Biases in phonology: explaining variation in Scottish Gaelic preaspiration

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1. Introduction

(1) OT factorial typology predicts a range of theoretically possible grammars. **Typological gaps** can result: systematic mismatches between predicted and attested constraint rankings. This creates a theoretical conundrum; there are (at least) two conflicting solutions: do we attribute typological gaps to

(2) Analytic bias or channel bias?

a. **analytic bias:** Assumes typology is a product of UG, or of cognition generally. Theory should be constrained so as to allow a tighter fit with typology, e.g. via the ***P-map*** (Steriade 2001, 2002). The P-map is a component of the phonological grammar, though which the projection and ranking of faith constraints are based on scales of perceptual similarity.

b. **channel bias:** Some constraint rankings are unattested because the relevant ***phonetic precursors*** do not occur. If good diachronic explanation available, to constrain theory is redundant and undesirable (Barnes 2002, Myers 2002, Ohala 2005 and others)

(3) This study provides hard evidence for the role of Channel Bias:

a. Evidence drawn from two asymmetries in the typology of Scottish Gaelic (SG) voiceless preaspirated stops.

b. Standard OT account of the two asymmetries massively overgenerates.

c. **Analytic bias:** A P-map based analysis resolves overgeneration, but depends on perceptual hierarchies congruent with SG asymmetries.

Experiment 1: perception experiment <u>finds no evidence</u> for perceptual hierarchy.

d. **Channel bias**: Typological asymmetries are due to systematic phonetic patterns consistent with asymmetries.

Experiment 2: production experiment <u>finds precursors</u> consistent with channel bias.

(4) Outline of remainder of talk:

§2. Preaspiration in Scottish Gaelic

§3. Standard OT analysis

§4. P-map analysis

§5. Experiment 1: perception

§6. Experiment 2: production

§7. Conclusions

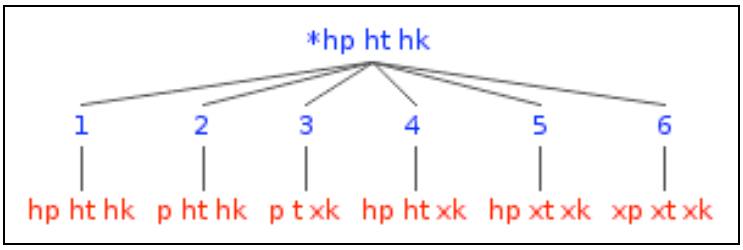
2. Preaspiration in Scottish Gaelic

(5) *preaspiration*: prototypically, a period of voiceless glottal frication [h] preceding a stop closure (e.g. Ladefoged and Maddieson 1996), or "reverse aspiration".

(6) Many (but not all) attested dialects of Scottish Gaelic (SG) feature an opposition between aspirated voiceless stops and unaspirated voiceless stops. Aspirated stops are postaspirated in initial position, but preaspirated in medial and final position.

(7) The prototypical preaspiration of earlier SG shows at least six configurations in the modern dialects (Oftedal 1956, Borgstrøm 1974, Ó Baoill 1980, Ó Murchú 1985, Clement 1994, Ó Maolalaigh 2007) (see appendix for map):

Figure 1. Preaspiration in SG dialects



(8) Variation is not random, but follows two strict and opposing place hierarchies:

a. Deaspiration (loss of preaspiration feature): Targets bilabial stops, then extends to dentals (dialects 1-3):

Labial >> Coronal >> Dorsal

b. Fortition (substitution of velar frication for prototypical glottal): Targets velar stops, then extends to dental stops, then bilabial (dialects 3-6):

Dorsal >> Coronal >> Labial

3. Standard OT analysis

(9) Reasonable to assume set of constraints that penalize preaspiration: *[hp], *[ht], *[hk] etc.:

a. Implicational asymmetry: presence of preaspiration implies (post)aspiration; reverse not true (Clayton 2008).

b. Globally, preaspiration extremely rare (20-30 languages?) (Silverman 2003).

c. *[hp], *[ht], *[hk] must be freely rankable to allow two opposing hierarchies.

(10) Attested variation arises through interaction with MAX (prohibiting deletion) and IDENT[place] (prohibiting fortition).

a. High-ranked MAX and ID[place] yield dialect 1 [hp ht hk]:

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

b. Low-ranked ID[place] ⇒ dialect 6 [xp xt xk]:

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

c. High-ranked ID[place] and *[hp] ⇒ 2 [p ht hk]:

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

(11) However, unattested grammars can also be generated:

a. If *[hk] is ranked above MAX instead of *[hp], unattested [hp ht k] results:

/hk/	ID[place]	*hk	MAX	*hp	*ht
xk	*!				
hk		*!			
💣 k			*		
/hp ht/					
p t			*!		
xp xp	*!				
💣 hp ht				*	*

b. If *[hp] and MAX outrank ID[place], the result is unattested [xp ht hk]:

/hp/	MAX	*hp	ID[place]	*hk	*ht
p	*!				
💣 xp			*		
hp		*!			
/ht hk/					
t k	*!				
xt xk			*!		
💣 ht hk				*	*

(12) **Problem: assuming these constraints, no way to account for two patterns in standard OT: the model overgenerates, predicting grammars that violate the two attested asymmetries.**

4. Provisional P-map analysis resolves overgeneration

(13) Via the P-map, projection and ranking of faith constraints are based on scales of perceptual similarity. The winning candidate incurs the smallest perceptual departure from the target form.

a. In this analysis, place-specific versions of MAX and IDENT are used (notation after Steriade 2001):

i. MAX[h]/V_T: prohibits deletion of preaspiration before [p], [t], [k]

ii. ID[h_x]/V_T: prohibits substitution of [x] for [h] before [p], [t], [k]

(in tableaux, ID[pl]/_T)

b. No longer necessary to assume place-specific anti-preaspiration constraints, so unitary *[hT] used instead.

(14) If P-map responsible for SG hierarchies, implies the following rankings:

a. Deaspiration:

MAX[h]/V_k » MAX[h]/V_t » MAX[h]/V_p

= Perceptual difference between [h] and nil greatest before [k], least before [p]. (*Ensures that deaspiration targets labial stops first.*)

b. Fortition:

ID[h-x]/V_p » ID[h-x]/V_t » ID[h-x]/V_k

= Perceptual difference between [h] and [x] greatest before [p], least before [k]. (*Ensures that fortition targets dorsal stops first.*)

(15) If individual place-specific faith constraints rank below *hT, either deaspiration or fortition can apply partially. But fixed rankings ensure this happens in the proper sequence, so attested hierarchies are not violated.

a. If ID[h-x]/V_k ranked below *[hT] ⇒ dialect 4 [hp ht xk]:

/hk/	ID[pl] /_p	ID[pl] /_t	MAX[h] /_k	MAX[h] /_t	MAX[h] /_p	*hT	ID[pl] /_k
k			*!				
☞ xk							*
hk						*!	
/ht/							
t				*!			
xt		*!					
☞ ht						*	
/hp/							
p					*!		
xp	*!						
☞ hp						*	

b. MAX[h]/V_p ranked below *[hT] ⇒ 2 [p ht hk]:

/hk/	ID[pl] /_p	ID[pl] /_t	ID[pl] /_k	MAX[h] /_k	MAX[h] /_t	*hT	MAX[h] /_p
k				*!			
xk		*!					
☞ hk						*	
/ht/							
t					*!		
xt		*!					
☞ ht						*	
/hp/							
☞ p							*
xp	*!						
hp						*!	

(16) **Problem: this P-map analysis is provisional, unless the entailed perceptual scales can be empirically confirmed.**

5. Perception experiment: no perceptual scale found

(17) Methods

a. *Hypothesis*: Listeners will show a varying, place-dependent ability to distinguish preaspirated from non-aspirated stops: labial stops will be more difficult to distinguish than dorsal stops.

= evidence for perceptual scale entailed by P-map regarding the deaspiration hierarchy:

MAX[h]/V_k » MAX[h]/V_t » MAX[h]/V_p

b. Design:

i. 2AFC perception test: participants asked to distinguish wordforms differing only by presence/absence of PA.

ii. Stimuli presented pairwise; each stim A and B recorded by different reader.

iii. Participants respond "same/different" via keyboard.

iv. Stimuli presented in pairs using the ACTUATE software (Westbury Labs) and a laptop computer, through circumaural headphones.

c. Stimuli:

i. Gaelic-like nonwords, read in a frame sentence *Thubhairt mi X da thùras* [xuɾ̥t mi X da hʊrəs] "I said X two times."

ii. Read by speakers of the Lewis dialect (dialect 1: hp ht hk), because most conservative.

iii. Two sets of stimuli: those with preaspiration, those without.

iv. Stim set 1 featured PA in either medial or final position, following [u] and [a] (short), in 3 POA = 12 configurations:

[tahpa]	[tahta]	[tahka]	[tahp]	[taht]	[tahk]
[tuhpa]	[tuhta]	[tuhka]	[tuhp]	[tuht]	[tuhk]

v. Stim set 2 identical, except medial and final stops unaspirated.

d. Participants: 9 Sc Gaelic, 12 Polish, 11 Amer. English speakers.

i. Multiple language populations, because if P-map is part of UG, all three populations should respond uniformly.

ii. Gaels included because PA/nonaspirated contrast native; Polish speakers as having little or no L1 experience with aspiration contrasts at all (Gussman 2008); English speakers as having L1 experience with a *post*aspiration contrast.

iii. Widely varying age, but predominately 40's, 50's.

iv. All fluent speakers of English: Gaels essentially native speakers; Poles having 10 or more years of experience.

e. Results (Table 1):

i. Some L1-related variation:

- Gaels lowest error rate overall (as we might expect)
- English highest error rate.
- Better Polish performance than English due to coda [x] in Polish?

ii. No clear pattern associated with place of articulation.

Table 1. Errors in distinguishing preaspirated & unaspirated tokens

% Errors	ahk-ak	aht-at	ahp-ap		ahka-aka	ahta-ata	ahpa-apa
GAELS	29	33	44		15	11	15
POLES	79	71	79		42	22	39
ANGLES	86	86	64		70	52	64
	uhk-uk	uht-ut	uhp-up		uhka-uka	uhta-uta	uhpa-upa
GAELS	22	17	50		11	22	19
POLES	42	46	58		19	19	44
ANGLES	59	73	55		42	39	48

(18) **Result: Without solid evidence for a perceptual scale congruent with the deaspiration hierarchy *Labial >> Coronal >> Dorsal*, no basis to conclude the P-map (or similar analytic bias) is responsible for this hierarchy.**

(19) Second experiment in progress to test for perceptual basis to fortition hierarchy *Dorsal >> Coronal >> Labial.*

6. Production experiment: precursors found

(20) According to the Channel Bias hypothesis, phonological typology can be attributed to the presence or absence of certain *phonetic precursors*: "systematic errors in transmission between speaker and hearer, caused largely by subtle phonetic interactions which serve as precursors for phonologisation" (Moreton 2008).

☞ *If the Channel Bias hypothesis is correct, then such precursors will be present in speaker's production of preaspiration, where they can be experimentally identified.*

(21) **Hypotheses**:

1. **Frequency**: Phonemically preaspirated stops will occasionally be realized without PA, especially labial stops.

Assumption: unreliable realization of the preaspiration cue will be conducive to a failure of learners to acquire the feature.

2. **Duration:** preaspiration cue is longest in velar stops, shortest in bilabial stops.

Assumption: a shorter cue before bilabials is easier to overlook (for learners); a longer, more robust cue before velars is more readily misperceived as [x].

(22) Methods:

a. Consultants:

i. 8 native speakers of dialects 1 & 4

ii. Age range: mid-20's to mid-60's

iii. balanced male/female

b. Stimuli:

i. 36 SG words x 2 presentations = 76 tokens

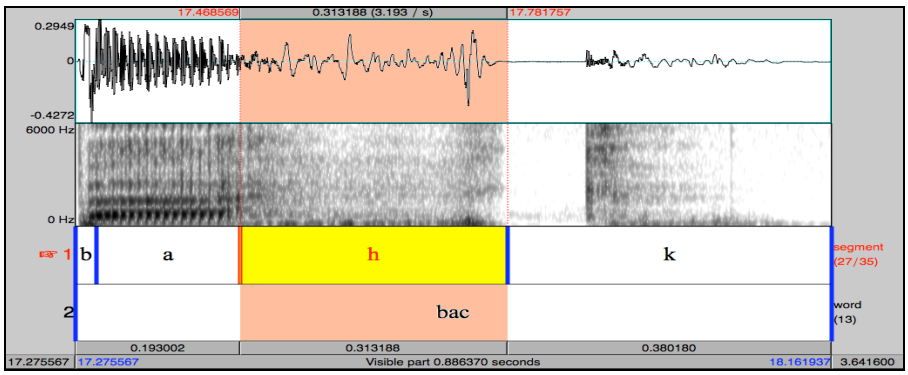
ii. [hp ht hk~xk] in medial /CVhT/ & final position /CVhT/

c. Data collection:

i. stims twice each in random order

ii. speakers recorded reading words from list; each word produced in frame sentence *thubhairt mi* ___ [hur̥t mi] "I said ___".

Figure 2. Spectrogram of *bac* [bahk] "hollow"



d. Analysis:

Duration, frequency of PA measured using Praat software (Boersma and Weenink 2006) (Figure 2).

e. **Results**:

Both hypotheses were confirmed. Robust precursors for the two asymmetries were found:

i. Frequency: preaspiration is frequently omitted before bilabial stops, most reliably produced before velar stops.

ii. Duration: Preaspiration in labial consonants (avg. 89ms) is shorter than dentals (avg. 110ms) ($t = 3.6$, df = 189, $p = .0004$, mixed-model ANOVA), and that in dentals is shorter than in velars (avg. 138ms) ($t = 3.78$, df = 189, $p = .0002$).

Table 2. Omission of phonemic PA (%)

	Labial	Dental	Velar
V:CV	72.2	33.3	6.7
VCV	6.3	21.4	6.3
V:C	20.0	0.0	0.0
VC	8.8	0.0	3.6

Table 3. Duration of PA cue, by context

Avg (ms)	Labial	Dental	Velar	
	89	110	138	
Avg (ms)	VC	V:C	VCV	V:CV
	160	100	112	70

7. Summary & Conclusions

(1) A standard OT account of the six variant configurations of preaspiration in Scottish Gaelic leads to significant overgeneration.

P-map account previsionally resolves the overgeneration issue. Problematically, however, a perception experiment fails to find empirical evidence that the deaspiration hierarchy can be traced to the perceptual scale entailed by the P-map.

(2) On the other hand, the Channel Bias Hypothesis clearly supported: robust phonetic precursors consistent with both the deaspiration and fortition hierarchies have been identified via a production experiment.

(3) *Best-case scenario for P-map*: second perception experiment finds a perceptual basis for the fortition hierarchy; thus, AB mimics CB. Cf. Wilson 2006: velar palatalization has both analytic and channel bias correlates.

Worst-case scenario: Second perception experiment also unsuccessful, and P-map account fails altogether.

(4) This study does not rule out the possibility of typological patterns due strictly to analytic bias, e.g. vowel height-height correspondence (Moreton 2008). Rather, it emphasizes that both CB and AB have significant roles to play.

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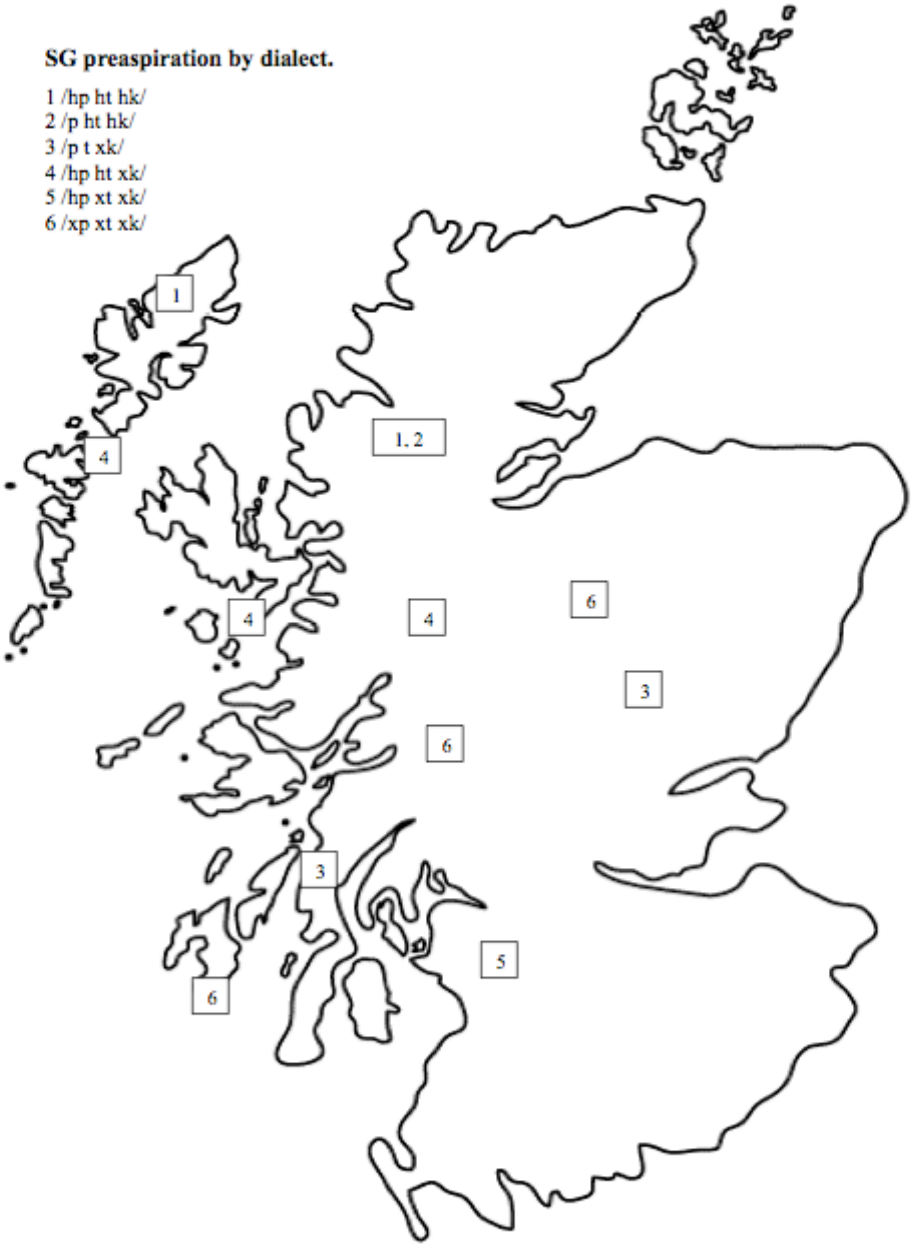
Appendices

1. Word list used in production experiment:

	labial	**dental**	**velar**
t^hV	put /p^hu^ht/ 'buoy'	tog /t^hok/ 'raise'	cop /k^ho^hp/ 'foam'
Vt^h	cnap /k^hna^hp/ 'lump'	brot /pro^ht/ 'soup'	breac /$prea^hk$/ 'salmon'
Vt^hV	copag /k^ho^hpak/ 'weed'	bata /ba^hta/ 'stick'	poca /p^ho^hka/ 'bag'
t^hV:	pòg /p^ho:k/ 'kiss'	tùch /t^hu:x/ 'make hoarse'	càbag /k^ha:pak/ 'cheese'
V:t^h	pàp /p^ha:^hp/ 'Pope'	bòt /po:^ht/ 'boot'	bòc /po:^hk/ 'puff'
V:^htV	ròpach /ro:^hpax/ 'squalid'	bàta /pa:^hta/ 'boat'	pràcais /p^hra:$^hkɪʃ$/ 'chit-chat'
tV	bac /pa^hk/ 'hollow'	dad /tat/ 'jot'	gob /kop/ 'beak'
Vt	cab /k^hap/ 'gob'	ged /kɛt/ 'though'	cog /k^hok/ 'fight'
VtV	clabog /k^hlapok/ 'bargain'	spadag /sp^hatak/ 'quarter'	daga /taka/ 'pistol'
tV:	bò /po:/ 'cow'	dòcha /to:xa/ 'probably'	gèadh /ki:ax/ 'goose'
V:t	còb /k^ho:p/ 'plenty'	clàd /k^hla:t/ 'wool comb'	bròg /pro:k/ 'shoe'
V:tV	cùbaid /$k^hupɪtʃ$/ 'pulpit'	fàdadh /fa:tax/ 'kindling'	bròg an /pro:kan/ 'shoes'

2. Approximate distribution of Scottish Gaelic dialects: