

# On the Perceptual Robustness of Preaspirated Stops

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## Introduction

Some phonological structures are crosslinguistically abundant while others are rare. For instance,

- *Postaspirated* voiceless stops [p<sup>h</sup> t<sup>h</sup> k<sup>h</sup>] occur in 25.5% of UPSID languages (Maddieson & Precoda 1989), but
- *Preaspirated* stops [hp ht hk] in fewer than 1% (a few dozen worldwide)

Less frequent structures must be:

- A. *harder to transmit* between generations, or
- B. *harder to innovate* in the first place (Moreton 2008, Harris 2007, Greenberg 1978).

Prevailing explanations for the scarcity of preaspirated stops assume (A): preaspirated stops are infrequent because they are hard to hear = *lower transmission rate*.

This paper presents 2 types of evidence that instead favor (B): preaspirated stops must be rarely innovated:

- **experimental**: a perception experiment shows that preaspirated stops are no harder to hear than postaspirated stops, and
- **typological**: abundance and distribution of preaspirated stops suggests that they are hard to innovate, but stable once innovated.

## Hypothesis 1: Preaspiration is hard to transmit

### “Perceptual Inferiority” Hypothesis

Prevailing assumption: preaspirated stops are perceptually inferior to postaspirated stops:

- Bladon (1986): preaspiration is an “auditory-phonetic dinosaur”, unlike postaspiration
- Silverman (1997, 2003): preaspiration is perceptually “suboptimal”, postaspiration “optimal”
- Kingston’s (1990) “Binding Principle”: better to coordinate contrastive glottal gestures with stop release, not closure onset.

The PIH formalized:

*Given two voiceless stops that differ only in presence or absence of aspiration, listeners discriminate them more reliably if the aspiration follows the release of the stop (postaspirated) than if the aspiration precedes the stop closure (preaspirated).*

## Perception Experiment

Compare listeners’ abilities to discriminate voiceless stops based on aspiration type:

1. **postaspirated vs. unaspirated, OR**
2. **preaspirated vs. unaspirated**

### Method

- 2AFC paradigm, “same/different”
- Stimuli presented pairwise, randomly: AA (same), AB (different), BA (different), BB (same)
- Participants listened through headphones

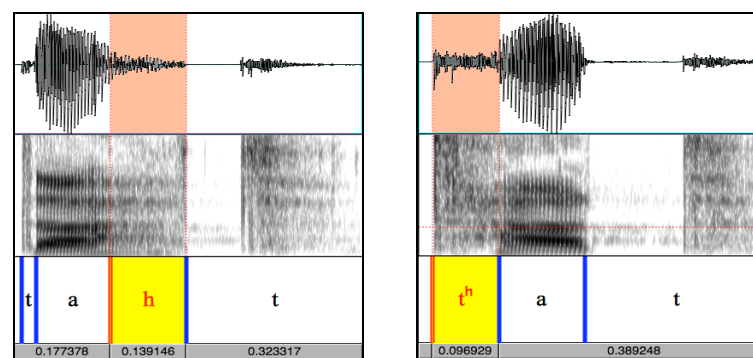
### Stimuli

- Gaelic-like nonword minimal pairs (Lewis Gaelic contrasts unaspirated and aspirated stops; aspirated stops are *postaspirated* initially, *preaspirated* medially and finally)
- recorded by 3 male Lewis Gaelic speakers
- 238 distinct stimulus pairs
- 3 types: *initial*, *medial* or *final* position
- V = [a] or [u], P = [p] [t] or [k]

Table 1: Stimulus types

	post vs unasp	pre vs unasp
initial	[P <sup>h</sup> Vt] < > [P <sup>h</sup> Vt]	
medial		[tV <sup>h</sup> Pa] < > [tV <sup>h</sup> Pa]
final		[tV <sup>h</sup> P] < > [tV <sup>h</sup> P]

Fig. 1. Example stimuli: [taht] & [t<sup>h</sup>at]



## Participants

3 participant populations control for L1 effects:

### 9 Scottish Gaelic speakers:

- have L1 familiarity with both aspiration types
- any difference in ability to discriminate PreA and PostA should proceed from inherent differences between aspiration types.
- should do best overall, since stimuli L1-like.

### 12 Polish speakers:

- have a congruent *lack* of L1 experience with both kinds of aspiration (Gussman 2007)
- again, differences in performance due to differences in PreA, PostA perceptibility.
- but higher overall error rate expected, since stimuli not L1-like.

### 11 Am. English speakers:

- L1 experience only with postaspiration, so expected to discriminate postaspiration better than preaspiration.

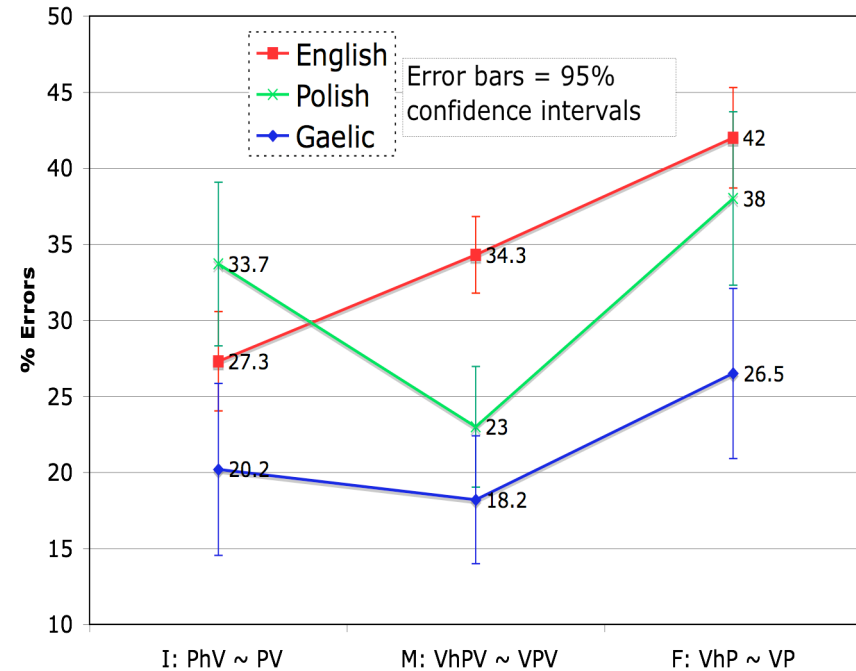
## Results

**Results do not support the Perceptual Inferiority Hypothesis: no evidence that postaspiration is easier to discriminate than preaspiration.**

Results were analyzed by generalized linear regression, are summarized in Figure 2.

- Gaels discriminated medial preaspiration as reliably as initial postaspiration (difference insignificant,  $\beta = 0.9886$ ,  $\chi^2 = 0.0$ ,  $p = .9663$ ).
- Poles did *better* on medial preaspiration contrast than on initial postaspiration ( $\beta = 1.5285$ ,  $\chi^2 = 5.92$ ,  $p = .015$ ).
- Final position was the most difficult for all groups (initial vs. final:  $\beta = 0.5168$ ,  $\chi^2 = 41.54$ ,  $p = <.0001$ ; medial vs. final:  $\beta = 0.5241$ ,  $\chi^2 = 38.66$ ,  $p = <.0001$ ).
- Predicted L1 effect: only English speakers better at postaspiration than preaspiration (initial vs. medial:  $\beta = 0.6346$ ,  $\chi^2 = 8.93$ ,  $p = .0028$ ; initial vs. final:  $\beta = 0.3912$ ,  $\chi^2 = 23.50$ ,  $p = <.0001$ ).
- Also as predicted, Gaels had the lowest overall error rate: (21.6%) vs. Poles (31.6%) and English speakers (34.5%).

Fig. 2. Confusion rates (% errors)



## Hypothesis 2: Preaspiration is hard to innovate

Preaspirated stops are not harder to hear than postaspirated stops. But they may be harder to innovate.

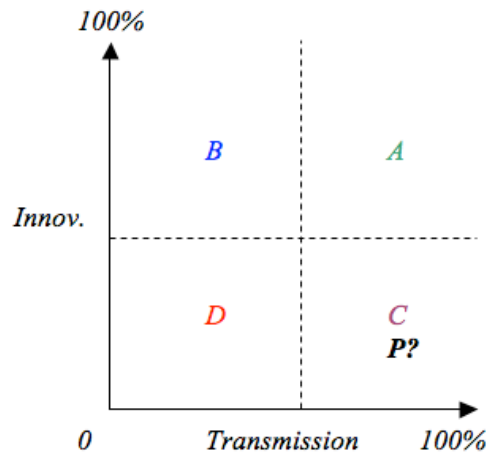
**Problem:** Innovation rate hard to measure.

**Solution:** Greenberg's State-Process Model

### The State-Process model

Greenberg's (1978) State-Process model predicts that structures with differing rates of innovation, transmission will exhibit different typological characteristics (Fig 3).

Fig. 3. State-Process model



**A. front unround vowels (99.56%)**

High innovation rate, high transmission rate = nearly universal distribution.

**B: front round vowels (10.2%)**

High innovation rate, low transmission rate = much less common, randomly distributed.

**C. uvular consonants (18.4%)**

Low innovation rate, high transmission rate = common, clustered areally, genetically.

**D. velar implosives (1.11%)**

Low innovation rate, low transmission rate = extremely scarce (Maddieson 2008a, 2008b; Maddieson & Precoda 1989).

**P. Preaspirated stops?** Lower innovation rate than uvulars, similar transmission rate?

Typological evidence:

**1. Clustered:** Preaspirated stops are clustered (Fig. 3) in:

- Northern Germanic & adjacent languages, including Sami, Scottish Gaelic
- Central Algonquian
- Uto-Aztecan

Fig. 4. Global distribution of preaspirated stops



**2. Seem diachronically robust:**

- present in the Northern Germanic languages for 1000+ years (Helgason 2002, Hansson 1999)
- in Scottish Gaelic at least 500 years (Clement 1994).

Why hard to innovate?

Possibilities include:

- Antecedent structures/patterns uncommon or seldom co-occur
- Those structures have weak precursors
- Competition among multiple precursors
- Cognitive biases (cf. Moreton 2008, Wilson 2006)

**Conclusions:**

1. Experimental evidence shows that the rarity of preaspirated stops cannot be due to a perceptual inferiority to e.g. postaspirated stops.
2. Instead, typological evidence suggests that preaspirated stops are innovated too infrequently to achieve greater abundance.
3. Greenberg's (1978) State-Process model provides a useful framework for inferring innovation and transmission rates based on the typological characteristics of linguistic structures.

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