Gradient Trends against Phonetic Naturalness: The Case of Tarma Quechua

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Introduction. The interaction of phonetic naturalness with phonological phenomena has been the subject of much recent debate, e.g. Coetzee and Pretorius (2010), Gouskova et al. (2011). We present here the case of a phonotactic restriction on segmental features (specifically, the feature [± voice]) that is both lexically *gradient* and phonetically *unnatural* (operating against universal phonetic tendencies): a restriction against post-nasal voiced and post-obstruent voiceless stops in Tarma Quechua (TQ). To our knowledge, this the first reported truly unnatural gradient phonotactic restriction that is statistically significant across the lexicon, phonetically real, and shows clear signs of productivity. This case is theoretically interesting because it suggests that the power of phonetically arbitrary restrictions extends not only to categorical bans of certain sequences (Coetzee and Pretorius 2010), but even to manipulating the relative frequencies of certain sequences in the lexicon.

Tarma Quechua. Lexical analysis shows that TQ has an unnatural phonotactic restriction: [+voice] in labial and velar stops surfaces most frequently after a voiceless obstruent (86.1%) (e.g. [takba], [mutgi]) and least frequently in post-nasal position (9.5%) (e.g. [xumpa], [wajuŋka]). Intervocalically, [+voice] and [-voice] are almost equally frequent (42.5% voiced) (e.g. [waguj], [tuki]). Moreover, obstruent clusters that disagree in voicing (TD) are significantly more frequent (86.1%) in TQ than clusters that agree in voicing (TT or DD, 13.9% and 0%, respectively) if the second consonant is either a labial or a velar. This distribution, where *voiceless* stops are significantly more frequent post-nasally and *voiced* stops are more frequent after a voiceless obstruent (Figure 1, Table 1), is highly unnatural, especially considering that obstruent clusters with [-voice][+voice] laryngeal features are the most frequent in the language. An acoustic phonetic analysis of TQ data reveals the phonetic reality of these phonotactic restrictions (Figure 2).

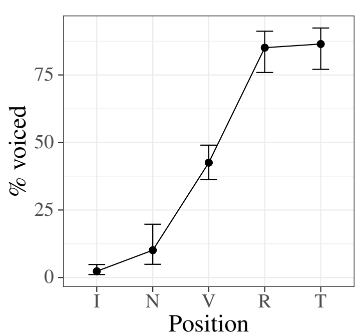

Figure 1: Percentage of voiced stops according to position (I - initial, N - post-nasal, V - intervocalic, R - post-sonorant, T - post-obstruent)

Table 1: Logistic regression model

	Est.	z	Pr(>|z|)
(Int.)	-0.0	-0.3	0.7952
V vs. R	2.0	6.2	0.0000
V vs. T	2.2	6.1	0.0000
V vs. N	-1.9	-4.5	0.0000
V vs. I	-3.4	-8.4	0.0000
[k] vs. [b]	-0.5	-2.3	0.0191

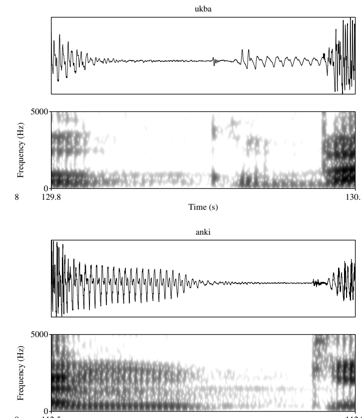

Figure 2: Waveforms and spectrograms of [kb] and [ŋk]

Signs of the unnatural phonotactic restriction's productivity come from morphophonology and loanwords. In TQ, a set of suffixes has an allomorph with an initial voiced stop that is selected after voiceless obstruents and intervocalically ([tamya-ya-n nuqa-ntʃik-**baq**]), but a voiceless allophone gets selected after a nasal ([wayi-n-**pa** pasa-ʃun]; Creider 1968:12-13). Moreover, a percentage of the Spanish loanwords in the language is affected by the unnatural restriction: Sp. *cotpe* > [kutbi] (Adelaar 1977). Thus, we conclude that TQ has a gradient preference for the phonetically unnatural value of [±voice] in two environments: post-nasally and after a voiceless obstruent.

Natural gradience bias. The unnatural gradient phonotactic restriction in TQ opens up a theoretical question for the theory of Markedness in weighted-constraint theories like Harmonic Grammar (HG). The canonical assumption in OT (Prince and Smolenky 1993/2004) is that the universal constraint set CON contains only a proper subset of all imaginable Markedness constraints, which allows the grammar to encode typological asymmetries. For weighted-constraint theories like HG, if we restrict CON and disallow unnatural constraints, we show that HG predicts that natural elements in a given environment will always be more frequent than unnatural ones (a generalization that we call the "Natural Gradience Bias"; cf. Hayes 2016).

For example, let us assume the natural constraint *NT, its unnatural counterpart *ND, and a faithfulness constraint FAITH, as well as inputs /NT/ and /ND/ and outputs [NT] and [ND]. If CON is restricted to natural constraints (i.e., does not contain *ND), then [NT] cannot have more probability than [ND] across inputs. Instead, [NT] and [ND] have equal probability across inputs if the faithfulness constraint FAITH has a positive infinite weight and the markedness constraint *NT has a finite weight, and [ND] has a higher probability than [NT] across inputs in all other cases.

Discussion. For most languages, this generalization has desirable predictions: all gradient phonotactic restrictions reported previously (both as trends in the lexicon, e.g., Pater and Coetzee 2008, and as tacit phonotactic knowledge obtained from experiments, e.g. Albright 2009) indeed operate in the natural direction, where the natural element is preferred and more frequent than the unnatural one in a given environment.

However, the distribution of the feature [$\pm$voice] in TQ goes against the NGB generalization: the natural constraints *NT and *T[-voice] will not be able to give [NT] a higher probability than [ND], or [TD] a higher probability than [TT], as is the case in TQ. We are assuming Coetzee and Pater's (2008) approach to linking lexical and grammatical probabilities. This suggests that HG with restricted CON undergenerates, and CON must include the constraints *ND (cf. Coetzee and Pretorius 2010) and *T[-voice] (which prefers TD clusters over TT clusters).

Even though TQ motivates an analysis that uses unnatural constraints, there is evidence that the phonotactic generalization discussed above goes back to the distribution of fricativization in the development of Pre-TQ voiceless stops. This, in turn, suggests that the synchronically unnatural restriction arose through a sequence of natural sound changes rather than through a single unnatural sound change. The synchronic and diachronic evidence from TQ, taken together, speaks to the question of the place of phonetic (un)naturalness in language. The TQ data reinforce the position that sound change is necessarily phonetically motivated (*pace* Blust 2005), but sequences of sound changes are allowed to produce synchronically unnatural results (*pace* Kiparsky 2006).

Selected References. Adelaar, W. 1977. *Tarma Quechua: Grammar, texts, dictionary.* De Ridder. • Albright, A. 2009. Feature-based generalisation as a source of gradient acceptability. *Phonology* 26(1): 9-41. • Blust, R. 2005. Must sound change be linguistically motivated? *Diachr* 22(2): 219-269. • Coetzee, A., and Pater, J. 2008. Weighted constraints and gradient restrictions on place co-occurrence in Muna and Arabic. *NLLT*, 26(2), 289-337. • Coetzee, A.W. and R. Pretorius. 2010. Phonetically grounded phonology and sound change: The case of Tswana labial plosives. *J Phon* 38: 404-421. • Creider, C. 1968. A morphological sketch of Tarma Quechua. MA Thesis. • Hayes, B. 2016. Varieties of Noisy Harmonic Grammar. Handout at the 2016 *AMP* at USC. • Gouskova, M., E. Zsiga, O. Tlale Boyer. 2011. Grounded Constraints and The Consonants of Setswana. *Lingua* 121(15): 2120-2152. • Prince, A. and P. Smolensky. 1993/2004. *Optimality Theory: Constraint Interaction in Generative Grammar*. Malden, MA: Blackwell.