleting languages in the sample have Coalescence, although 8 of the 11 O-Gliding languages do.

The fourth prediction, in (23d), is that O-Deleting languages will always manifest Glide Formation with both /u/-plus-/o/ and /i/-plus-/e/. This follows from the fact that the single O-Deleting type produced by the analysis, L5, has Glide Formation with both of these sequences. This prediction, which is adhered to by all 7 O-Deleting languages in the survey, is all the more interesting in that the implication appears to work both ways, that is, O-Gliding languages do not glide either of the sequences /u/-plus-/o/ or /i/-plus-/e/. This is discussed in (23e). Note that my analysis does not strictly predict this implication, however, since the O-Gliding types L1 and L9 both glide these sequences. In fact, neither of these types is clearly attested, although Lamba might be an example of L9[2] and Bemba comes close to L1. I claim, however, that the absence of these patterns has a very plausible explanation. A characteristic of both L1 and L9 is that they have a perceptually difficult contrast between high round glides arising from /u/ and Non-High round glides arising from /o/; such a contrast would tend to be lost historically. Thus, while I do

[2]Also, Gonja differs from L9 only in that it has /Ca#i/ > [Cai], /Ci#e/ > [Ce].

not strictly rule out the L1 and L9 patterns, they are expected to be diachronically unstable, and thus their rarity is not surprising.

In summary, although Glide Formation exhibits considerable cross-linguistic variation in its behavior, this variation is subject to some surprising yet seemingly robust restrictions. Both the restrictions and the observed variation can be accounted for by the variable ranking of a small number of constraints, some of which deal specifically with glides and glide-plus-vowel sequences, while others are independently needed to account for other phenomena.

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Appendix: Brief account of the typology in (19)

/Ca#i/: Ce violates PARSE(F,i), PARSE(F) (once).
C<a>i violates *+hi, PARSE(F) (twice).

Consequences: *+hi >> PARSE(F,i) yields Ce.
PARSE(F,i) >> *+hi yields C<a>i.

/Cu#a/: Cwa violates only *+hi.
CWa violates hi-w, PARSE(F) (once).
C<u>a violates only PARSE(F) (twice).

Consequences: hi-w, PARSE(F) >> *+hi yields Cwa.
*+hi >> PARSE(F) >> hi-w yields CWa.
PARSE(F) >> *+hi >> hi-w yields Cwa.
*+hi, hi-w >> PARSE(F) yields C<u>a.

/Co#a/: Cwa violates undominated *INS(F).
CWa violates hi-w, PARSE(F) (once).
C<o>a violates only PARSE(F) (twice).

Consequences: hi-w, PARSE(F) >> *+hi yields C<o>a.
*+hi >> PARSE(F) >> hi-w yields CWa.
PARSE(F) >> *+hi >> hi-w yields CWa.
*+hi, hi-w >> PARSE(F) yields C<o>a.

/Cu#o/: CWo violates undominated RELATIVE CONSTRICTION.
Cwo violates only *+hi.
C<u>o violates only PARSE(F) (twice).

Consequences: PARSE(F) >> *+hi yields Cwo.
*+hi >> PARSE(F) yields C<u>o.

/Ci#a/: Cya violates only *+hi.
CYa violates hi-y, PARSE(F) (once).
C<i>a violates only PARSE(F) (twice).
Ce violates PARSE(F,i) (once), PARSE(F) (once)

Consequences: Ce is never possible because universal PARSE(F,i) >> PARSE(F) entails that this candidate will always be worse than C<i>a.

hi-y, PARSE(F) >> *+hi yields Cya.
*+hi >> PARSE(F) >> hi-y yields CYa.
PARSE(F) >> *+hi >> hi-y yields Cya.
*+hi, hi-y >> PARSE(F) yields C<i>a.

/Ce#a/: Cya violates undominated *INS(F).
CYa violates hi-y, PARSE(F) (once).
C<e>a violates only PARSE(F) (twice).
Ce<a> violates PARSE(F,i)

Consequences: Ce is never possible because universal PARSE(F,i) >> PARSE(F) entails that this candidate will always be worse than C<e>a.

hi-y, PARSE(F) >> *+hi yields C<e>a.
*+hi >> PARSE(F) >> hi-y yields CYa.
PARSE(F) >> *+hi >> hi-y yields CYa.
*+hi, hi-y >> PARSE(F) yields C<e>a.

/Ci#e/: CYe violates undominated RELATIVE CONSTRICTION.
Cye violates only *+hi.
C<i>e violates only PARSE(F) (twice).

Consequences: PARSE(F) >> *+hi yields Cye.
*+hi >> PARSE(F) yields C<i>e