Naturalness as a heuristic for (in)complete neutralization: Xhosa's 'unnatural' labial palatalization

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1. Introduction

Phonologists and phoneticians have long asked whether a process's cross-linguistic likelihood is a result of "naturalness[1]." A significant body of literature argues that certain phonological patterns are typologically more common because of their phonetic naturalness (see, e.g., Ohala 1990, Steriade 1997, 2008), or that such patterns are favored because of biases in learning or history (Wilson 2003, 2006, Blevins 2004, Hayes et al. 2009, among many others). (It should be noted that some have argued against these claims, suggesting that phonology is "substance free," such as Anderson 1981 and Reiss 2017.)

Yet, "unnatural" processes do exist. One example, discussed below, is the case of labial palatalization in Xhosa (Bantu), in which palatalization occurs in contexts different from typological predictions (Bennett and Braver 2020).

This palatalization process leads to the neutralization of an underlying contrast between labials and palatals: in the palatalization context, both underlying labials and underlying palatals surface as palatal. Early studies of neutralization assumed that underlying segments and their analogous derived segments surfaced with identical phonetic realizations. For example, in German final devoicing, underlyingly voiceless segments were cited as being identical to voiceless segments derived through devoicing (e.g., Trubetzkoy 1939:235, Jakobson et al. 1952:9). More recent studies, however, have shown that underlyingly voiceless and devoiced segments maintain a small acoustic distinction (Mitleb 1981, Port et al. 1981, Port and O'Dell 1985, inter alia). One question this paper addresses is whether the neutralization caused by Xhosa's labial palatalization is complete or incomplete—are derived palatals and underlying palatals acoustically distinguishable?

[1] Here and throughout, I assume that "natural" processes are those which are motivated by articulation, acoustics, or learning; "unnatural" processes are those that do not. A more thorough discussion of naturalness—including the *degree* of such motivation needed to count as natural—is outside the scope of this paper.

This sort of *incomplete neutralization* (IN) occurs when a contrast is neutralized at the phonological level, but a trace of the underlying contrast is detectable at the phonetic level. IN appears to violate standard assumptions of the modular feed-forward model (Chomsky and Halle 1968, Keating 1996, Pierrehumbert 2001, Bermúdez-Otero 2007) in which the phonetic module has no access to underlying phonological information: since the segments in question are rendered identical at the phonological level, the phonetics should, under these assumptions, also be identical.

In spite of this theoretical contradiction, IN has been reported in numerous languages and contexts: final devoicing in German (see above), Catalan (Dinnsen and Charles-Luce 1984), Dutch (Warner et al. 2004), Russian (Dmitrieva 2005, Kharlamov 2012), Polish (Slowiaczek and Dinnsen 1985), and Afrikaans (van Rooy et al. 2003); flapping in American English (Fisher and Hirsh 1976, Herd et al. 2010, Braver 2014); morphological tone in Cantonese (Yu 2007); among others.

A number of proposals have been put forward to model IN (e.g. van Oostendorp 2008, Yu 2011, Braver 2019). At the same time, some researchers have argued that IN is external to the grammar proper, and is due to factors like hyperarticulation in the laboratory setting or effects of orthographic representation (Fourakis and Iverson 1984, Warner et al. 2006; see Kharlamov 2012 for extensive discussion). None of these proposals, though, have made clear predictions about what sorts of processes are most likely to show incomplete (as opposed to complete) neutralization. I propose here that one heuristic might be whether a process is phonetically natural or unnatural.

In the remainder of this paper, I discuss the basic properties of labial palatalization in Xhosa and describe a study designed to determine whether this process results in complete or incomplete neutralization. I conclude with discussion about the possibility that naturalness may be a way to predict which processes are more or less likely to be incompletely neutralized.

2. Labial palatalization in Xhosa

Xhosa has a typologically unusual process of labial palatalization. In most cases, processes of palatalization are triggered by high and front vocoids, and preferentially target coronals or dorsals (Bateman 2007, 2010, Kochetov 2011). In Xhosa, however, palatalization is triggered by the suffixal verb extension /-w-/, and applies to only labials (see Bennett and Braver 2020 for additional details). (1) below shows a schematic representation of the labial palatalization process.[2] The addition of the passive /-w-/ affix in (2b) triggers palatalization in which /ᵐb/ becomes [ⁿd͡ʒ]. The examples in (3) and (4) respectively show that palatalization does not apply to non-labials and is not triggered by high front vocoids.

[2]Tone marking follows the conventions of the *Greater dictionary of IsiXhosa* (Tshabe et al. 2006); vowels without tone markings systematically vary depending on dialect and/or speaker. Stimuli were given to participants in Xhosa orthography which does not mark tone; as such, IPA transcriptions of the stimuli given here also do not mark tone.

(1) *Xhosa labial palatalization*

a. /...B.../ + /-w/ → ...J...-w
labial + labial → *palatal* + labial

b. [p’] → [tʃ]   [ɓ] → [c’]   [m] → [ɲ]
[p^{h}] → [$tʃ^{h}$]   [b] → [dʒ]   [^{m}b] → [^{n}dʒ]

(2) *Palatalization occurs with the passive affix /-w-/*

a. uku-ɬâ$^{\mathbf{m}}$**b**-à	b. úkù-ɬà$^{\mathbf{n}}$**d͡ʒ**-w-à	c. *úkù-ɬà$^{\mathbf{m}}$**b**w-à
INF-wash-FV	INF-wash-PASS-FV	
‘to wash’	‘to be washed’	

(3) *Palatalization does not apply to non-labials*

a. úkù-fú^{n}d-à	b. úkù-fú^{n}d-w-à
INF-study-FV	INF-study-FV
‘to study’	‘to be studied’

(4) *Palatalization is not triggered by high front vocoids [i] and [j]*

a. úkù-k͡x’a**ɓ**ájìj-à	b. *úkù-k͡x’a**c’**ájìj-à
INF-ridicule-FV	
‘to ridicule, make a fool of’	

3. Method

18 native speakers of Xhosa from Eastern Cape, South Africa, were presented with 40 nonce words in a frame indicating an active verb, and were asked to produce the corresponding passive verb, as in (5).[3]

(5)

active (ukwenza)		passive (ukwenziwa)
iyafamba	→	**iya______wa**

20 of these words had a stem-final (underlying) palatal, and the remaining 20 had a stem-final palatalization undergoer. Since the passive /-w-/ affix triggers the palatalization described here, participants were expected to produce these latter 20 forms with derived palatals.

Among the palatalization undergoers, half of the stimuli had stem-final [^{m}b] (expected to palatalize to [^{n}dʒ]) and the remaining half had stem-final [m] (expected to palatalize to

[3] This experimental task is described in Bennett and Braver (2020), where the percentage of trials palatalized was examined. The acoustic measures discussed here were not analyzed in that paper.

[ɲ]. 40 additional real word fillers were also included. Sample stimuli are given in (6) and (7).

(6) *Underlying palatals*

	Active (stimulus)		Passive (expected response)	
a.	iyasonja	[ija-so^{n}dʒ-a]	iyasonjwa	[ija-so^{n}dʒ-w-a]
b.	iyabanya	[ija-ɓaɲ-a]	iyabanywa	[ija-ɓaɲ-w-a]

(7) *Palatalization undergoers*

	Active (stimulus)		Passive (expected response)	
a.	iyahlama	[ija-ɬam-a]	iyahlanywa	[ija-ɬaɲ-w-a]
b.	iyasamba	[ija-sa-^{m}b-a]	iyasanjwa	[ija-sa-^{n}dʒ-w-a]

Two acoustic measures were taken for all stimuli: (a) the change in F2 from the midpoint to the endpoint of the vowel preceding the target sound and (b) F2 at the midpoint of the nasal portion of the target sound (either [ɲ] or the nasal portion of [^{m}dʒ]). For stimuli resulting in [^{m}dʒ], the center of gravity (COG) of the fricative portion was also measured.

Linear mixed models were run with each of the three acoustic measures as dependent variables, derived/underlying status and segments ([^{m}b] vs. [^{n}dʒ]) as fixed effects, and random intercepts for speaker and item. Random slopes were excluded in all models, as was segment type in the fricative COG model, as they were not justified by backward model selection. p-values were adjusted for multiple comparisons by an anticonservative method (Benjamini and Hochberg 1995); both adjusted and unadjusted values are provided in the regression table (Table 2).

Tokens in the derived condition for which participants did not palatalize the target segment were removed from the analysis, resulting in a total of 531 tokens across all conditions and participants.

4. Results

Each acoustic measure is discussed below; mean differences are provided in Table 1, and a regression table is provided in Table 2.

4.1 F2 change in preceding vowel

The underlying/derived status of the stimuli did significantly affect the change in F2 from midpoint to endpoint of the vowel preceding the target segment ($t(39.69) = -0.27$, $p = 0.99$). As shown in Figure 1, underlyingly palatal tokens had a mean F2 change of 436.77 Hz and derived (palatalized) tokens had a mean F2 change of 444.31 (mean difference: 7.54 Hz).

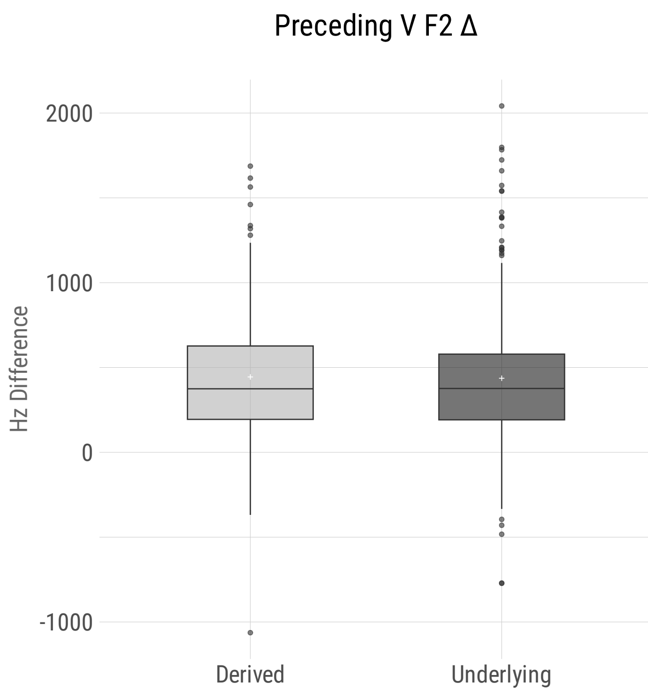

Figure 1: F2 slope from midpoint to endpoint of vowel preceding target segment. Here and throughout, means are marked with ‘+’.

4.2 F2 at midpoint of nasal portion

The underlying/derived status of the stimuli also failed to significantly affect the midpoint F2 of the nasal portion of the stimuli (t(39.47) = -0.05, p = 0.96). As shown in Figure 2, underlyingly palatalized tokens had a mean F2 in the nasal portion of 1819.36 Hz, while derived tokens had a mean of 1754.30 ms (mean difference: 65.06 Hz).

4.3 Fricative portion COG

Finally, the underlying/derived status of the stimuli failed the significantly affect the COG of the fricative portion of stimuli with [^{n}dʒ] (t(263.79) = -1.03, p = 0.91). As shown in Figure 3, the mean COG for underlyingly palatal tokens was 1982.49 Hz, while the mean for derived tokens was 2019.02 Hz (mean difference: 36.53 Hz).

4.4 Summary

To summarize, the derived/underlying status of the stimuli did not significantly impact any of the three acoustic measures. Mean differences are given in Table 1. and a regression table for the linear mixed model is provided in Table 2.

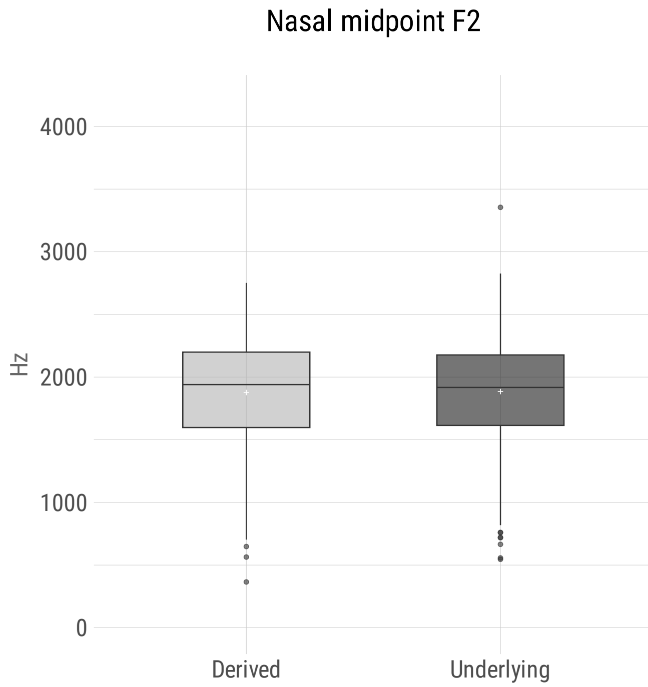

Figure 2: F2 at midpoint of nasal portion.

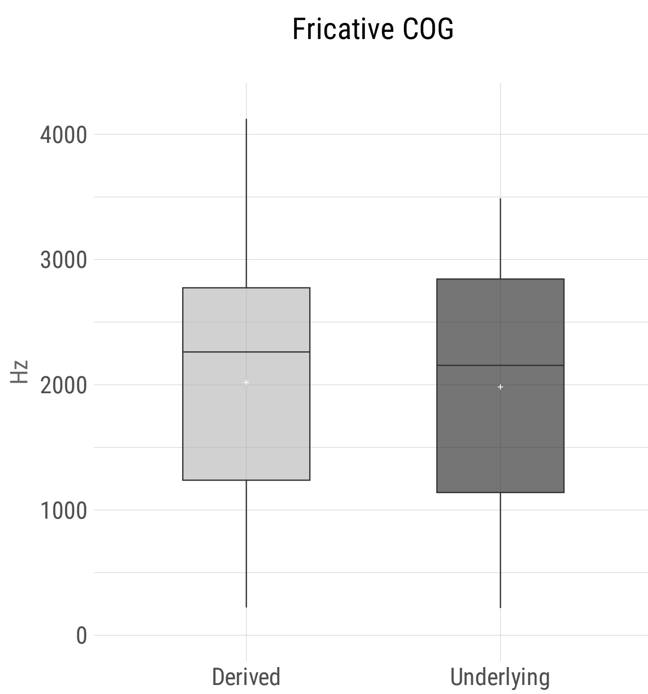

Figure 3: COG of fricative portion in [ⁿdʒ] tokens.

Table 1: Mean values and differences for the acoustic measures. All values in Hz.

Measure	Underlying mean	Derived mean	Difference
F2 Δ	436.77	444.31	7.54
Nasal midpoint F2	1819.36	1754.30	65.06
Fricative COG	1982.49	2019.02	36.53

Table 2: Regression table for all acoustic measures.

		β	95% CI	t	df	p (unadj.)	p (adj.)
F2 Δ							
	intercept	337.90	[235.63, 440.17]	6.64	47.91	< 0.001	< 0.001
	derived	**-14.57**	**[-124.03, 94.88]**	**-0.27**	**39.69**	**0.79**	**0.99**
	segments	232.4	[123.63, 341.18]	4.32	38.13	< 0.001	< 0.001
Nasal midpoint F2							
	intercept	1722.08	[1604.26, 1839.90]	29.44	44.76	< 0.001	< 0.001
	derived	**-2.72**	**[-107.49, 102.04]**	**-0.05**	**39.47**	**0.96**	**0.96**
	segments	336.39	[232.92, 439.87]	6.59	36.51	< 0.001	< 0.001
Fricative COG							
	intercept	2061.95	[1682.27, 2441.63]	11.33	19.9	< 0.001	< 0.001
	derived	**-81.2**	**[-235.86, 73.46]**	**-1.03**	**263.79**	**0.30**	**0.91**

5. Discussion

For the acoustic measures examined here, underlyingly palatal tokens were not found to significantly differ from derived (palatalized) tokens. While ‘the absence of evidence is not evidence of absence,’ the very similar group means across all three measures lend support to the claim that this underlying contrast is completely neutralized phonetically.

Further analysis is needed to verify this finding. As described by Bennett and Braver (2020), speakers varied widely in the percentage of derived trials on which they actually produced the target segments as palatalized. While beyond the scope of this paper, it is possible that there is a link between participants’ likelihood of palatalizing and the degree of neutralization evident in the acoustic measures. Along similar lines, it is possible that the underlying and derived palatal tokens do indeed differ, but on some acoustic measure not examined here. Further examination of these two properties is necessary before concluding that this case shows complete phonetic neutralization.

If, though, such further analysis supports the claim that this contrast is completely neutralized, this would put Xhosa’s labial palatalization in a small class of contrasts that have been found to be completely neutralizing (for a case of putative complete neutralization, see Kim and Jongman 1996).

The most widely cited cases of incomplete neutralization are found in processes of final devoicing (see §1), which has been argued repeatedly to be natural or phonetically motivated (see Iverson and Salmons 2011 for discussion). The contrast between ‘natural’ final devoicing (which incompletely neutralizes) and ‘unnatural’ labial palatalization (which appears to be completely neutralizing, modulo the caveats above) suggests that phonetic naturalness, or at least typological frequency, may be related to the likelihood of a contrast being incompletely neutralized. A more thorough examination of the typology of neutralization and its relation to phonetic naturalness is deserving of further study.

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