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Phonological teamwork in Kalahari Basin languages

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Abstract

This paper describes the complex, multiple-trigger, cumulative assimilation processes targeting the initial vowel (V_1) of bimoraic stems in Kalahari Basin languages (KBA), first described by Anthony Traill (1985) in East !Xoon (Tuu). The focus is on two languages: East !Xoon and Glui (Khoe-Kwadi). The goal is to describe these processes in as much detail as is possible from the available published and unpublished sources. Marked differences between the two languages in focus are brought to light, thus giving an idea of the so far unnoticed diversity of V_1 realization in KBA languages. Finally, this paper briefly highlights important problems posed by such cumulative processes to phonological theory, many of which had already been identified by Traill (1985).

Keywords: gradience, multiple trigger, cumulative assimilation

Introduction

This paper describes a complex kind of cumulative coarticulatory/assimilatory effect involving multiple triggers and targeting the first vowel of bimoraic lexical roots in many Kalahari Basin Area (henceforth KBA) languages. The focus is on two linguistic varieties: the East !Xoon dialect of Taa (Tuu family) and Glui (Khoe Kwadi).

Lexical roots in most KBA languages are subject to very strict phonotactic restrictions on both shape and internal phoneme distribution (Beach 1938; Traill 1985; Miller-Ockhuizen 2001; Miller 2010; Nakagawa 2006; Nakagawa 2010; Naumann 2016; see Güldemann and Nakagawa, this volume for an overview and up-to-date summary). As shown in (1) below, lexical roots are always bimoraic, and may be of three shapes only.¹

- (1) $OV_1C_mV_2$ (O = onset, either C, or cluster C_1C_2 ; C_m = medial consonant)
- OV_1V_2 (likely from $OV_1\epsilon_mV_2$)
- OV_1N (probably from OV_1NV_2)

Building on research by Beach (1938) and Traill (1985), Nakagawa (2010) analyzes the distribution of consonants and vowels within KBA lexical roots as shown in Figure 1. The root-initial consonant(s) (O) is the locus of maximal lexical distinction, most of the consonants, including all clusters, being attested in this position. The medial consonant C_m and final N are, on the other hand reduced to sonorants (and /b/ = [b~β]) and nasals respectively. As for vowels, V_1 is underlyingly specified only for guttural features (i.e. phonation type) and non-dorsal features (i.e. rounding). Only V_2 is specified for dorsal features (height and backness) and nasality. This analysis, based on Glui data, holds for most KBA languages (cf. Güldemann & Nakagawa, this volume).²

O	V_1	C_m	V_2
Obstruents	Non-dorsal	Sonorants	Dorsal
incl. clusters	[+round]	(Obstruents)	[+high, +low]
(Sonorants)	[guttural]		[±back]
			[±nasal]

Figure 1. Distribution of C and V features in KBA lexical roots (after Nakagawa 2010)

1. The term “root” follows the terminological tradition set by Beach’s (1938) phonetic study of Khoekhoe.
 2. The following phonation types are attested in KBA languages (not all languages have all of them): pharyngealized /A^ʕ, U^ʕ/, glottalized /A^ʔ, U^ʔ/, breathy /A^h, U^h/, strident /A^ʰ, U^ʰ/, pharyngealized and glottalized /A^{ʕʔ}, U^{ʕʔ}/, glottalized and breathy /A^{ʔh}, U^{ʔh}/. Nasality usually spreads leftward from V_2 (or N) to V_1 , while pharyngealization has a tendency to spread rightward from V_1 to V_2 in $C(C)V_1V_2$ roots (cf. Güldemann & Nakagawa, this volume).

Taking only vowel quality into account, V_1 is thus underlyingly either [–round] /A/ or [+round] /U/. On the surface, however, V_1 displays a wide range of possible realizations: /U/ may be realized as [u], [ʊ], [ɔ], or [o], while /A/ covers a larger range, from peripheral [a, e, i] to central [ɪ, ə, ɜ, ɐ]. These realizations are entirely determined by complex coarticulatory and assimilatory processes involving some or all of the neighboring consonants and vowels (V_2 , O, C_m , N).³

The object of the present paper is precisely to characterize these coarticulatory/assimilatory effects in two languages: East !Xoon (Tuu) and Glui (Khoe-Kwadi). These effects are interesting for at least two reasons. First, they constitute a particularly complex and rich case of “subphonemic teamwork” (Lionnet 2016, 2017): they indeed often involve scalar effects with more than one trigger, as well as complex trade-off relations between competing triggers. Second, these teamwork effects seem to blur the distinction between (gradient) phonetics and (categorical) phonology, and to question aspects of contemporary phonological theory. For the sake of both simplicity and saving space, this paper focuses exclusively on /A/, but similar generalizations hold for /U/.

Section 1 describes the principles governing the realization of V_1 /A/ in East !Xoon. Section 2 describes the phonetic underpinnings of the East !Xoon patterns, as analyzed by Traill (1985). Section 3 looks at the effect of the intervening second consonant in complex onsets, specifically at the transparency of all but the uvular fricative [χ] and affricate [qχʰ]. Section 4 describes the realization of V_1 /A/ in Glui, and shows that despite striking similarities with East !Xoon, they are substantially different. Section 5 briefly highlights the relevance of these patterns for phonological theory. This is followed by a conclusion.

1. The case of East !Xoon

Reliable phonetic and phonological descriptions are available for two dialects of Taa: East !Xoon (or !Xóǒ; Traill 1985) and West !Xoon (Naumann 2016). In this section, I use Traill’s East !Xoon data (mostly because Traill presents richer acoustic and articulatory data), adopting the phonological (re)analysis developed by Naumann (2016) for West !Xoon, in particular with regard to the consonant system. Naumann identifies more consonantal contrasts than Traill did, and, based on preliminary comparative data, says that most of these contrasts are probably also present in the eastern dialect.⁴ The consonant inventory of Taa is presented in Table 1 below, where the shaded cells indicate the consonants that take part in the multiple-trigger raising and fronting assimilation described in this section.

3. Throughout this paper, the IPA symbol [a] stands for the low back vowel [ɑ].

4. Bradfield (2014) similarly adopts Naumann’s inventory while using Traill’s East !Xoon data.

	Egressive			Ingressive					Egressive			
	labial	alveolar	alv. affr. /palatal	labial	dental	alveolar	palatal	lateral	velar	uvular	uvular-affricate	glottal
Oral stops												
<i>Plain</i>	p	t	ts̄	⊙		!	‡		k	q		(?)
<i>Voiced</i>	b	d	d̄z̄	⊙	↓	!↓	‡↓	↓	g	g		
<i>Vl. aspirated</i>	p ^h	t ^h	ts̄ ^h	⊙ ^h	^h	! ^h	‡ ^h	^h	k ^h	q ^h		
<i>Vd. aspirated</i>	b ^h	d ^h	d̄z̄ ^h	⊙ ^h	↓ ^h	!↓ ^h	‡↓ ^h	↓ ^h	g ^h	g ^h		
<i>Vl. ejective</i>	p'	t'	ts̄'	⊙'	'	!'	‡'	'	k'	q'	q̄χ'	
<i>Vd. ejective</i>			d̄z̄'		↓'	!↓'	‡↓'	↓'	g'	g'	ḡB'	
Nasal stops												
<i>Plain (vd.)</i>	m	n	ɲ	⊙	~	!~	‡~	~	ŋ			
<i>Voiceless</i>						!~	‡~	~				
<i>Glottalized</i>	ʔm	ʔn		ʔ⊙	ʔ~	ʔ!~	ʔ‡~	ʔ ~				
Fricatives	f	s							χ			h
Sonorants	w	l, r	y									
Obstruent clusters												
<i>Plain+ q</i>				⊙q	q	!q	‡q	q				
<i>+voice</i>				⊙q	↓q	!q	‡q	q				
<i>Plain+ q^h</i>				⊙q ^h	q ^h	!q ^h	‡q ^h	q ^h				
<i>+voice</i>					↓q ^h	!q ^h	‡q ^h	q ^h				
<i>Plain+ q'</i>				⊙q'	q'	!q'	‡q'	q'				
<i>+voice</i>					↓q'	!q'	‡q'	q'				
<i>Plain+ χ</i>		t̄χ	ts̄χ	⊙χ	χ	!χ	‡χ	χ				
<i>+voice</i>		d̄χ	d̄z̄χ	⊙χ	↓χ	!χ	‡χ	χ				
<i>Plain+ q̄χ'</i>	p̄q̄χ'	t̄q̄χ'	ts̄q̄χ'	⊙q̄χ'	q̄χ'	!q̄χ'	‡q̄χ'	q̄χ'				
<i>+voice</i>		d̄z̄q̄χ'	d̄z̄q̄χ'	⊙q̄χ'	↓q̄χ'	!q̄χ'	‡q̄χ'	q̄χ'				
<i>Plain+ ?</i>				⊙?	?	!?	‡?	?				
<i>+voice</i>				⊙?	↓?	!?	‡?	?				
<i>Plain+ h</i>				⊙h	h	!h	‡h	h				
<i>+voice</i>				⊙h	↓h	!h	‡h	h				

Table 1. Consonants of West !Xoon (Taa), including clusters (after Naumann, 2016)

Truill (198: 69-70) notes that V_1 /**a**/ (/A/ in the notation adopted here) is subject to coarticulatory and assimilatory raising and fronting effects from neighboring segments:

The vowel **a** has the greatest number of contextual variants and is subject to assimilatory pressure from both a preceding consonant and succeeding consonant or vowel. It is raised and fronted when followed by **i**, **e** either contiguously, or after an intervening consonant. The greatest assimilatory effect on **a** is exerted by the combined effects of a preceding dental consonant such as **t**, **l**, **ʈ** and a following **i**, **n**. In this environment, **a** is pronounced either as a lowered-high and slightly centralized vowel [ɪ̠], or as a raised-mid central [ɜ]. In certain cases, it may assimilate fully to the high tongue position of the surrounding consonants and [i] yielding a long [i:].

The assimilation patterns described by Truill involve several potential triggers, sometimes operating together: /A/ partially or fully assimilates to a following front vowel /i e/ if it is preceded by a subset of coronal consonants, which includes all coronal egressive consonants, and all the dental /| ʃ |ʰ.../ and palatal /ɸ ʧ |ʰ.../ clicks. This set of coronal consonants is shaded in Table 1, and detailed in Table 2 below. I will henceforth represent it as $C_{[+]}$ (vs. $C_{[-]}$ for the consonants that do not participate in the assimilatory patterns; the coronal consonants included in $C_{[-]}$ are shown in Table 2).⁵

Included coronals (= $C_{[+]}$)	Egressive:	t, d, tʰ, dʰ, tʳ, s, ts, dʒ, tsʰ, dʒʰ, tsʳ, dʒʳ
	Clicks	and ɸ series
Excluded coronals ($\subset C_{[-]}$)	Clicks:	! and series

Table 2. $C_{[+]}$ and $C_{[-]}$ coronals in East !Xoon

The target vowel may be modal /A/, glottalized /Aʔ/, or breathy /A̤/, but not pharyngealized /Aʕ, Aʕʔ/ or strident /A̤ʕ/, which are not affected. This is expected, as pharyngealization is articulatorily antagonistic to raising (cf. Section 2). The effects mentioned by Truill are illustrated in (2)-(4) below with words taken from his dictionary (Truill 1994; see also Truill 1985: 91).⁶

- (2) /A/ → [i] / $C_{[+]} _ i$
- | | | | |
|-------|-------|---------------------|-------------------------------------|
| /tʰi/ | [tʰi] | ‘pad (of paw)’ | cf. pl. tʰba-tê |
| /sʰi/ | [sʰi] | ‘come to-CLASS.1ii’ | cf. sá-ā ‘come to-CLASS.2ii’ |
| /ʃi/ | [ʃi] | ‘see-CLASS.1’ | cf. deverbal form ʃāā |
| /ɸi/ | [ɸi] | ‘steenbok’ | cf. pl. ɸaba-tê |

5. The only two coronal egressive consonants that are not in this list are **n** and **ʔn**. There are very few lexical stems in the dictionary that start with either of these consonants (**n** = 25, **ʔn** = 4), and none of them presents the phonotactic characteristics conducive to the raising and fronting assimilation. This is very likely to be an accidental gap.

6. Truill does not provide a phonetic transcription for each entry in the dictionary, but only for a few (most of the time to indicate raising and fronting). Many entries where the conditions for raising and fronting are met do not include such a transcription. It is unclear whether these are exceptions or if this is just due to inconsistency on the part of the author. I tentatively assume the latter.

- (3) /A/ → [e] / C_[+]__e
 /t̪ʰe/ [t̪ʰe] ‘welcome-CLASS.3’ cf. deverbal form t̪ʰa
 /ʃ̪e/ [ʃ̪e] ‘see-CLASS.3i’ cf. deverbal form ʃ̪ā
 /ʃ̪e/ [ʃ̪e] ‘jaw’ cf. pl. ām(a)-t̪e
- (4) /A/ → [ɜ] ~ [ɪ] / C_[+]__C_m i
 a. C_m = non-coronal **b, m**
 /ʔ̪i d̪ʰābi/ [ʔ̪i d̪ʰɔbi] male name
 /s̪āmi/ [s̪ɔmi] ‘spin’
 /ʃ̪ābi/ [ʃ̪ɔbi] ‘young steenbok’
- b. C_m = coronal **n, l**
 /t̪ʰāli/ [t̪ʰɔli] ‘skin for carrying a child’
 /s̪āni/ [s̪ɔni] ~ [s̪ini] ‘pre-orbital gland, scent mark’
 /ʃ̪āli/ [ʃ̪ɔli] ‘fold-CLASS.1ii’

The examples (2)-(4) above illustrate two types of changes: total assimilation of /A/ to V₂ (raising and fronting of /A/ to [i] or [e]), and partial assimilation (raising of /A/ to [ɜ ~ ɪ]). Both are allophonic.

As shown in (5), total assimilation of /A/ to [i] or [e] is also observed when the initial consonant is a glottal stop /ʔ/, which lacks a place feature, and is thus articulatorily neutral, i.e. neither C_[+] nor C_[-].

- (5) /A/ → { [i], [e] } / ʔ__ { i, e }
 /ʔ̪i d̪ʰābi/ [ʔ̪i d̪ʰɔbi] male name
 /ʔ̪ā-i/ [ʔ̪ii] ‘eat-CLASS.ii’ cf. deverbal form ʔ̪ā
 /ʔ̪ā-e/ [ʔ̪ee] ‘eat-CLASS.3i’

These examples constitute evidence for the intrinsic full assimilatory effect of a front V₂ on an immediately preceding /A/, in the absence of any effect from the other neighboring segments.

With any other initial consonant, i.e. C_[-], only partial assimilation is attested: /A/ is raised to [ɜ], and sometimes fronted to [æ ~ ɛ ~ e], as shown in (6) and (7) below, with the few examples I could find in Traill’s (1994) dictionary, where indication of this partial assimilation is unfortunately only rarely provided.⁷

- (6) /A/ → [ɜ ~ æ ~ i] / C_[-](C₂)__i
 /ʃ̪āi/ [ʃ̪ɛi] ‘non-burning end of a stick’
 /ʃ̪āi/ [ʃ̪æi] ?⁸

7. Bradfield (2014: 36) notes that in Traill’s East !Xoon (!Xóō) recordings on the UCLA phonetics lab archive “all <-ai> words with back clicks appear to show the same degree of raising as other cases of moderate raising. There is not enough data to make any statistically meaningful claim, but both auditory impression and acoustic measurements suggest this. For example, in one recording <!hai> appears to show considerable assimilation, varying from [əi] to [ei] in the same speaker.”

8. This example is given by Traill (1994: 40) without a translation. It is probably one of the following three words, for which no phonetic transcription is provided in the dictionary: ʃ̪āi

- (7) /A/ → [ɜ~æ~ɛ] / C_[-](C2)___e
 /ǀǂǃǄǅ/ [ǀǂǃǄǅ] ‘die down (of the wind)’
 /ǁǂǃǄǅ/ [ǁǂǃǄǅ] ‘three’
 /ǀǂǃǄǅ ǁǂǃǄǅ/ [ǀǂǃǄǅ ǁǂǃǄǅ] personal name

The C_[-] consonants in (6) and (7) are not neutral (contrary to /ʔ/, cf. (5)), but seem to counteract the effect of the following front vowel, by preventing it from affecting the target vowel to the full extent of its power.

The nature of the intervening C_m in the C_[+]___C_mi context also seems to be relevant to the assimilation pattern (the only six C_m attested in East !Xoon are /b/ [b~β], /j/ [j~j], /m/, /n/, /ɲ/, and /l/). As can be seen in (4)a above, when C_m is non-coronal [b, m], the cumulative effect of C_[+] and /i/ raises /A/ to [ɜ]. When C_m is a coronal [l, n], as in (4)b, raising to [ɪ] (/ǀǂǃǄǅ-i/ → [ǀǂǃǄǅɪ]) and even full assimilation to [i] (/sáni/ → [sáni] ~ [sini]) are attested, which indicates that the intervening coronal helps the assimilation by adding some of its assimilatory power. Finally, a palatal C_m (mostly /ɲ/, /j/ being extremely rare in C_m position) seems to be strong enough as a trigger to have a raising and fronting effect on V₁ /A/ even when the following vowel is the low back vowel /a/, as shown in (8).

- (8) /A/ → [ɜ~e~i] / C_[+]___ɲa⁹
 /ǀǂǃǄǅ/ [ǀǂǃǄǅ] ‘marriage’
 /ǀǂǃǄǅ ǁǂǃǄǅ/ [ǀǂǃǄǅ ǁǂǃǄǅ] personal name
 /ǀǂǃǄǅ/ [ǀǂǃǄǅ] ‘dew claw of a lion’¹⁰
 /ǀǂǃǄǅ/ [ǀǂǃǄǅ] ‘pout’
 /qǀǂǃǄǅ t^hǂǃǄǅ/ [t^hǂǃǄǅ] ~ [t^hǂǃǄǅ] ‘work metal, hammer flat’

The properties of the assimilation pattern described so far are summarized in Table 3, where the degree of assimilation is represented by different shades of gray (the non-low back vowels /o, u/ are omitted for the sake of simplicity). Note that it is not clear what effect the combination of C_[+]___ and ___C_me (i.e. C_[+]___Je, C_[+]___Le, and C_[+]___Be) has on V₁ /A/: based on Traill’s description quoted above, one would expect /A/ → [ɜ] raising. One would also expect the raising and fronting effect of ___C_me to be less important than that caused by ___C_mi (e.g. [ɜ~e~e] rather than [ɜ~ɪ~i]). However, I could not find any illustration of this in Traill’s (1985) description, nor in his dictionary, which could be an indication either that there is no effect, or that the effect is less salient. I will thus ignore the C_[+]___C_me contexts in the remainder of the discussion.

‘hole dug by sexually mature wildebeest and hartebeest to mark territory’, ǁǂǃǄǅ ‘persistent rains’, or ǁǂǃǄǅ ‘move close together’.

9. There are three more C_[+]___ɲa words in the dictionary for which no phonetic transcription is given: tǂǃǄǅ ‘thank’, ǁǂǃǄǅ ‘red’, and ǀǂǃǄǅ ‘black’. Whether these are exceptions is unclear. Note also the /A/ → [i] full assimilation in /mǂǃǄǅ/ → [mí:a] (from [míɲa]) ‘kin’, despite the initial C_[-].

10. This and the next word are listed in the dictionary as ǀǂǃǄǅ and ǀǂǃǄǅ respectively. I have taken the liberty to interpret V₁ as being underlyingly /A/, in accordance with the analysis adopted here.

	OV ₁ V ₂			OV ₁ C _m V ₂								
	<u>i</u>	<u>e</u>	<u>a</u>	<u>Ji</u>	<u>Je</u>	<u>Ja</u>	<u>Li</u>	<u>Le</u>	<u>La</u>	<u>Bi</u>	<u>Be</u>	<u>Ba</u>
ʔ ₋	i	e	a	-	-	-	-	-	-	-	-	a
C _[+] ₋	i	e	a	-	-	3~i	3~i	3?	a	3	3?	a
C _[-] ₋	3~e	3~ε	a	-	a	a	a	a	a	a	a	a

Table 3. Realization of V₁ = /A/ in all O₋(C_m)V₂ contexts in East !Xoon (“-” = unattested combination)

Table 3 clearly illustrates the cumulative effect at work in this pattern, and the different levels of assimilatory strength of the co-triggers involved. The post-target front vowels {i,e} are strong enough to fully assimilate an immediately preceding /A/, as revealed by their effect in isolation, that is, with neutral /ʔ/ in onset position (cf. (5) above). This makes them the strongest triggers. All the other co-triggers are weaker: they do not have any effect on their own. However, they can team up with other weak co-triggers to either raise /A/ to a non-low central vowel [3~ɛ] or raise and front it to [i, e], depending on their relative strengths, as illustrated in the trigger strength hierarchy in Table 4 and Table 5.

<i>High/front assimilatory strength</i>					<i>Counteracting effect</i>			
<i>super-strong</i>	<i>strong</i>	<i>weak</i>			<i>weak</i>	<i>strong</i>		
<u>i</u>	>	<u>e</u>	>	C _[+] ₋ , <u>J</u>	>	<u>L</u>	<	C _[-] ₋ , <u>B</u>

Table 4. Trigger strength in East !Xoon fronting/raising

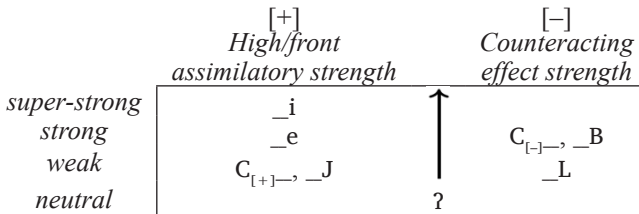


Table 5. High/front assimilatory strength scale in East !Xoon

The strength of the effect of /i e/ on a preceding /A/ also depends on distance: it disappears when both vowels are separated by an intervening consonant, unless the consonant immediately preceding the target is of the C_[+] type, in which case the conjoined effort of these two co-triggers still depends on the nature of the intervening consonant. Intervening palatals (C_[+]) are strong enough to qualify as one of the two co-triggers needed to raise /A/ to [3] and sometimes even to fully assimilate it to [i]. Dentals (< C_[+]) are only strong enough to help two existing co-triggers to push the assimilation a little further than [3]. Finally, labials (< C_[-]) seem to have a similar counteracting effect to that of initial C_[-].

The effects of all the possible trigger combinations are summarized in Table 6, where the notation [a~b] stands for a continuum of attested phonetic realizations from [a] to [b], e.g. [ɜ~i] refers to any realization between [ɜ] and [i] on the low/back to high/front diagonal, including [ɿ], [ɛ], [e] (cf. Figure 2 below).

Trigger strength					Triggers	Effect
ss[+]	s[+]	w[+]	w[-]	s[-]		
✓		(✓)			(C[+])_i	/A/ → [i] strongest effect
	✓	(✓)			(C[+])_e	/A/ → [e]
✓		✓		✓	C[+]_Li	/A/ → [ɜ~i]
		✓✓			C[+]_J	
✓				✓	C[-]_i	/A/ → [ɜ~e]
	✓			✓	C[-]_e	/A/ → [ɜ~ɛ]
✓		✓		✓	C[+]_Bi	/A/ → [ɜ] weakest effect
		✓			C[+]_J	/A/ = [a] no effect
		✓			_Li	
✓			✓	✓	C[-]_Li	
✓				✓	_Bi	
✓				✓✓	C[-]_Bi	
		✓		✓	C[-]_J	
				✓	C[-]_	

Table 6. Trigger combinations and their effects in East !Xoon

I have until now ignored one of the triggering contexts mentioned by Traill (1985: 70; 1994: 40): C_[+]__N, where N represents a coda [m] or [n]. We saw earlier what effect the three nasals [m, n, ŋ] have when they occupy the C_m slot in a C_[+]__C_mV₂ word (cf. (8) and preceding prose). Traill (1994: 40) does not establish any difference between coda nasals and C_m nasals with respect to their role in high/front assimilation, and simply lists C_[+]__m, C_[+]__n, and C_[+]__ŋ as cotriggering contexts. However, coda nasals do not behave like C_m nasals. Coda [n] systematically causes /A/ to raise to [ɜ], whatever the nature of the preceding consonant(s), as illustrated in (9). Note that coda [m] does not seem to have any effect on a preceding /A/ (or at least, no <C(C)am> entry in the dictionary includes a phonetic transcription that would show a raising effect).

- (9) /A/ → [ɜ] / __n
- a. C_{1[+]}(C₂)_n
- /tÁ-n/ [tɜ́n] ‘to-CLASS.5’
 - /sÁ-n/ [sɜ́n] ‘come to-CLASS.5i’
 - /ts’Án/ [ts’ɜ́n] ‘taste’
 - /Ān/ [Āɜ́n] ‘head’
 - /ʔĀn-tê/ [ʔɜ́n-tê] ‘sack (pl.)’
- b. C_{1[-]}(C₂)_n
- /k-Ān/ [kɜ́n] ‘copula-CLASS.5’
 - /b-Ān/ [mɜ́n] ‘because-1SG’ (NB: nasal harmony)
 - /||q^hĀ-n/ [||q^hɜ́n] ‘different-CLASS.5’

The examples in (10) below show that /n/ has this raising effect only when in coda position.¹¹

- (10) /ʔʌn/ [ʔʌn] ‘penis (sg.)’
 /ʔʌna/ [ʔʌna] ‘penis (pl.)’

Given the lack of difference between C_[+]__n and C_[-]__n, I have decided to exclude coda nasals from the set of triggers, tentatively choosing to see the systematic raising effect it causes as an independent phenomenon. It would not be difficult to include it among the triggers, but would complicate the already complex description.

2. Phonetic underpinnings

As noted by Traill (1985: 114), these assimilation patterns involve both raising and fronting. This is clearly shown in the vowel plot in Figure 2, where the various realizations of /A/ form a diagonal from low/back [a] to high/front [i].

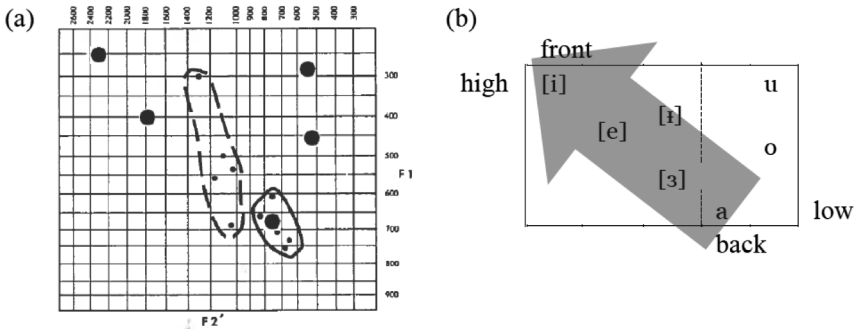


Figure 2. (a) F1 by F2' (i.e. F2–F1) plot of East !Xoon modal [i e a o u]. The large dots represent average values from V1'V2 and V1V2 sequences (V1 = V2). The scatter for non coarticulated [a] (solid line) and raised [a] (broken line) is plotted with small dots. (adapted from Traill’s (1985: 71-72) Figures 5 and 6). (b) a schematized version, the arrow highlighting the [a] - [i] diagonal along which the realizations of V1 /A/ are distributed

The role of the C_[+] consonants “seems to be that they facilitate the raising process” (Traill 1985: 114). Traill shows that the crucial explanation of the different behavior of C_[+] and C_[-] consonants lies in their articulatory properties: C_[+] consonants are laminal, C_[-] are not. C_[+] consonants thus involve extensive contact between the front part of the tongue and the region of the palate comprised between the upper teeth and the alveo-palatal region, and can only be articulated with a raised and fronted tongue body, which is directly responsible for the raising/fronting effect. This distinction explains why alveolar [ʔ] does not belong to the C_[+] category, despite being coronal like all C_[+]: it is indeed not laminal, but apical. In order to maintain the apico-alveolar closure during the production of [ʔ], the post-apical

11. Alternatively, one could see the difference between [ʔʌn] and [ʔʌna] as resulting from the counteracting effect of the following low/back vowel, preventing raising.

part of the lamina is lowered and kept away from the palate. The same can be said about the articulation of lateral [l] ($\subset C_{[-l]}$), which also involves an apico-alveolar constriction. Traill (1985: 109) notes that “the two laminal clicks [l̥] and [l̥ʰ] have generally a greater amount of tongue contact with the palate than the apical clicks [l̥] and [l̥].” This can be seen on the tracings in Figure 3.

The high and front position of the tongue involved in the articulation of laminal segments is what is important here, in particular after the anterior release. As shown in Figure 3 with the superimposed tongue outline for the hold positions of the five clicks and the vowels [i, e, a], the articulation of the laminal clicks [l̥, l̥ʰ] brings the middle and front parts of the tongue to a position that is very close to that required for the production of [i] and [e]. “Conversely, the apicality of [l̥] and [l̥] and its magnification during suction introduces an articulatory distance from [i] and [e]” (Traill 1985: 116).

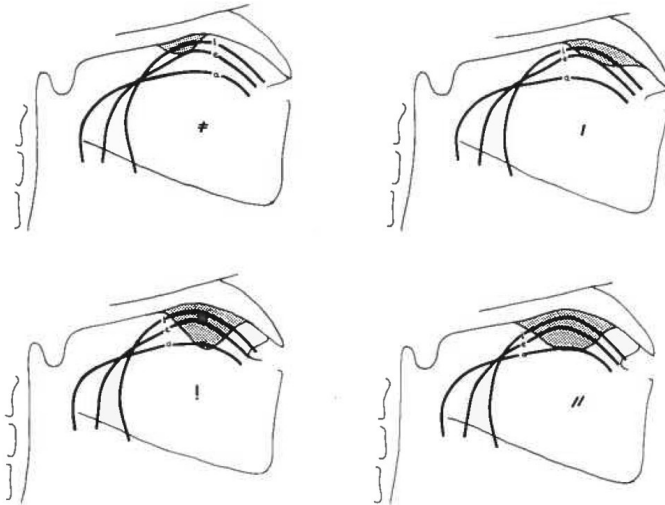


Figure 3. Tongue positions for the suction cavities [l̥ʰ] [l̥], [l̥], and [l̥] prior to release (shaded areas) with the tongue positions of the vowels [i e a] superimposed (adapted from Traill 1985: 115, Fig. 27)

Finally, the tracings on Figure 4 (a-b) clearly show the intermediate articulatory position of [ɜ] between [a] and [i]: the tongue in [ɜ] is raised away from [a] and towards [i], without reaching the height of [e]. Interestingly, “if one examines the position of the root of the tongue for [ɜ], one sees that there is a wider pharynx for [ɜ] than for [e]. The largest assimilatory change from the tongue position of [a] thus lies in advancing the tongue root toward the tongue root position of [i]” (Traill 1985: 73-74). In other words, this assimilation clearly involves both raising of the tongue dorsum, and fronting (or absence of retraction) of the tongue root: the acoustic diagonal identified in Figure 2 above is mirrored in articulation by a diagonal that takes the tongue body from a low and retracted position for [a], through an intermediate position for [ɜ] and [e], to a high and advanced position for [i].

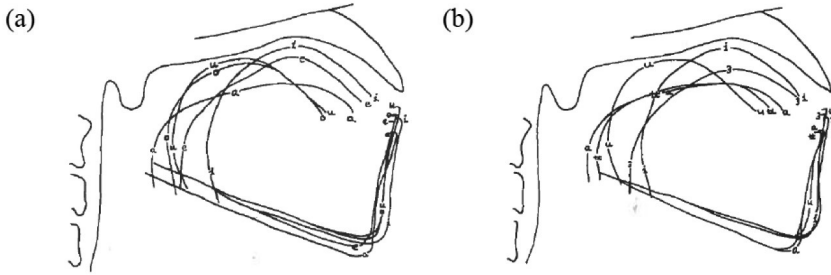


Figure 4. Tongue and jaw positions for one subject, traced from a single frame during the steady state production of the vowels (a) [i e a o u] as first vowel in the demonstrative *ti'i*, *ta'a*, *te'e*, *tu'u*, and the nonsense form *to'o*; (b) [ɜ ʊ] in *tán* [tán] 'to it' and *tùm* [tùm] 'swallow', plotted against the positions for [i a u] (Traill 1985: 73-74, Fig. 7 & 8)

The fact that pharyngealized [aʰ] and strident [a̠ʰ] are not affected by the high/front assimilation also has a clear articulatory basis: their articulation involves a significant retraction and lowering of the tongue root (in particular for the strident vowels, which involve aryepiglottal trilling), which is antagonistic with fronting and raising (see Traill 1985: 75-77, Fig. 9 & 11a). The assimilatory pattern described above is thus clearly rooted in both articulation and perception.

3. Intervening consonant in complex onset

Finally, it must be noted that C_[+] clicks co-trigger the assimilation even when separated from the target vowel by a consonant, in the case of C_{click}C initial clusters, as shown in (11)-(13) below.

- (11) /A/ → [ɜ] / C_[+] Ci
 Cl.+ʔ /ʔÁli/ [ʔɜli] 'flick off from'

- (12) /A/ → [i] / C_[+] i
 Cl.+ʔ /ʔÁi/ [ʔii] 'lover' cf. pl. ʔàba-tê
 Cl.+h /hÁi/ [hi] 'posterior aspect of a body part' cf. pl. hába-tê
 Cl.+qʰ /qʰÁi-sà/ [qʰii-sà] 'backwards, behind'¹²
 Cl.+qʰ /qʰÁi/ [qʰii] 'buffalo' cf. pl. qʰába-tê

- (13) /A/ → [e] / C_[+] e
 Cl.+ʔ /ʔÁ-e/ [ʔée] 'chase-CLASS.3ii' cf. deverbal form ʔáá
 Cl.+q /qÁe/ [qée] 'Nama' cf. pl. qám
 Cl.+qʰ /qʰÁe/ [qʰée] 'bush sp.' cf. pl. qʰám

12. This word is spelt qʰii-sà in the dictionary. I have taken the liberty to interpret V₁ as being underlyingly /A/, in accordance with the analysis adopted here.

However, the seven consonants that can occur as the second element in a stem initial cluster [q q^h q' χ q̄χ' ? h] do not all behave alike. While [? h q q' q^h] are inert and transparent to the assimilatory effect exerted by the initial consonant, as shown in (11)-(13) above, the uvular fricative [χ] and ejective affricate [qχ'], on the other hand, block the effect of the preceding C_[+]: [C_[+]χ] and [C_[+]q̄χ'] clusters behave like C_[-] consonants.

The reason for this is likely due to the length of these two consonants: “the duration of [the intervening consonant] varies but may be considerable, from a mean 28ms for the uvular accompaniment [q], to a mean 88ms for the glottal stop accompaniment [ʔ], to a mean of 130ms for the velar fricative accompaniment [x]” (Traill 1997: 108; cf. also Traill 1993). That fricatives and affricates should be longer than stops is in no way surprising, and the longer the second consonant in a C_{click}C cluster, the more time the front part of the tongue has to move towards the low target position necessary for the articulation of the following [a] (taken to be the default realization of /A/). There seems to be a length threshold beyond which the intervening consonant blocks the effect of C₁ on the target vowel: [ʔ, q, q', q^h, h] are below the threshold, [q̄χ', χ] above.

Finally, it must be noted that this cumulative raising and fronting coarticulatory and/or assimilatory pattern in East !Xoon looks entirely “natural.” Whether it is phonological or can be reduced to phonetic implementation is, however, unclear. To answer this question, we need more reliable data on whether the effects noted are categorical or gradient (or either, depending on context), how much intra- and inter speaker variation there is, or what role frequency plays. The description presented above is thus only preliminary, and requires both more data and further analysis.

4. The case of Glui

A similar pattern is attested in Glui (Khoe-Kwadi; Nakagawa 1996, 2006, 2010), but it appears to be less phonetically natural, more deeply phonologized than in Taa. The Glui vowel inventory is presented in Table 7: the same five basic vowel qualities as in Taa are attested, as well as the same underspecification of V₁ for dorsal features. The only difference is that Glui has only one non-modal phonation type: pharyngealization.

The different phonetic realizations of V₁ /A/ are relatively similar to Taa: [a, a, e, e, i], illustrated in (14)-(20) (ignoring nasalization). They are distributed along the same diagonal between low back [a] and high front [i]. The conditioning of the realization of /A/ is however different from Taa in non-trivial ways. Indeed, the set of consonants co-triggering raising and fronting (C_[+]) includes not only laminal consonants, as in Taa, but also velars (except ejective [k'] and nasal [ŋ]), and labial consonants, as shown in Table 8, where the C_[+] consonants are shaded.

I will first look at assimilatory patterns targeting /A/ in O_V₂ context. In Glui, like in Taa, V₂ [i] is strong enough to fully assimilate a previous /A/, as shown by the example in (14), where the glottal plosive /ʔ/ in root onset position is articulatorily neutral. Whether [e] has the same effect is unknown, for lack of data.¹³

13. Examples in this section are taken from Nakagawa (1996) and Nakagawa *et al.* (2004).

		V ₁ features		V ₂ features				V ₁ allophones
		[round]	[phar]	[high]	[low]	[back]	[nasal]	
V1	/A/	-	-					[a ḁ e e i ĩ ā ī]
	/U/	+	-					[u o ũ]
	/a ^s /	-	+					[a ^s ā ^s]
	/u ^s /	+	+					[u ^s ũ ^s]
V2	/i/			+	-	-	-	
	/e/			-	-	-	-	
	/a/			-	+	+	-	
	/o/			-	-	+	-	
	/u/			+	-	+	-	
	/ĩ/			+	-	-	+	
	/ā/			-	+	+	+	
	/ũ/			+	-	+	+	

Table 7. Distribution of vowel features in disyllabic roots in Glui (after Nakagawa 2010)

	labial	alveolar	alv. affr. /palatal	palatal	dental	alveolar	palatal	lateral	velar	uvular	uvular- uvular- aricate	glottal
<i>Plain</i>	p	t	ts̄	c	ʃ	!	‡		k	q		ʔ
<i>Voiced</i>	b	d	dz̄	ɟ	ʒ	!	‡		g	ɢ		
<i>Vl. aspirated</i>	p ^h	t ^h	ts̄ ^h	c ^h	ʃ ^h	! ^h	‡ ^h	^h	k ^h	q ^h		
<i>Vl. ejective</i>		tʼ	ts̄ʼ	cʼ	ʃʼ	!ʼ	‡ʼ	ʼ	kʼ	qʼ	q̣χʼ	
<i>Nasal plain</i>	m*	n**			ĩ	!	‡		ŋ			
<i>Fricatives</i>		s								χ		h
<i>Sonorants</i>	w ^{Cm}	r ^{Cm}		j								
<i>Plain+ ʔ</i>					ʔ	!ʔ	‡ʔ	ʔ				
<i>Plain+ h</i>					h	!h	‡h	h				
<i>Plain+ q</i>					q	!q	‡q	q				
<i>+voice</i>					q	!q	‡q	q				
<i>Plain+ q^h</i>					q ^h	!q ^h	‡q ^h	q ^h				
<i>+voice</i>					q ^h	!q ^h	‡q ^h	q ^h				
<i>Plain+ qʼ</i>					qʼ	!qʼ	‡qʼ	qʼ				
<i>Plain+ χ</i>		t̄χ	ts̄χ		χ	!χ	‡χ	χ				
<i>Plain+ q̣χʼ</i>		t̄q̣χʼ	ts̄q̣χʼ		q̣χʼ	!q̣χʼ	‡q̣χʼ	q̣χʼ				

*attested in O, C_m coda **attested only in C_m and coda ^{Cm}attested only in C_m

Table 8. The consonant system of Glui (Nakagawa 2006: 109, 139; 2010)

- (14) /A/ → [i] / (ʔ)___i
 /ʔÁi/ [ʔii] ‘to seem’

Contrary to Taa, palatal consonants in onset position are also strong enough to fully assimilate /A/ to [i], irrespective of the neighboring consonants or vowels, as shown (15).

- (15) /A/ → [i] / Pal___
 /cÁé/ [cié] ‘to be standing’
 /ʒÁā/ [jiā] ‘owner’
 /ʒÁō/ [jiō] ‘to burn’
 /cÁbè/ [cibè] ‘to flash the lightning’
 /ʒÁná/ [jiná] ‘to flatter’

/A/ is also fully assimilated to [i] or [e] when wedged between a C_[+] and [i] or [e]:

- (16) /A/ → [i] / C_[+]___i
 /ḍzÁi/ [ḍzî] ‘to tire’
 /|Ái/ [|î] ‘song’
 /‡Ái/ [‡î] ‘to be skillful’
 /bÁi/ [bí] ‘plant sp.’
 /kÁi/ [kí] ‘to choose fat game’

- (17) /A/ → [e] / C_[+]___e (C_[+] ≠ Pal, cf. (14))
 /tsÁé/ [tséé] ‘to work’
 /|Áé/ [|éé] ‘wildebeest’
 /‡Áē/ [‡éē] ‘ear’
 /bÁè/ [béè] ‘to cause to fail’
 /kÁrē/ [kééré] ‘to return’

Interestingly, /A/ is realized [e] when wedged between a C_[+] and the high back vowel [u], as illustrated in (18).¹⁴

- (18) /A/ → [e] / C_[+]___u (C_[+] ≠ Pal, cf. (14))
 /ts^hÁū/ [ts^héū] ‘hand, finger’
 /|Áu/ [|éū] ‘one’s character’
 /‡Áú/ [‡éú] ‘kori bustard’

This seems to indicate that [u] is a weaker trigger than [i]: its assimilatory effect seems to be a compromise between the two antagonistic forces of its articulatory characteristics: its height militates for raising, but the low position of the tongue dorsum and tip necessary for its articulation prevents it from raising /A/ all the way to [i] (assuming [i] is more fronted than [e]).

14. Note that sibilant fricatives and affricates seem to have a stronger effect than laminal clicks, triggering higher and more fronted realizations of /A/ as [e] ~ [ɛ] ~ [i] even when followed by [u] in at least three cases: /ḍzÁu/ [ḍzéú ~ ḍzíú] ‘to keep company’, tsÁú [tséú ~ tsíú] ‘to get fat’, sÁú [séú ~ síú] ‘to set a dog on something’ (Nakagawa, p.c.).

Finally, like in Taa, $C_{[-]}$ consonants (**[!]**, **[||]**, uvulars and ejective **[k’]**) have a strong counteracting effect on the assimilatory strength of a high V_2 : the observed raising in $C_{[-]}V_{[+high]}$ context is limited to **[e]** ($C_{[-]}$ = apical click series **[!]** **[||]**) and **[a]** ($C_{[-]}$ = uvulars and **[k’]**).¹⁵

- (19) /A/ → **[e]** / {**[!]**, **[||]**}__V[+high]
 - /ĩÁĩ/ [ĩéĩ] ‘lump’
 - /ʰÁũ/ [ʰéũ] ‘to clear away’
- (20) /A/ → **[a]** / {(click)Q, k’}__V[+high] (Nakagawa p.c.)
 - /qʰÁĩ/ [qʰaĩ] ‘stick sp.’
 - /qÁũ/ [qaũ] ‘cloud sp.’
 - /k’Ai/ [k’ai] ‘to belch’

/A/ is realized **[a]** in every other O_V_2 context, i.e. when V is **[o]** or **[a]** (except if O is palatal, cf. (14)), and in $C_{[-]}e$. This is summarized in Table 9, where gradient shading indicates the degree of the coarticulatory/assimilatory effect of the environment.¹⁶ Table 10 shows the trigger strength hierarchy (in OVV roots only).

	$_V_2 (C_m = \emptyset)$				
	i	u	e	o	a
1. Palatal	i	i	i	i	i
2. Alveolar + and † series	i	e	e	a	a
3. Labial	i	?	e	?	a
4. Velar	i	?	?	a	a
5. ! and series	e	e	a	a	a
6. (CLICK)Q, k’	a	a	a	a	a

Table 9. Realization of $V_1 = /A/$ in O_V_2 contexts in Glui

The intervening C_m also plays a role in this assimilatory pattern. In the interest of length, I will not go into too much detail here, and give only one example: $C_{[+m]}$ **[r]**, **[n]**, **[b]**, and **[m]** help non-palatal $C_{[+]}$ change /A/ to **[e]** even before non-high back **[a]** or **[o]**, as illustrated in (21).¹⁷

15. Hiroshi Nakagawa (p.c., 22 Dec. 2015)

16. For lines 1-2 and 5-6, the data and generalizations are borrowed from Nakagawa (1996). For lines 3-4, the data are from Nakagawa *et al.*'s (2004) unpublished Glui dictionary. “?” indicates lack of data. The shading (or lack thereof) of the four cells containing “?” is an extrapolation based on Nakagawa’s (1996) generalizations.

17. The fact that /A/ → **[e]** in (21) occurs irrespective of the place of articulation of C_m (whether coronal or labial) seems to indicate that this process is not triggered by the place of C_m , i.e. it might not be assimilatory/co-articulatory. One possible explanation, suggested by Hiroshi Nakagawa, is that this process is rather triggered by the prosodic shape of the template $OV_1C_mV_2$, in which V_1 is phonetically always short. The shortness of V_1 in this template may cause undershoot of V_1 in height. /A/ → **[e]** in (21) would thus be multi-triggerred, O being responsible for the fronting effect, and C_m for raising.

high/front	low/back
<i>strong</i> ↑	Palatal __
	__i
	__u
	__e
<i>weak</i> ↓	Alveolar, l, ʎ, Labial,
	Velar __
	__a, __o
	! __, ll __
	(CLICK)Uvular, k' __
	↓ <i>strong</i>
	↓ <i>weak</i>

Table 10. Assimilatory strength in Glui OV₁V₂ roots

- (21) /A/ → [e] / C_[+] C_m {a, o} (C_[+] ≠ Pal, cf. (14))
- /ḍzÀrà/ [ḍzèrà] ‘to be still small (fruit)’
- /ḶÀrō/ [Ḷèrō] ‘ostrich’
- /ḶĀnā/ [Ḷènā] ‘dregs’
- /Ábá/ [ébá] ‘to wear on the head’
- /kÁmá/ [kémá] ‘time, season’

This is summarized in Table 11. The only difference between Table 9 and Table 11 is in the six cells enclosed in the dotted line, representing the effect of [r n b m] in a C_m position.

		__C _m V ₂ (C _m = [r n b m])				
		i	u	e	o	a
1.	Pal __	i	i	i	i	i
2.	Alv + l and ʎ series __	i	e	e	e	e
3.	Lab __	?	?	?	?	?
4.	Vel __	i	?	?	?	a, e
6.	! and ll series __	a	a	a	a	a
7.	(cl)Q, k' __	a	a	a	a	a

Table 11. Realization of V₁ = /A/ in O __C_mV₂ contexts

Finally, similarly to Taa, only a subset of intervening consonants in complex onsets are neutral or transparent to the assimilatory pattern, the others having a backing or blocking effect. However, contrary to Taa, it is not the length, but the articulatory properties of the intervening consonant that determine whether it is neutral/

transparent or has a backing or blocking effect (Nakagawa 2006). The differences between the two languages are summarized in Table 12, where the dotted line in each of the language columns separates the blocking intervening consonants from the neutral ones: glottal vs. uvular in Glui, length threshold between [q^h] and [qχ'] in Taa.

		Glui	Taa	
<i>Glottal</i>	ʔ	neutral/transparent	neutral/transparent	<i>min length</i>
	h	neutral/transparent	neutral/transparent	
<i>Uvular</i>	q	backing/blocking	neutral/transparent	<i>max length</i>
	q'	backing/blocking	neutral/transparent	
	q ^h	backing/blocking	neutral/transparent	
	qχ'	backing/blocking	backing/blocking	
	χ	backing/blocking	backing/blocking	

Table 12. Neutral/transparent vs backing/blocking effect of intervening consonants in complex onsets in East !Xoon and Glui

5. Analytical issues and relevance for phonological theory

5.1. Analyses proposed so far

In trying to account for the East !Xoon facts with articulatory features, Traill (1985) encounters many problems. He first notes that this cannot be done in Chomsky & Halle’s (1968) feature system. He then notes that “the role played by [ɿ] and [ɿ̚] in [the assimilation patterns] seems to be that these two clicks facilitate the raising process and this points to a categorization of them as [+high].” His proposal is thus to analyze C_[+] consonants as [+high], and C_[-] as[-high]. A further specification is however needed: the feature [±high] is only relevant for the front part of the tongue. Indeed, [ɿ] and [ɿ̚] are also high by virtue of the velar closure; however, due to their apical articulation, the front part of the tongue is overall in a lower position than for the laminal articulation of [ɿ] and [ɿ̚], which is precisely what is relevant for the raising/fronting assimilation.

Note that it is even more difficult to account for the Glui data using only articulatory features. We saw in section 4 that C_[+] consonants in Glui do not constitute a natural class from an articulatory point of view: labial and velar consonants pattern with alveolar laminal consonants, despite being very different, both articulatorily and perceptually (labials and velars are grave, alveolar laminal consonants are acute). It is also noteworthy that phonetic natural classes do not always behave alike, as is the case with velars: [k] and [k^h] have an (unexpected) mild fronting/raising effect, while [k'] has a strong lowering/backing effect (more in line with the articulatory and perceptual properties of velar consonants). Finally, [u] acts as a co-trigger of raising and fronting, as in /ɿAu/ → [ɿeu], despite (i) not being a front vowel, and (ii) not involving a high position of the front part of the tongue (as per Traill’s definition of [±high]).

Ten years after his initial articulation-based proposal, Traill (1995) proposes a perceptual analysis crucially based on the feature [\pm grave] (Jakobson *et al.* 1952; Jakobson 1968). Front vowels and laminal (= $C_{[+]}$) consonants in East !Xoon are acute, i.e. [-grave], while back vowels and non-laminal (= $C_{[-]}$) consonants are [+grave]. The double-sided vowel assimilation pattern described above can thus be analyzed as in (22):

$$(22) \quad \begin{array}{ccccccc} a & \rightarrow & [i] & / & C_{[+]} & \text{---} & I \\ | & & | & & | & & | \\ [+grave] & & [+grave] & & [+grave] & & [+grave] \end{array}$$

However, this analysis runs into at least two problems. First, it only explains cases of double-sided assimilation involving two triggers, which, as we saw in Section 1, constitute only a subset of the East !Xoon data. Secondly, it models a categorical effect, and not the gradient effects that are at work in East !Xoon.

Finally, Bradfield's (2014: 13, 32-37) recent reanalysis of this pattern mostly follows Traill's (1985) generalizations, by distinguishing laminal clicks [ǀ] from non-laminal ones by their [high] and [back] specifications. The cumulative effects are somehow accounted for in a two-step process (similar to that suggested by Traill's short summary in his 1994 dictionary): "A first-mora plain, breathy or creaky ǀ is raised to ǀ when the second mora contains ǀ , or is a nasal, and the word starts with a dental non-click or ǀ ǀ " (moderate raising); "it is further raised to ǀ when the second mora is just ǀ " (full raising) (p.13). However, this generalization is only a rough approximation of the East !Xoon pattern, as we saw in Section 2, and falls short of accounting for the complexity and the gradience of East !Xoon raising/fronting assimilation. Some of Bradfield's generalizations also do not concord with mine, although we both draw from the same source (mostly Traill 1994). The independent effect of ǀ seems to always be full assimilation to ǀ and not partial raising to ǀ in Traill's (1985, 1994) data (cf. (5)). C_m is not transparent (compare (2)-(3) and (4)), although, as we saw, its counteracting effect is perhaps not due to coarticulation. Finally, uvular C_2 's do not all block "full A-raising": only ǀ and ǀ do (cf. (12) and (13)). It must be said here that extracting these generalizations from Traill's data is not an easy task, and the final picture, as can be gathered from Section 2, remains somewhat blurry on certain points.

It is also important to note that Bradfield's goal is not to explain or account for this pattern, but rather to show that his concept of "concurrent phoneme", applied to the entire segmental phonology of East !Xoon, is compatible with expressing such assimilation rules, and might help shed light on otherwise unexplained aspects for /A/ raising. The main advantage of the concurrent analysis in this case is that it seems to offer an explanation of the transparency of intervening uvular C_2 (/q'?). Indeed, if the click in C_1 and the uvular in C_2 position are concurrent, i.e. not phonologically ordered or linearized, then the uvular C_2 cannot be said to intervene between the laminal click causing the raising and the target vowel /A/: "the target vowel is immediately adjacent to both the click and the accompaniment." A problem for this analysis is of course the fact that there are "opaque/blocking" uvular C_2 , and that, as we saw in Section 3, it is the length of the intervening uvular C_2 that seems

to be the crucial criterion deciding whether it is transparent or opaque. This is not explained by the concurrent analysis, where all C_2 's should have the same status. Furthermore, his two rules (moderate and full raising) are mostly descriptive, and do not explain crucial aspects of /A/-raising, such as the gradience at work, as we said, but also the teamwork effect, which is only stipulated in the rules (both double-sided). The fronting effect is also left unexplained. This, of course, is perfectly acceptable for Bradfield's purpose. But an analysis of this assimilatory pattern must account for both raising and fronting, and Bradfield's hypothesis of a late rule "filling in [-back]" does not seem to be sufficient, in so far as it does not account for the gradient differences noted here between the potential co-triggers.

5.2. Challenges for phonological theory

The data described in this paper are potentially problematic for phonological theory in two ways. First, they seriously pose the question of the potential role of phonetics in phonological computation and the possibility of phonetic grounding in phonology. As mentioned above, the East !Xoon data are phonetically natural, i.e. the phonetic grounding (be it synchronic or historical) is clearly identifiable. The only problem is determining what is phonetic (i.e. purely mechanic), and what is phonological, i.e. part of the abstract sound system, determined by abstract rules or constraints. Indeed, while the weakest effects in Table 6 could easily be construed as coarticulation occurring in the (post-phonological) phonetic realization, the strongest effects definitely look like cases of systematic and unambiguous full assimilation of /A/ to [i] or [e], and have all the appearance of a categorical phonological pattern. Traill noted the problem posed by the complexity of the relationship between phonological specification and phonetic detail in East !Xoon, although he did not try to solve this issue: "optimal phonological specifications cannot meet the joint requirements of being non-redundant while at the same time being directly interpretable in terms of corresponding n -ary phonetic scales" (1985: 121).

The Glui data, on the other hand, points to a non-phonetically grounded account (except perhaps the weakest effects, i.e. the [ɐ, ɶ] realizations of /A/, which could be due to pure phonetic coarticulation), given the fact that the class of consonants triggering the cumulative raising/fronting effect do not form a phonetic natural class, as we saw.

The second challenge of the assimilatory effects described above is their cumulative and gradient nature. These effects constitute cases of "phonological teamwork", i.e. processes that involve multiple triggers, and complex, cumulative segmental interactions (Lionnet 2016). Of course, this is not a problem as long as such effects are only phonetic, and not phonological. However, if phonological, as seems to be the case in Glui (and possibly also in East !Xoon, at least partly), one needs to account for the necessity of this multiplicity of triggers. Traill had already noticed that problem in his 1985 articulatory account, and sketched the beginning of a solution, although he never pursued it: "it would be necessary to formulate a rule involving n -ary values of the feature [high] which would show how [a] was subject to increasing degrees of assimilation when followed by or both preceded and followed by the [n-high] segments [i], [e], [ɪ], [ɥ]" (1985: 114).

As I have shown elsewhere (Lionnet 2016: 167-176), the ganging effects modeled by either Local Constraint Conjunction (Smolensky 1993, 1995) in Optimality Theory (Prince & Smolensky 1993/2004), or weighted constraint models such as Harmonic Grammar (Legendre *et al.* 1990; Smolensky & Legendre 2006) can only model categorical processes, and not cumulative effects similar to the ones observed in V_1 raising/fronting in KBA languages.

A possible solution is to resort to gradient representations, e.g. phonetically grounded “subfeatures” representing various degrees of coarticulatory strength (Lionnet 2016, 2017). While nothing seems to preclude a subfeatural account of East !Xoon, where the fronting/raising pattern looks entirely phonetically grounded, it is a little harder to see how to implement a similar analysis of the Glui data, where phonetic grounding does not seem to be an available option, at least not for the entire data. This of course can only be determined with certainty when we have precise data on coarticulation and variation in both languages, and any proposed analysis will remain preliminary and hypothetical until tested against such data.

Conclusion

In conclusion, the principles governing the realization of V_1 in KBA languages involve very subtle cumulative effects arising from the interaction of up to three segments. These very complex principles vary greatly across languages, as clearly shown by the comparison between East !Xoon and Glui. It is not clear whether the processes at work are purely phonetic or (at least partly) phonological in some of these languages. Such complex, cumulative segmental interactions involving various degrees of assimilatory strength seem to require new, dedicated scalar representations, e.g. multi-valued features, subfeatures, etc. More research is needed in both the phonetic and phonological description of KBA languages, and in the still understudied question of gradience in phonology — both from a typological perspective (accruing the number of attested similar processes), and from a theoretical one (developing appropriate analytical tools, interrogating our understanding of how phonological computation works).

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Résumé

Cet article décrit les processus d'assimilation ciblant la voyelle initiale (V1) des racines bimoraïques dans les langues du bassin du Kalahari (KBA), processus complexes impliquant déclencheurs multiples et effets cumulatifs, décrits pour la première fois par Anthony Traill (1985) en !xoon oriental (tuu). Nous nous concentrons sur deux langues : le !xoon oriental et le glui (khoe-kwadi). Le but est de décrire ces processus le plus en détail possible à partir des sources disponibles, publiées ou non. Nous mettons en lumière les éléments marquants qui différencient les deux langues visées, illustrant ainsi la diversité, passée inaperçue jusqu'à présent, de la réalisation de V1 dans les langues KBA. Enfin, l'article souligne brièvement les problèmes importants que de tels processus cumulatifs peuvent poser à la théorie phonologique, et dont un grand nombre avaient déjà été identifiés par Traill (1985).