

## Phonetics in phonology: evidence from Scottish Gaelic preaspiration

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Through factorial typology, Optimality Theory is able to predict a range of theoretically possible grammars. However, factorial typology is sometimes too powerful a tool: there may be a systematic mismatch between the range of grammars predicted and those actually attested. Many scholars have offered solutions to this overgeneration problem; for instance, Wilson's *targeted constraints* (2001), and Steriade's *P-map* (2001) aim to constrain the predictive power of OT by invoking cognitive factors. However, other scholars (e.g. Ohala 2005, Barnes 2002, Myers 2002) assert that typological gaps may be accounted for through the diachronic operation of phonetic factors; it is therefore redundant to attempt to account for such gaps synchronically by attributing them to UG.

This paper provides strong support for the latter view, based on both OT and instrumental analyses of two implicational asymmetries in the typology of Scottish Gaelic (SG) preaspirated voiceless stops. First, the paper shows that a standard OT account of these asymmetries massively overgenerates. Second, the paper reports evidence for robust phonetic precursors for both asymmetries. Finally, it shows that the overgeneration characterizing the first OT analysis may be constrained by incorporating an analysis based on the P-map hypothesis (Steriade 2001). However, the P-map based analysis is crucially dependent on the phonetic factors; this dependency renders the P-map hypothesis vulnerable to criticism as a redundant synchronic expression of diachronic forces.

The first implicational asymmetry in SG preaspiration is *deaspiration*. In most SG dialects, labial, coronal, and dorsal voiceless stops are phonemically preaspirated. However, in some dialects, phonemic preaspiration has been lost in a subset of stops (Fig. 1) (Ó Maolalaigh 2007; Ó Baoill 1980; Oftedal 1956; Borgstrøm 1940, 1941). If present, deaspiration always affects labial stops, and sometimes also coronal stops, but never dorsals. The second asymmetry is *fortition*: in some dialects, preaspiration has changed from voiceless glottal [h] to voiceless velar [x]. When present, fortition invariably affects dorsal stops, sometimes coronals as well, and finally labials, but only if dorsals and coronals have also been affected.

In classic OT terms, these two asymmetries may be analyzed as repairs to \*[hT], a posited constraint militating against preaspiration. Assuming freely-ranked place-specific versions of \*[hT], such an analysis yields significant overgeneration, for instance by reranking \*[hk] from below \*[hp] to above it (see tableaux in Fig. 2). If the views expressed in Myers (2002) and Ohala (2005) are correct, it should be possible to identify phonetic factors accounting for these typological gaps.

A production experiment was conducted which identified robust phonetic precursors to both asymmetries. Preaspiration data were collected from eight native SG speakers representing dialect areas 1 and 4 (Fig. 1), which feature phonemic preaspiration in all places of articulation. It was found that the duration of the preaspiration cue was shortest before labial stops, and longest before dorsal stops. It was also found that many speakers frequently omitted preaspiration where phonemically it should have been present; this omission was most frequent before labial stops, least frequent before dorsals. Shorter and more frequently omitted preaspiration cues before labial stops could serve as a strong precursor to eventual loss of the cue altogether in that position, while a longer and more reliable preaspiration cue before dorsal stops could be conducive to its fortition from [h] to [x].

A P-map based extension to the earlier standard OT analysis resolves the overgeneralization problem, by formalizing these phonetic factors within a phonological grammar, and allowing the projection and fixed ranking of faith constraints to be based on perceptual similarities between target and surface forms. The rankings in (a) and (b) respectively express (1) that the perceptual difference between [h] and [x] is greatest before [p], least before [k], and (2) that the difference between [h] and nil is greatest before [k], and least before [p]. While attested configurations like [p ht hk] are permitted by these fixed rankings (Fig 3), unattested configurations like [hp ht k] are prohibited.

- a. ID[h-x]/V\_p >> ID[h-x]/V\_t >> ID[h-x]/V\_k
- b. MAX[h-Ø]/V\_k >> MAX[h-Ø]/V\_t >> MAX[h-Ø]/V\_p

Thus, via the P-map hypothesis, a constraint-based analysis of the typology of SG preaspiration can be constructed that resolves the overgeneration problems characterizing a traditional OT account. Problematically, this analysis depends on the formalization of phonetic factors which are explanatorily adequate without such formalization. Therefore, the argument that the P-map and similar extensions to standard OT amount to recapitulations of phonetic facts has considerable merit.

**Figure 1. Dialect variation in SG preaspiration**

1. [hp ht hk]    3. [p t xk]    5. [hp xt xk]  
 2. [p ht hk]    4. [hp ht xk]    6. [xp xt xk]

**Figure 2. Tableaux generating attested (a) and unattested (b) configurations**

a. [p ht hk]						b. [k hp ht]					
/hp/	ID[place]	*hp	MAX	*hk	*ht	/hk/	*hk	ID[place]	MAX	*hp	*ht
☞ p			*			xk		*!			
xp	*!					hk	*!				
hp		*!				☞ k			*		
/ht hk/						/hp ht/					
t k			*!			p t			*!		
xt xk	*!					xp xp		*!			
☞ ht hk				*	*	☞ hp ht				*	*

**Figure 3. P-map based analysis of attested [p ht hk]**

/hk/	ID[h-x]/ V_p	ID[h-x]/ V_t	ID[h-x]/ V_k	MAX[h-Ø]/ V_k	MAX[h-Ø]/ V_t	*hT	MAX[h-Ø]/ V_p
k				*!			
xk		*!					
☞ hk						*	
/ht/							
t					*!		
xt		*!					
☞ ht						*	
/hp/							
☞ p							*
xp	*!						
hp						*!	

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