On the rarity of pre-aspirated stops

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Introduction

- "Pre-aspiration"—[ʰp, ʰt, ʰk]—is usually employed as a cover term for a variety of configurations:
  homorganic spirant: **[fp, çt, xk]**
  vowel-influenced spirant: **[axk, içk]**
  variation with vowel length: **[aːt]~[aʰt]**

- **Just how rare are pre-aspirates? *Far rarer than the secondary literature suggests.***
- **Why are pre-aspirates so rare, and what accounts for their diachronic instability? *Well-established principles of aerodynamics, acoustics, and audition.***

Survey of systems

Secondary sources: Ruhlen 1975/6, Maddieson 1984, Steriade 1999. Primary sources as indicated.

Tarascan (Foster 1969)

- The alveolar pre-aspirates "var[y] to pre-sibilantization following a voiced vowel either word-medially or with intervening non-pausal juncture": **[st]**.

  [ˈpʰɑʰtɑn̥i] ~ [ˈpʰɑstɑn̥i] to touch the metate
  [pʰɑʰtsɨtɑn̥i] ~ [pʰɑstsɨtɑn̥i] to touch the table
  [kɑˈtʃuʰtʃan̥i] ~ [kɑˈtʃustʃan̥i] to cut off one's braid

- Pre-aspirates which follow [ɨ] freely vary with vowel length: **[ɨːt]**

  [ˈtsɨʰkun̥i] ~ [ˈtsɨːkun̥i] to drop from one's hand

Gaelic (Borgstrøm 1940, 1941, Dorian 1978)

- Ness and Bernera (on Lewis): Borgstrøm (1940): for [ʰc] and [ʰtʲ], the preaspiration is "distinctly palatal, without being as narrow as ç" (p.21): **[ç̟c, ç̟tʲ]**.

- Harris and Barra:
- Distribution with velars:
  Following back/low vowels: **[xk]**

[maxk]	son
[kʰrɔ̃xk]	a small field
[sɔxkirʲ]	quiet
[ʃæxk]	7

  Following front non-low vowels: **[çk]**

[miçkʲ]	sons
[fɛ̃çkʲiɲ]	to see
[kʰreçkʲ]	to sell

- Distribution with alveolars, following [i]: **[çt]**

[ljiçtʲirʲ]	letter
[içtɔ]	a feather

- Skye and Ross-Shire dialects: "a very distinct and long *h*, frequently with a slight velar friction": **[x̟t]**

Icelandic (Liberman 1978, 1982, Thráinsson 1978, Kingston 1990, Silverman 1997), and other Scandinavian languages

- Liberman's (1982) survey of earlier reports on Icelandic:
  -Goodwin 1905, 1908: **[fp, θt, xk]**
  -Einnarsson 1927: A non-laryngeal spirant after high vowels.

-Fries 1977: [xk], [çt], etc.

- Other Scandinavian languages (Liberman 1978:64ff):
  - Faroese: "Preaspiration is shorter and weaker than in Icelandic […] and sometimes sounds as a pharyngeal or a palatal fricative."
  - Stockholm Swedish: "…[A] voiceless or voiced fricative homorganic to a preceding vowel or a subsequent consonant, i.e. it may be velar, dental, or labial.": [xk, çt, fp] "Sometimes preaspiration alternates with a [j]-like epenthetic sound or with the extra length of a preceding vowel…"
  - Härjedalen Swedish: "either [h] or [x]."
  - West Norwegian (Jæren): "Preaspiration varies in force and length and sometimes vanishes altogether…in spectrograms it is perceivable as a high frequency [s]-like noise."

- Liberman's summary: "The place of its articulation is never fixed at one point: sometimes a pharyngeal noise seems to predominate, but more often than not it is assimilated to surrounding vowels and consonants…very few investigators have noticed (or even admitted) the influence of preceding and following sounds on Icelandic preaspiration, while in other languages the non-pharyngeal variants of preaspiration are perceived by all. The dynamic peculiarities of preaspiration in Icelandic…are much more salient in Faroese, Stockholm Swedish, and in Gimsøy and Senja."

- Lule Sami (Engstrand 1987): "pre-aspiration" is a cover term for various phonetic realizations of this

series: “[T]he noise sound in question is frequently fricative rather than aspirative, particularly in the palatal and velar contexts.”

Toreva Hopi, and other Hopi dialects (Whorf 1946)

- “The pre-aspirates do not occur in Sipaulovi or Polacca, being replaced by plain stops, preceded by long vowels [[Vht] >> **[Vːt]**].
- “…in Toreva h-clusters are very rare, and when they do occur, obviously something different from the preaspiration.”

Eastern Ojibwa (Bloomfield 1957), and Cree (Horden 1881)

- Eastern Ojibwa fortis stops are “often preceded by a slight aspiration.”

- Cree pre-aspiration: “It is usually breathed at the end of the syllable aspirated, and some words depend on the aspirate for their signification…But the aspirate is not uniformly observed, some tribes, and even members of the same tribe, aspirating their words very much more than others; it is therefore quite impossible to lay down strict rules for its observance.”

Goajiro (Holmers 1949a)

- “Rough h (or sometimes a weak Spanish jota)”: **[x]**; “the pre-aspiration, as in teʻkiˑ *my head* is not used by many speakers.” (p.49).
- Many speakers have vowel length instead of the pre-aspiration: [meːkeːra] ~ [me^{h}keːra], [peːkeːraː] ~ [pe^{h}keːraː]: **[Vːk]**.

Fox (Jones 1910 (revised by Michelson), Bloomfield 1924)

- Jones (/Michelson): [ʻk, ʻt, ʻp]: "denotes a whispered continuant before the articulation of k, t, and p…it occurs also before *h*": **[xk, çt, fp]**.
- "The closure is so gradual that the corresponding spirant is heard faintly before the stop, so that the combination is the reverse of the (af)fricative."
- Before labials: "äʻpyʻtcⁱ *when he came* is to be pronounced nearly as äfpyʻtcⁱ with bilabial *f*"
- Before dentals: "audible hiss" before t, while the palatal also has a "hiss of breath" before oral closure. This "whispered continuant" also occurs before [h], and since the author(s) do not refer to this cluster as a geminate [h], this continuant is not laryngeal in origin.

Huautla Mazatec (Pike and Pike 1947, Kirk 1966, Steriade 1994, Silverman 1995)

- Pre-aspirated alveolar stops:

  [ʰti˩] fish

  [ʰtse˩˥] a sore

  [ʰtʃi˩] small

- Pre-aspirated velar stops: [sk] clusters:

  [ʰka˩˨] stubble [skˀao˥] it will break

- Proto-Mazatec: *st *sk

  ↓ ↙ ↘

  Huautla Mazatec: [ʰt] [ʰk] [sk]

Summary of results:

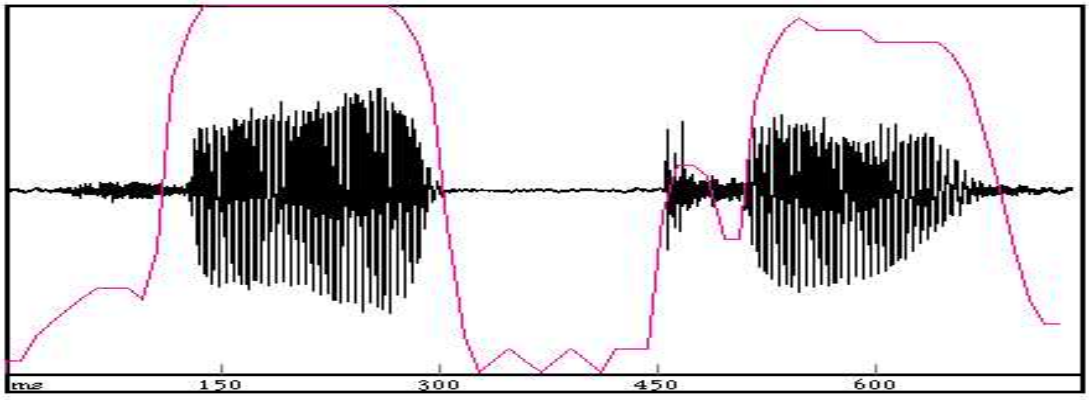
Pre-aspiration is remarkably unstable both synchronically and diachronically	
Genuine across-the-board pre-aspiration is extremely rare	
[^{h}p, ^{h}t, ^{h}k]	**Icelandic (?), Oraibi Hopi**
When present, pre-aspirated stops typically vary with spirant-stop clusters. This spirant is typically homorganic to the following stop	
[^{h}p, ^{h}t, ^{h}k] ~ [fp, çt, xk]	**Tarascan, Gaelic, Stockholm Swedish, Lule Sami, Toreva Hopi (?), Fox**
The spirant is sometimes influenced by the preceding vowel quality	
[i^{h}t, a^{h}t] ~ [içk^{j}, axk]	**Harris Gaelic, Barra Gaelic, Stockholm Swedish**
Pre-aspiration is often implemented as a velar spirant	
[xp, xt, xk]	**Red Point Gaelic, Goajiro, Härjedalen Swedish**
Pre-aspiration/pre-spirantization may vary with vowel length	
[V^{h}p, V^{h}t, V^{h}k] ~ [Vːp, Vːt, Vːk]	**Tarascan, Gaelic, Ojibwa, Cree, West Norwegian (Jæren), Hopi, Goajiro**
[fp, çt, xk] ~ [Vːp, Vːt, Vːk]	**Hopi, Goajiro**
Pre-aspiration may diachronically derive from [s]-stop clusters	
[st, sk] ~ [^{h}t, ^{h}k]	**Mazatec**
Pre-aspirates/spirants are limited to stressed domains	
['V^{h}t]/['Vçt] ~ [Vt]	**Tarascan, Ness Gaelic, Bernera Gaelic, Scandinavian, Hopi**

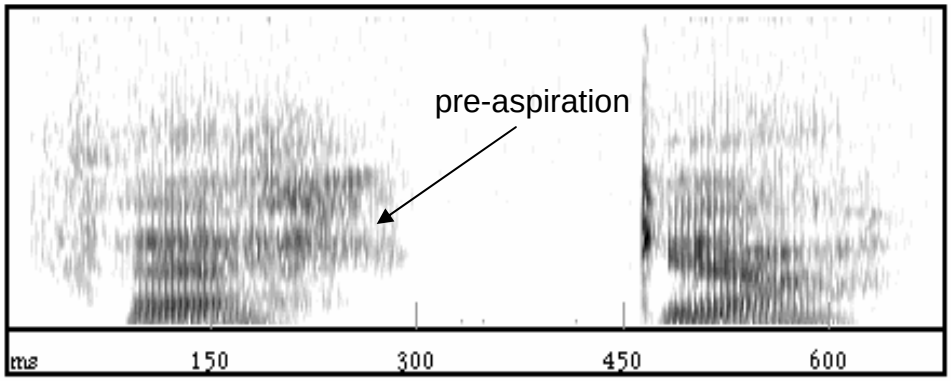
Aerodynamic, acoustic, and auditory disadvantages of pre-aspirated stops

- Post-aspirates: the transition interval from a voiceless stop into a following vowel is an especially salient acoustic event which involves the pressurized expulsion of air that has been trapped behind the oral occlusion.
- The resulting high volume and velocity of particle flow produces an especially robust acoustic signal (at the burst, and the interval immediately following) which is particularly well-suited to bear contrastive information.

- Pre-aspirates do not possess a stop closure immediately preceding the laryngeal abduction, there is no build-up of pressure to increase particle flow during the laryngeal.
- **Given the absence of a robust burst, the noise associated with pre-aspirates is not so saliently present in the signal.**

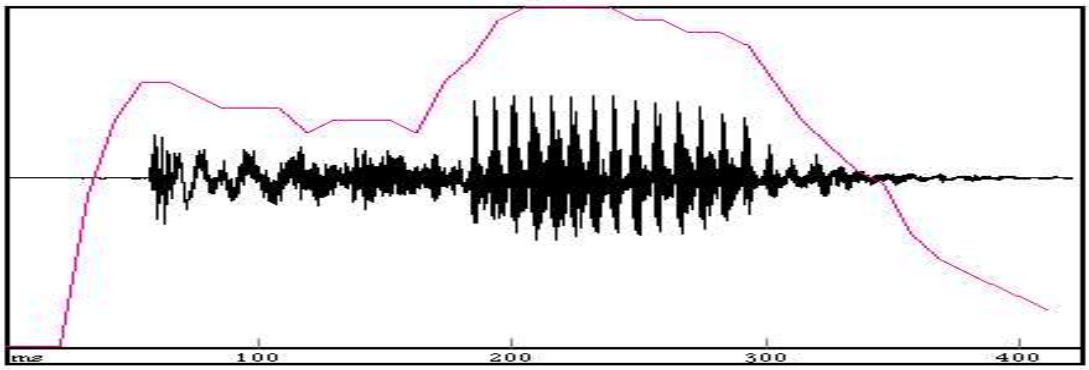
θehkja (Icelandic): broadband noise followed by silence, followed by sudden onset of periodicity, especially in formant regions:

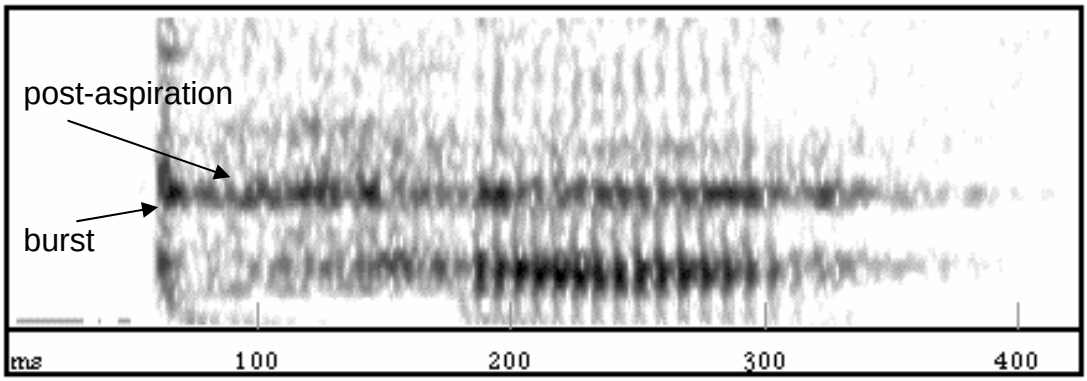




θ e h k j a

thæ (Jalapa Mazatec): Silence followed by sudden onset of noise, especially in formant transition regions, followed by periodicity:





t h æ

- Delgutte (1980): there is a pronounced peaking of auditory nerve activity at the sudden onset of spectral energy; the shorter the rise time, and the greater the intensity increase, the higher the peaking, but also the more precipitous the subsequent reduction in firing.
- Short-term adaptation: the auditory nerve fires less robustly as the same sound continues to be produced over time.
- Delgutte 1980: “In general, at the beginning of a speech segment, units tuned to the major frequency components of the preceding (adapting) segment would discharge at lower rates. Thus, short-term adaptation would increase contrast between successive segments in the profile of

discharge rate versus CF [characteristic frequency]" (p.848).

- Pre-aspiration is realized as a devoicing of the latter portion of the previous vowel. Thus there is little spectral shift in the transition from modal vowel to voicelessness.
- Consequently, the auditory nerve undergoes short-term adaptation: neural discharge decays throughout the vowel-h sequence.
- Bladon 1986: "Such temporal information as is imparted by preaspiration must in any case depend wholly on the detection of offsets—which does not make for a robust outlook...**given that pre-aspiration suffers from an accumulation of auditory handicaps, it would not be a risky prediction that languages would rarely make use of this auditory-phonetic dinosaur**."

Final discussion

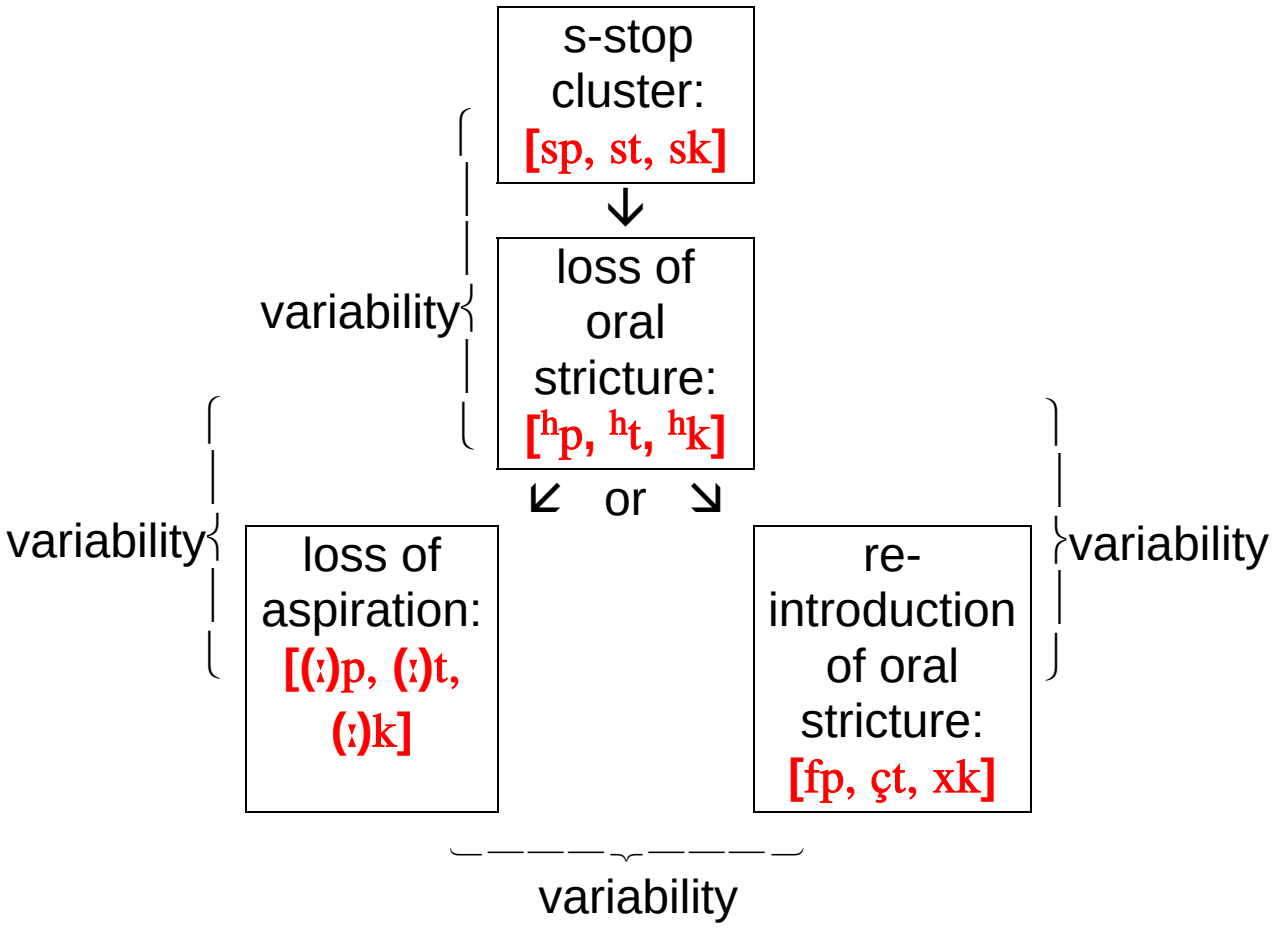
- So pre-aspirates are diachronically unstable. In order to salvage their contrastive function, an oral constriction might be introduced to enhance their noise characteristics, thus resulting in a series of pre-spirants, or "reverse affricates":
  [ʰp, ʰt, ʰk] → [fp, çt, xk]

- Alternatively, all traces of noise might disappear from the acoustic signal, and vowel length may survive:
  [Vʰp, Vʰt, Vʰk] → [V(ː)p, V(ː)t, V(ː)k]

- Pre-aspiration best survives under stress.

- As our typological study has demonstrated these are the patterns that are present is purported cases of pre-aspiration.

- In the case of Huautla Mazatec, at least some pre-aspirates diachronically derive from [s]-stop clusters. However, there are no languages in the survey in which homorganic spirant-stop clusters vary with [s]-stop clusters (***[sp, st, sk] ~ [fp, çt, xk]**).
- If the diachronic route from s-stop clusters to the pre-spirantized stop first passes through a stage of unstable pre-aspiration, then the absence of this second pattern of variation may be accounted for.
- Since some internal sound changes have been argued to proceed from the variability in speech production (Paul 1880, Martinet 1975, Ohala 1989, Janda and Joseph 2001), it follows that the form of immediate diachronic neighbors is constrained by the variability found at the synchronic level.
- Consequently, as [s]-stop clusters vary with pre-aspirates, and pre-aspirates vary with pre-spirantized stops and/or vowel length, then it follows that these sorts of variation will also be found among diachronic neighbors, for example, **{sk–hk}**, **{hk–xk–(ɤ)k}**.
- Moreover, as s-stop clusters are hypothesized to be diachronically non-adjacent to reverse affricates, we do not expect them to often vary with each other: ***{sp-fp}, {sk-xk}**.



- And indeed, this is exactly what our typological investigation has shown.

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