On the rarity of pre-aspirated stops¹

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Pre-aspirated stops, known to be quite rare in the world's languages, are shown herein to be significantly rarer still. Their aspiration component is typically reinforced by an oral gesture that is influenced by the following stop and/or the preceding vowel. Alternatively, the aspiration component weakens to zero and is replaced by vowel length. In this typological study I document the phonetic details of so-called pre-aspirates and offer phonetic explanations for their rarity and their diachronic instability.

I. INTRODUCTION

If we interpret the term 'pre-aspirated stop' in its most narrow and literal sense, we are talking about an oral closure preceded by noise generated exclusively at the larynx, a consequence of air flowing rapidly through laxed, abducted vocal folds, with no downstream (i.e. oral) noise source. The only oral influence on the spectral shape of this noise should be a consequence of the resonant properties of the vocal tract. Articulatory and consequent spectral variation in pre-aspiration should thus be largely parasitic on the surrounding vocalism, including the formant transitions into the following oral closure. Under this interpretation, pre-aspiration is largely the mirrorimage of post-aspiration, which is known to typically lack a downstream noise source. However, a careful reading of the primary literature on preaspirated stops indicates that many putative cases of this sound pattern do not involve aspiration at all. Instead, 'pre-aspiration' is usually employed as a cover term for a variety of configurations which typically involve a spirant largely homorganic to a following oral closure (e.g. [fp, ct, xk]), and/or a spirant that is influenced by the preceding vowel quality (e.g. [axk, ick]). In certain other cases, the term 'pre-aspiration' is employed for a primary vowel length distinction, which might only rarely vary with a slight devoicing at the vowel's end (e.g. $[a:t] \sim [a^h t]$). Finally, some researchers report that pre-aspiration is rare or absent for most speakers of the given language, and survives only sporadically, again oftentimes varying freely or systematically

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with a spirant. Clearly, the variation we observe among pre-aspirated stops is far greater than what we would expect if pre-aspirates were simply mirrorimages of post-aspirates.

Of course, it should come as no surprise that so-called aspiration should be subject to context-dependent variation. Indeed, this is a defining characteristic of allophonic alternation (and, more broadly, of complementary distribution). The present focus is on the documentation and explanation of this variation. While primary sources sometimes acknowledge that 'preaspiration' is indeed a cover term for a variety of phonetic configurations, the secondary literature is typically remiss in carefully documenting this variability. The result is that a terminological shorthand has evolved into a conventionalized labelling error. In this paper, then, my goal is to set the record straight on the rarity of pre-aspirated stops. Individual case studies are presented in section 2.

In section 3 I consider aerodynamic and acoustic explanations for my typological findings whereby, unlike post-aspirates, pre-aspirates vary with a downstream noise source ('pre-spirants'), and also vary with vowel length. I especially consider the poor acoustic salience of pre-aspirates in comparison to their post-aspirated counterparts. I also propose that the introduction of pre-aspiration into a system may sometimes be due to the loss of the oral features of an alveolar spirant ([sp, st, sk]) or due to an early opening of the glottis for the following voiceless stop. This results in a sound pattern ([hp, ht, ^hk]) for which the phonetic cues are particularly meagre. The instability of this pattern may lead in one or both of two directions: pre-aspiration's weak cues may lead to its eventual elimination from the system (with or without surviving vowel length) ([(:)p, (:)t, (:)k]) and/or to the re-introduction of a downstream noise source that enhances the salience of the otherwise jeopardized contrast ([fp, ct, xk]). The peculiar result of such sound changes is that pre-aspiration may take diametrically opposed phonetic forms, even within the same language. The spirant involves a narrow oral constriction and a large glottal opening before the stop, whereas the latter half of a long vowel involves a wide open oral cavity and approximated vocal folds.

Given its acoustic properties, it follows that genuine pre-aspiration may best survive under stress, where its enhanced acoustic prominence increases its chances of diachronic survival (see also Steriade 1999 on this point). Indeed, in several languages investigated, pre-aspirates or their spirantized counterparts are only found in stressed positions.

2. Survey of systems

In this section I consider individual systems in detail. The major works consulted for the typological study are Ruhlen 1975/6 (containing 706 segment inventories) and Maddieson 1984 (containing 317 segment inventories). Several additional cases are reported by Steriade (1999). Almost all languages

from these sources which are reported to possess pre-aspirates, as well as several additional cases, are investigated. Criteria for inclusion here are (i) the system's being listed by Ruhlen, Maddieson, and/or Steriade as possessing pre-aspirates; (ii) my awareness of other systems not mentioned in these sources, but reported elsewhere as having similar patterns; and (iii) the availability of primary source material. In most cases, original sources were available at the libraries of the University of Illinois and University of Edinburgh.

For each language, I consider in as much detail as is available the articulatory and acoustic properties of the relevant sounds. It is not always the case that linguistic descriptions of the patterns are sufficiently detailed to draw unequivocal conclusions. In such cases, a sufficient number of puzzle pieces are usually provided in the source to come to a fairly conclusive answer. I further consider, again in as much detail as is available, the variability of pre-aspiration across allophones, across dialects and across time (diachrony). Indeed, I will argue that all of these sorts of variability are intimately related. As I am not working in a segmental theory of phonology, I draw no distinction between systems characterized by their source as possessing h-stop clusters or single pre-aspirated segments. This distinction - real or imagined - has no bearing on the issues of present concern. Especially, I attach no segment-theoretic importance to the duration - relative or absolute - of aspiration, vocalism, and/or oral closure. Throughout, transcriptions are in accordance with the conventions of the International Phonetic Association's alphabet (IPA).

2.1 Tarascan (Foster 1969)

In Tarascan (a language of indeterminate origin spoken in Michoacán, Mexico) pre-aspirates alternate with post-aspirates. While aspirates are always realized as post-aspirates in word-initial position, word-medially they are often transcribed by Foster as pre-aspirates in the context of an immediately preceding stressed vowel, as in (I).

(I) um'ba^hpani to heap things on the floor of the room $a' \Lambda a^h k u ni$ to cut oneself on the hand

In (2) I provide the Tarascan consonant inventory. As pre-aspirates are regarded as derived variants of post-aspirates, they are not listed by Foster.

(2) Tarascan consonant inventory

Foster reports that the pre-aspirates vary with both pre-spirantized stops and vowel length. The alveolar pre-aspirates 'var[y] to pre-sibilantization following a voiced vowel either word-medially or with intervening nonpausal juncture' (p. 19): [^ht, ^hts, ^htʃ] vary with [st, sts, stʃ], respectively, as in (3a). She provides no specifics on the phonetic details of the pre-aspirated labials and velars, and so we remain in the dark as to whether they too vary with some sort of pre-spirantization. She does report, however, that preaspirates which follow [i] freely vary with vowel length (p. 17), as in (3b).

(3)	(a)	Variable pre-sibilants	
		'p ^h a ^h tani ~ 'p ^h astani	to touch the metate
		p ^h a ^h tsitani ~ p ^h astsitani	to touch the table
		ka't∫u ^h t∫ani ∼ka't∫ust∫ani	to cut off one's braid
	(b)	Variable vowel length	
		'tsi ^h kunį ~ 'tsi:kunį	to drop from one's hand

I should point out that Tarascan does not possess independent clusters of the form [st, sts, stʃ] which would minimally contrast with the pre-aspirated variants but would neutralize with the pre-sibilant variants (although it does have [sk] clusters). That is, the only source of these sounds is as free variants of [^ht, ^hts, ^htʃ]. Consequently, this variation never neutralizes lexical distinctions. Indeed, as I explore in section 3, it may well be the case that pre-aspiration may be reinforced as pre-spirantization EXACTLY BECAUSE it enhances the acoustic distinction among contrastive values.

Tarascan is thus the first of many cases we will see in which pre-aspiration is applied as a cover term for a number of phonetically distinct properties. Oftentimes, as in Tarascan, the so-called pre-aspirate varies with a prespirant, its place of articulation homorganic to the following stop closure. Elsewhere, it is influenced by the preceding vowel quality. In Tarascan, so-called pre-aspiration is variably realized as a lengthening in the context of a preceding [i], without any aspiration or spirantization whatsoever. Despite, presumably, a common diachronic origin, the variable realizations of Tarascan pre-aspiration deviate in diametrically opposed directions. As I noted in the introduction, a spirant involves a narrow oral constriction and a large glottal opening before the stop, whereas the latter half of a long vowel involves a wide open oral cavity and approximated vocal folds.

2.2 Gaelic (Borgstrøm 1940, 1941; Oftedal 1956; Dorian 1978; Ó Baoill 1980)

While Gaelic has post-aspirates in word-initial position, pre-aspirates are found in medial position following stressed vowels, where they are in opposition to plain occlusives. This makes their distribution largely identical to that of Tarascan pre-aspirates. On the Isle of Lewis (the Ness and Bernera dialects), Borgstrøm (1940) reports that the pre-aspiration is 'a short but quite audible h ... shorter than an ordinary h in the same dialect' (pp. 2f.). Examples are provided in (4).

(4) Gaelic pre-aspirates kla^hk grasp! $a^{h}k^{j}(a)$ with her $a^{h}t$ a fester

The Gaelic consonant inventory is presented in (5) (from Borgstrøm 1940, 1941). As Foster does for Tarascan, Borgstrøm lists only the post-aspirated alternant, since he treats the pre-aspirates as derived positional variants.

(5)	Gae	lic	conson	ant	invent	ory
	h	, h	ih	h	1 h	-

p"	t"	t ^{jn}	C	K ¹¹
b	d	dj	ł	g
f	S	∫j	ç	х
v			Z	Y
m	n	η		
	1	λ		ł
	r	r ^j		

According to Borgstrøm (1940: 21), intervocalic [h] is 'only slightly influenced by surrounding palatal articulations'. However, for [^hc] and [^ht^j], the pre-aspiration is 'distinctly palatal, without being as narrow as ς' : [ςc , ςt]. In fact, Borgstrøm (1940: 18) reports that the two palatal series are regularly pre-palatalized in addition to having a very short palatal offglide. This characterization of pre-aspiration as being palatal in post-palatalized contexts shows that Borgstrøm employs the superscripted 'h' as a cover term for a variety of phonetically distinct configurations, at least one of which involves a supralaryngeal constriction.

Actually, spirantization in the context of a following palatal would seem especially likely; the high airflow resulting from the wide open glottis is prone to excite the air at the approximated oral articulators here, given the long constriction area along the tongue. However, such homorganic spirantization is found at other places of articulation as well in Gaelic, casting doubt on an account which implicates a special interaction between airflow and the palatal region. Borgstrøm discusses dialects south of Lewis (Harris and Barra): 'Corresponding to the real preaspirated phonemes in Lewis ... all the southern dialects have groups consisting of h, x or c followed by unaspirated occlusives' (1940: 167). Regarding the velar pre-aspirates, [xk] seems to predominate in the context of a preceding back vowel (but also [æ]), exemplified in (6a), while [ck] is usually found following front vowels, as in (6b) (note especially the $[x] \sim [c]$ alternation when 'son' is pluralized). Finally, [hk] is found 'only in a few late loanwords' (1940: 168), as in (6c). (6) *Southern Gaelic*

(a)	maxk	son
	k ^h rðxk	a small field
	səxkir ^j	quiet
	∫æxk	seven
(b)	miçk ^j	sons
	fẽçk ^j in	to see
	k ^h reçk ^j	to sell
(c)	du ^h kəy	to wade (<eng. <i="">duck)</eng.>
	∫l ^j a ^h k	slack
	smɔʰkəɣ	to smoke

Regarding the pre-aspirated alveolar stops, they are genuinely laryngeal in most contexts, but are realized as palatal fricatives following [i] (for example, [ljiçt^jir^j] 'letter', [içtɔ] 'a feather'); the labial stop is pre-palatalized only rarely, and is typically genuinely pre-aspirated (for example, $[t^{h}a^{h}p\epsilon \ ljæ^{h}t]$ 'thank you', $[k^{h}r\tilde{a}^{h}p]$ 'a lump') (Borgstrøm 1940: 169). If pre-aspiration were simply a mirror image of post-aspiration, then any oral component reportedly present in the one context should be reported in the other as well. That post-aspiration is not deemed worthy of further comment by Borgstrøm strongly suggests that the two are not equivalent in their phonetic properties: pre-aspirates are oftentimes pre-spirantized, but post-aspirates do not seem to be post-spirantized.

Borgstrøm (1941) also reports on the Skye and Ross-shire dialects. He writes that pre-aspiration on Skye 'is identical with that of the Southern Hebridean [Harris and Barra] dialects' (p. 43). In Red Point (Gairloch) and Aultbea, pre-aspiration involves 'a very distinct and long h, frequently with a slight velar friction; this h is, however, different from x, which has more friction, and there exist such pairs as *bohk* 'a buck' *boc* $\sim boxk$ 'poor' *bochd*. When the occlusive is palatal, h is not affected by the palatality' (pp. 100f.).

Ó Baoill (1980) also reports that pre-aspiration is often realized as [x] 'even before /p/ and /t/', and also before [ç] (p. 83). Certainly, there can be no proximate aerodynamic reason for a velar spirant to appear before a labial closure; the explanation for this downstream noise source clearly lies elsewhere. Ó Baoill goes so far as providing the unconventional transcriptions $[ma_h^kk]$ 'a son', and $[k^ha_h^kt]$ 'cat'.

Regarding the Leurbost dialect, Oftedal (1956: 98f.) writes:

Postaspiration consists, in principle, of a voiceless interval with escape of breath between the explosion of the stop and the onset of voice in the following sound. Preaspiration is practically the inverse: a voiceless interval after the voiced part of a preceding vowel, or devoicing of a preceding voiced consonant.

But while this characterization is correct in principle, it is somewhat inaccurate in practice. Oftedal provides a narrow transcription of one of his recordings (p. 330). Of the approximately 175 words in this passage, only five contain stops in the pre-aspirating context. Four of these five are transcribed with a superscripted palatal fricative 'ç', while only a single form contains genuine pre-aspiration: ['ŋchui^ct'əm] *an tuiteam*, [a^hkɛ] *aca*, ['t'ui^ct'əm] *tuiteam*, ['jē^ckiN'] *fhaicinn*, ['fē^cki] *faiceadh* (these transcriptions are copied exactly from Oftedal, and so are not in strict accordance with the current IPA).

Finally, Dorian (1978: 41) writes that pre-aspiration is entirely absent in East Sutherland Gaelic, including Brora, Golspie and Embo.

In Gaelic dialects, then, genuine pre-aspiration is present to different extents depending on the dialect, the place of articulation of the following stop, and/or the quality of the preceding vowel. However, the term 'preaspiration' actually encompasses a variety of distinct phonetic forms, many of which involve supralaryngeal constrictions of a fricative nature. None of this variability is reported for the post-aspirates of Gaelic, strongly suggesting that pre- and post-aspiration are not mirror-images of each other. This casts strong doubt on an analysis in which the oral noise source is solely an automatic consequence of proximate aerodynamic forces. Indeed, given that airflow during post-aspiration is typically greater than airflow during pre-aspiration, a purely proximate aerodynamic account of the downstream noise source here would incorrectly predict post-aspiration to be more likely spirantized than pre-aspiration.

2.3 Icelandic (Liberman 1978, 1982; Thráinsson 1978; Kingston 1990; Silverman 1995) and other Scandinavian languages

Icelandic possesses both lexically contrastive and allophonic pre-aspirated stops. As discussed below, the series is sometimes described as involving a supralaryngeal constriction. The Icelandic consonant inventory is presented in (7).

(7) Icelandic consonant inventory

р	t	с	k
p^h	t ^h	c ^h	k ^h
ĥр	^h t	^h c	^h k
f	S	ç	Х
V	ð		
m	n		
l,ſ			
W		j	
h			

Intervocalically, pre-aspiration is contrastive with plain geminates, with aspirated stops in some dialects, and with plain singleton stops in others, as is illustrated in (8).

(8) V^hk (e.g. 'va^hka to walk to and fro)
V:k^h (e.g. 't^ha:k^ha take)
V:k (e.g. 'sa:ka story)
Vk: (e.g. 'vak:a a cradle)

Also, pre- and post-aspiration bear an allophonic relationship in certain contexts. For example, $['k^{h}a:k^{h}+a]$ 'cake (nom. sg.)' alternates with $['k^{h}a^{h}k+na]$ 'cake (gen. pl.)'.

Non-alternating pre-aspirates are contrastive in morphologically simple contexts where the preceding vowel is stressed; some examples, from Thráinsson (1978), are in (9).

(9) Icelandic non-alternating pre-aspirates
 [']k^ha^hpi hero
 [']θa^hka thank
 [']ha^htyr hat

Also, as is illustrated in (10), pre-aspiration is lexically contrastive where the involved stop closure precedes l or n, which in turn precedes an unstressed vowel.

(10) Icelandic pre-aspirates before sonorants

εpn	appie	o pna	open
'aj ^h tla	intend	'vɛ ^h tnı	hydrogen
'ɛʰkla	lack	'va ^h tna	wake up

Pre-aspirated alternants arise when a morpheme-final aspirate is followed by a homorganic aspirate. Homorganicity here may be lexical or derived through syncope and/or assimilation. Moreover, the homorganic cluster is not geminated, but instead is realized as a singleton stop closure. Postaspiration does not appear here. In (II), in the case of diphthongs, preaspiration is indicated as a devoicing of the offglide ([-ajt-]).

(II) Icelandic pre-aspirated alternants

majt ^h + a	\rightarrow	'majːtʰa	meet (inf.)
$majt^h + t^h + I$	\rightarrow	'majtı	meet (past)
$vejt^h + a$	\rightarrow	'vej:t ^h a	grant (inf.)
$vejt^h + t^h + i$	\rightarrow	'vejti	grant (past)
$nit^{h} + a$	\rightarrow	'nixt ^h a	utilize (inf.)
$nit^{h} + t^{h} + a$	\rightarrow	'ni ^h ta	utilize (past)

Additionally, pre-aspirated alternants appear upon attaching an l- or n-initial suffix to an aspirate-final root, as in (12).

(12) Icelandic pre-aspirated alternants before sonorants $p^{h}ip^{h}+a \rightarrow p^{h}ip^{h}a$ pipe (nom. sg.) $p^{h}ip^{h}+na \rightarrow p^{h}i^{h}pna$ pipe (gen. pl.) $kat^{h}+a \rightarrow kat^{h}a$ street (nom. sg.) $kat^{h}+na \rightarrow ka^{h}tna$ street (gen. pl.)

Finally, to different degrees in different dialects, sonorants preceding aspirates vary with their devoiced counterparts. When devoiced, a plain stop follows; when not devoiced, an aspirate follows. Examples are in (13).

(13) $u_{i}^{h}pa \sim u_{i}^{h}pa$ coat hejmta ~ hejmt^ha demand vanta ~ vant^ha lack vinka ~ vink^ha wave

Liberman (1982) writes that certain researchers have reported that preaspiration varies with pre-spirantization, for example, [fp, θ t, xk] (Goodwin 1905, 1908), [x], [ç], etc. (Fries 1977), and a non-laryngeal spirant after high vowels (Einarsson 1927), although he tells me that most researchers insist that this is a mischaracterization of their phonetic properties (Anatoly Liberman, personal communication 2001). Nonetheless, Gunnar Hansson (personal communication 2002) has demonstrated for me that pre-aspiration is clearly palatal in the context of a preceding [i]. Both Ní Chasaide (1985) and Ladefoged & Maddieson (1996) report that pre-aspiration is of a longer duration (and involves a wider glottis and greater airflow) than does postaspirates have largely sustained themselves diachronically; the consequent increased salience affords pre-aspiration a better chance of survival at the diachronic level.

Although of different diachronic origins, pre-spirantization is reported in a number of other Scandinavian languages as well. Regarding sounds that have traditionally been characterized as pre-aspirates, Liberman (1978: 64ff.) clarifies their phonetic characteristics in the following ways:

- Faroese: 'Preaspiration is shorter and weaker than in Icelandic ... and sometimes sounds as a pharyngeal or a palatal fricative.' ('Pharyngeal' refers to a standard [h], i.e. 'laryngeal' Anatoly Liberman, personal communication 2001.)
- Stockholm Swedish: '[P]reaspiration is realized as a voiceless or voiced fricative homorganic to a preceding vowel or a subsequent consonant, i.e. it may be velar, dental, or labial. Sometimes preaspiration alternates with a [j]-like epenthetic sound or with the extra length of a preceding vowel.'
- Härjedalen Swedish: 'preaspiration resembles either [h] or [x]'.
- West Norwegian (Jæren): '[P]reaspiration varies in force and length and sometimes vanishes altogether. It is usually pharyngeal, but before [t] it is almost indistinguishable from [f] ... in spectrograms it is perceivable as

a high frequency [s]-like noise.' ('[f]' is 'probably a typo' for [s] – Anatoly Liberman, personal communication 2001.)

Liberman goes on to make the following generalizations about Scandinavian pre-aspirates (p. 65):

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.

The ink Liberman affords the phonetic properties of pre-aspiration is notable especially in contrast to the total absence of exposition regarding the particulars of post-aspiration. Clearly, the pre-aspirates are not simply mirror-images of the post-aspirates, but deviate from pure aspiration in now-familiar ways. His conclusions for Scandinavian are in keeping with the present findings concerning so-called pre-aspirates at the cross-linguistic level: typically, sounds which have been labelled as 'pre-aspirated' are in fact pre-spirantized, and may also vary with vowel length or with zero, thus lacking a noise component altogether.

A similar pattern is present in Lule Sami, an areal neighbor of Scandinavian. Engstrand (1987) reports that this language has a series of stops which he terms 'pre-aspirated', which contrasts with a plain voiceless series intervocalically. However, he reports that 'pre-aspiration' is a cover term for various phonetic realizations of this series: 'the noise sound in question is frequently fricative rather than aspirative, particularly in the palatal and velar contexts' (p. 105). Ní Chasaide & Gobl (1993) document that there is some anticipatory vocal fold spreading in Swedish voiceless stops, and also sometimes in English and Italian, suggesting that one diachronic source of pre-aspiration is a temporal expansion of the laryngeal opening gesture to precede the oral closure. Docherty & Foulkes (1999) find a similar pattern in Tyneside English, and further find that this pre-aspiration is occasionally realized as pre-spirantization. Indeed, Paul Foulkes (personal communication 2002) tells me that pre-aspiration in Tyneside actually encompasses a variety of sounds, including breathy offsets to vowels, and high-frequency fricative energy which is more or less pre-spirantization in the case of many [t]s. It is also sometimes palatal after [i], and occasionally velar before [k].

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

Eastern Ojibwa (an Algonquian language of Ontario) possesses a series of optionally slightly pre-aspirated stops. Bloomfield reports that Eastern

PRE-ASPIRATED STOPS

Ojibwa possesses fortis stops that are 'often preceded by a slight aspiration', and 'only occur after vowels', although within the phrase, certain particles often lack this initial vowel. A second stop series is usually voiceless, although 'between vowels and especially after nasals they are often partly or wholly voiced ... and are never aspirated' (p. 8). In (14), I list the Eastern Ojibwa consonant system.

(14) Eastern Ojibwa consonant inventory
(^h)p (^h)t (^h)t∫ (^h)k
p t t∫ k
s
$$\int$$

m n

Closely-related Cree also possesses pre-aspirates. As in Ojibwa, preaspiration is rather irregular in terms of its phonetic properties:

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. (Horden 1881: 2)

As in all the cases we have investigated thus far, pre-aspiration in Eastern Ojibwa and Cree is variable in its realization – in particular, varying with its complete absence – although no mention is made of any supralaryngeal component. But when pre-aspiration is indeed present, it is only 'slight'.

2.5 Goajiro (Holmers 1949a)

Holmers (1949a) describes pre-aspiration in Goajiro (an Arawakan language of Colombia and Venezuela) as 'rough h (or sometimes a weak Spanish jota)' (p. 47). It is not fully clear what a 'rough h' is, but Holmers' comparing some instances of pre-aspiration to 'Spanish jota' certainly implicates the presence of some sort of constriction with velar frication. Although one of his consultants 'pre-aspirates profusely' (p. 47, fn. 10), nonetheless, 'the pre-aspiration, as in te'ki. "my head", is not used by many speakers' (p. 49). Indeed, many speakers have vowel length instead of the pre-aspiration: [me:ke:ra]~[me^hke:ra], [pe:ke:ra:]~[pe^hke:ra:]. In (15) is the consonant inventory of Goajiro.

(15) *Goajiro consonant inventory*

p	t	t∫	k
^h p	^h t	^h t∫	^h k
S	ſ		
m	n		
r,l			
W		j	

Pre-aspiration is reportedly in contrast with [h]+stop clusters. All short stressed final vowels are followed by [h], although it is rarely audible, instead being realized as a 'very short i (or y)' (p. 49) ('y' = IPA 'j'). In other contexts also, when [h] precedes a stop in sequence, [ih] is usually [ij]: [taihtai] 'I put', [pəihtai] 'thou puttest' and [ihpah] 'stone' are usually pronounced [taijtai], [paijtai] and [ijpah], respectively. Approximately thirty years after Holmers' report, Ladefoged and Maddieson recorded a single Goajiro speaker, finding that he rarely pre-aspirated, although he sometimes employed a breathy-voiced offset before stop closure (Ladefoged & Maddieson 1996: 72f.); perhaps this is Holmers' 'rough h'. Despite the existence of morpheme-final [h]s, in at least one context derived pre-aspirates are not created when a stop immediately follows. Instead, for example, the initial stop of the nominalizing particle [kal] is geminated, with concomitant loss of the root-final [h], shown in (16) (see Holmers 1949b for a full discussion of the [kal] particle).

(16) *Goajiro derived pre-aspirates* $mah + kal \rightarrow mak:al$ place (*ma^hkal) cooking pot (*uʃu^hkal) $u(uh + kal \rightarrow u(uk:al)$ $ka_{ih} + kal \rightarrow ka_{ik}$ (*kaſi^hkal)

To summarize, so-called pre-aspiration in Goajiro was rarely actually encountered by Holmers, often being absent altogether with vowel length in its place, and when present, is described as variably possessing a velar constriction. Furthermore, at least some morphological contexts eliminate pre-aspiration in favour of gemination. Finally, the h-stop cluster is typically yodized (as in, for example, Stockholm Swedish). The Goajiro pattern thus possesses all the elements that should now be familiar: so-called preaspiration varies with its absence, varies with vowel length or may involve a supralaryngeal gesture. It is also subject to loss upon morphological derivation.

moon

2.6 Fox (Jones 1910 (revised by Michelson), Bloomfield 1925)

Both Trubetzkoy (1939) and Steriade (1999) write that Fox (an Algonquian language) possesses pre-aspirates. In (17) is the consonant inventory, showing pre-spirants instead of pre-aspirates.

(17) *Fox consonant inventory*

k t p fp st çc b d g ts t∫ ſ s m n 1

My reasoning for these transcription changes is that Jones (/Michelson) transcribes the relevant stop series ['k, 't, 'p], where the turned apostrophe 'denotes a whispered continuant before the articulation of k, t, and p... it occurs also before h' (Jones (/Michelson) 1910: 742). Michelson adds that

[t]he closure is so gradual that the corresponding spirant is heard faintly before the stop, so that the combination is the reverse of the fricative. Thus $\ddot{a}^{t}py^{t}c^{i}$ when he came is to be pronounced nearly as $\ddot{a}fpy^{t}c^{i}$ with bilabial *f*. (p. 742)

The expression 'reverse of the fricative' was probably intended as 'reverse of the Affricative', since 'affricative' is the term Jones employs to denote affricates, whereas he always uses the term 'spirant' to denote fricatives. Anyway, the reverse of a fricative would simply be another fricative – which would make no sense to mention – whereas the 'reverse of an affricate' is in keeping with the authors' description of these sounds: $[pf] \rightarrow [fp]$. The other two stops are characterized in terms similar to the labial. Jones reports that the dental possesses an 'audible hiss' before t, while the palatal also has a 'hiss of breath' before oral closure. Indeed, 'hiss' is a word rarely used to describe the broadband noise, with its comparatively low centre of gravity, characteristic of aspiration, and seems more suited to the high-frequency noise of a sibilant fricative. Transcribing these sounds as [st, cc] thus reflects the reported 'corresponding spirant [which] is heard faintly before the stop' (p. 742). This 'whispered continuant' also occurs before [h]. For the sound transcribed ['h], '[t]he tongue is drawn back and raised high, making the airpassage narrow; it has a sudden release at the moment almost of seeming closure' (p. 742). It is thus clear that this spirant is not laryngeal in origin: the author(s) do not refer to this cluster as a geminate [h]. Regarding plain [h], Jones (/Michelson) writes that 'it is soft breath with feeble friction passing the vocal chords, and continuing on through the narrowed glottis', with no mention of 'hiss' or 'spirant', thus clearly juxtaposing it to spirants which may precede stop closures or [h]. As the source does not suggest that these sounds are pre-aspirates, I conclude that Fox has a series of 'reverse affricates'.

Bloomfield (1925) does not further illuminate the particulars of the 'reverse affricate' series, but the conclusion may be clearly drawn anyway: Fox does not possess a series of pre-aspirates. Instead, it has a series of 'reverse affricates', the place of articulation of which seems to be determined by the following stop closure. Its patterning is consistent with our previous results.

2.7 Southern Paiute (Sapir 1930)

Although not usually regarded as a language with pre-aspiration, Southern Paiute has a vowel devoicing process that is comparable to the cases we have been considering. Its consonant inventory is presented in (18).

р	$\mathbf{p}^{\mathbf{w}}$	t			ķ	k	$\mathbf{k}^{\mathbf{w}}$	q	qw
p^h	pŵ	t ^h			ķ ^h /ķ ^x	k ^h	k ^w	q^h	qw
			ts	t∫					
				t∫ ^h					
Φ	$\Phi^{ m w}/ m w$	s			x,∕×∕j	\mathbf{X}/\mathbf{X}	$\mathbf{X}^{\mathbf{W}}$	χ	χw
\mathbf{V}	v^w/w				γ∕j °	Y	χ^{w}		
m	m^w	n		n	ņ	ŋ	$\mathfrak{y}^{\mathrm{w}}$		
m	m^w	ņ			1		ŋŵ		
		r							
		ŗ							
h,?									

Under certain accentual conditions, short vowels devoice in the context of a following voiceless geminate. Sapir (1930: 33) writes the following about their phonetic character:

[A] moment of free untimbred breath ... is generally audible after the unvoiced vowel proper and before the consonantal closure; before guttural stops (q, qw), less frequently before other stops, this ... develops to a weak guttural spirant (indicated ^{-x-}), which has a palatal timbre after *i* (indicated ^{-x-}), a very brief but sharp x sound as in German *ich*).

Some examples follow in (19).

(19) Southern Paiute pre-aspirates

pi ^x kamɔ?°	sore-handed
'po:t:o ^x qwarm	being round
jų ^x 'quts:	fawn
pũŋ'qamu ^x qwiçaih	keeps calling on
nu ^x 'qwintu	stream

Thus, while the interval immediately before the stop closure is sometimes realized as pure voicelessness, it is also sometimes realized with a velar or palatalized oral constriction which results in a spirantized sound.

2.8 Chamicuro (Parker 1994) and other Maipuran languages (Payne 1991)

As in Tarascan, Gaelic, and Icelandic, Chamicuro (a Maipuran (Arawakan) language of Peru) has plain stops, and pre-aspirates when the preceding syllable is stressed. The consonant inventory is provided in (20).

(20) Chamicuro consonant inventory

р	t	ts	t∫		tş	k
		S	ſ		ş	
m	n		n			
	1		λ			
w				j		
?,h				,		

PRE-ASPIRATED STOPS

The language is very unusual in that laryngeals (both [h] and [?]) are found pre-consonantally, though never pre-vocalically. In (21) are some examples of pre-aspirates.

(21)	Chamicuro pre-aspirates			
	apehta	sardine		
	pt∫ahtoki	wild, savage, fierce		
	şohta	big		
	uit∫ehki	it burns		
	watoşamahti	I wash		

Payne (1991) reconstructs Proto-Maipuran with a syllable-final *h. In most daughter languages, this [h] has been lost, surviving as vowel length or other 'non-standard sequences' (p. 455). It has best survived in Chamicuro, and also in Amuesha, although even in these languages it has been lost in some words. So, while Chamicuro has a series of genuine pre-aspirates, its Maipuran neighbours have almost all lost this laryngeal gesture, usually replacing it with vowel length or some other sound.

2.9 Toreva Hopi and other Hopi dialects (Whorf 1946)

The Toreva dialect of Hopi (a northern Uto-Aztecan language of Arizona) is reported by Ruhlen (1975/6) and Steriade (1999) to possess pre-aspirates; the Hopi pre-aspirates are also mentioned by Trubetzkoy (1939). However, it actually has a number of different phonetic realizations in various dialects. The consonant inventory is presented in (22).

(22) *Toreva Hopi consonant inventory*

p ^h p	t ^h t	t∫ ^h t∫	c/c^{j} ^{h}c	$\overset{c^{w}}{{}^{h}c^{w}}$	k ^h k
S					
\mathbf{V}					
m	n		n	$\mathfrak{p}^{\mathrm{w}}$	ŋ
m	ņ				ŋ
1,1					0
ļ					
W			j		
W			j		
h,?			0		

In Hopi, as in Tarascan, Scandinavian, Gaelic, and Chamicuro, preaspirates may appear only when immediately following a stressed vowel (Whorf 1946: 160); pre-aspiration is not found in other contexts, and indeed, the aspiration alternates with its absence: 'pa:sat(,a) 'field abs.obj.sg' -'Pe^h,pasa 'thy field const.nom.sg.'. Furthermore, as in Goajiro, the preaspirates de-aspirate upon certain derivational processes (Whorf 1946: 162).

They occur 'secondarily and rather irregularly in certain reduplications, prefixations, and suffixations' (Whorf 1946: 162, fn.7). Regarding the dialectal distribution of the pre-aspirated consonants, they appear in the Oraibi and Toreva dialects:

The pre-aspirates do not occur in Sipaulovi or Polacca, being replaced by plain stops, preceded by long vowels ([Vht] \ge [V:t]). In Oraibi the preaspirates do not exist as single phonemes but are represented by h plus stop, h occurring freely before all consonants in Oraibi, whereas in Toreva h-clusters are very rare, and when they do occur, obviously something different from the preaspiration. (sic; Whorf 1946: 160, fn. 5)

The incidence of pre-aspirates in the various dialects of Hopi was clearly quite low at the time of Whorf's writing. They were non-existent in the Sipaulovi and Polacca dialects. In Oraibi, they only appeared when the preceding vowel was stressed, and in Toreva were subject to certain morphologically conditioned deletions. Although he juxtaposes the Toreva pre-aspirates to the rare h-plus-stop sequences, Whorf does not discuss the phonetic particulars of their differences. Clearly, either the h-stop sequences, or the pre-aspirates, or perhaps both, are not genuinely pre-aspirated, but instead consist of 'obviously something different'.

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

The Huautla dialect of Mazatec (along with the Mazatlán de Flores, Santa María Jiotes, and San Jerónimo Teocatl dialects; Oto-Manguean languages of Oaxaca, Mexico) possesses pre-aspirates in contrast with post-aspirates. Also of interest is the fact that pre-aspiration contrasts with [s]-stop clusters before the velar stop ($[^{h}k] - [sk]$), but only the pre-aspirate is present with the alveolar stop; [st] is missing. The Huautla Mazatec native consonant inventory is presented in (23) (from Kirk 1966).

(23) Huautla Mazatec consonant inventory

		15	IJ	15	ĸ
1	t ^h	ts ^h	t∫ ^h	tsh	$\mathbf{k}^{\mathbf{h}}$
1	ⁿ t	^h ts	^h tf	^h ts	^h k
1	ť	ts ²	t∫ ^ŗ	tsr	k۲
5	5		ſ		
5	s ^h		ſh		
5	s ²		۲ ²		
m ^h 1	n ^h		η^h		
^h m ¹	'nn		ĥη		
m ² 1	n²		η²		

 ${}^{p}m$ ${}^{p}n$ ${}^{p}n$ ${}^{p}n$ ${}^{p}n$ ${}^{l}n$ ${}^{l}n$ p ${}^{r}n$ ${}^{j}n$ ${}^{h}w$ ${}^{h}j$ ${}^{p}w$ ${}^{p}j$ ${}^{h}n$ ${}^{p}n$ p

Mazatec is perhaps unique in possessing pre-aspirates in word-initial position. Some examples of pre-aspirated stops and [sk] clusters are presented in (24) (from Pike & Pike 1947).

(24)	Huautla Mazatec pre-aspirated alveolar stops				
	^h ti	fish			
	^h tse	a sore			
	^h t∫i	small			
	Pre-	aspirated velar stops	[sk] clusters		
	^h ka	stubble	sk ² ao it will b	reak	

Regarding the absence of [st], Kirk (1966: 8of.) reconstructs the Proto-Mazatec reflex of modern [ht] as *st. This suggests that present-day [sk] and [hk] might both originate in proto-Mazatec *sk, with some of these forms having evolved – perhaps on analogy with [ht] – into [hk] sequences, although Kirk provides no cognate sets involving Huautla [hk] forms. This proposed diachrony is outlined in (25).



2.11 Sanskrit (Allen 1953)

A similar sound change seems to have taken place in Sanskrit, with the further innovation of pre-spirantization. Concerning root-final [h], Allen (1953: 50) writes:

This voiceless breathing primarily occurs only in final position *in pausa*, where historically it replaces *s (or less frequently *r). Corresponding to -h *in pausa*, there appeared in junction with initial voiceless consonants the appropriate homorganic fricatives (viz. -x, $-\int$, -s, -s, - Φ).

In other words, [s] has gone to [h], but when pre-aspirates would be created at morpheme boundaries, pre-spirants were found instead.

2.12 Summary

The table in (26) shows the sorts of variation that have been documented in our typological investigation. Variation here refers to any or all of the following: (1) conditioned or free synchronic variation, (2) dialectal variation, (3) diachronic change (' \sim '=free or conditioned variation; ' \geq '=diachronic change; '-'=stress-conditioned alternation).

	Variation (schematic)	Language examples
A	[^h p, ^h t, ^h k]	Chamicuro, Toreva Hopi(?), Mazatec
В	$[^{h}p, ^{h}t, ^{h}k] \sim [fp, ct, xk]$	Tarascan, Gaelic, Stockholm Swedish, Lule Sami, Toreva Hopi(?), Fox, Southern Paiute
С	$[i^ht, a^ht] \sim [i \varsigma k^j, axk]$	Harris Gaelic, Barra Gaelic, Stockholm Swedish
D	[xp, xt, xk]	Red Point Gaelic, Goajiro, Härjedalen Swedish
E	$[V^{h}p, V^{h}t, V^{h}k] \sim / \\ \gg [V:p, V:t, V:k]$	Tarascan, Gaelic, Ojibwa, Cree, West Norwegian (Jæren), Hopi, Goajiro, Maipuran, Hopi
F	$[fp, ct, xk] \sim [V:p, V:t, V:k]$	Goajiro
G	$[(sp,) st, sk] \ge [(^{h}p,) ^{h}t, ^{h}k] (\ge [(\Phi p,) st, xk])$	Mazatec, Sanskrit
Η	['V ^h t]/['Vçt] - [Vt]	Tarascan, Ness Gaelic, Bernera Gaelic, Icelandic, Scandinavian, Hopi, Chamicuro

(26) Summary of results

Summarizing the major findings, consider the following statements:

- Pre-aspiration is remarkably unstable both synchronically and diachronically.
- Genuine across-the-board pre-aspiration is very rarely found (A).

- When present, pre-aspiration typically varies with spirant-stop clusters (B, C).
- This spirant is typically homorganic to the following stop (B).
- The spirant is sometimes influenced by the preceding vowel quality (C).
- In some cases pre-aspiration is often implemented as a velar fricative (D).
- Alternatively, pre-aspiration/pre-spirantization may vary with vowel length, synchronically and/or diachronically (E, F).
- Pre-aspiration may diachronically derive from [s]-stop clusters (G).
- It is often the case that pre-aspirates/spirants are limited to stressed domains (H).

In the next section I consider phonetic reasons for the patterns that have emerged from this typological investigation.

3. PHONETIC REASONS FOR PRE-ASPIRATES' DIACHRONIC INSTABILITY

In this section I consider the articulatory, aerodynamic, and acoustic characteristics of the relevant sound patterns. I go on to consider a possible diachronic scenario of the rise and fall of pre-aspiration.

The rarity of pre-aspiration has been previously observed by Kingston (1985, 1990). He especially considers their rarity in comparison to the overwhelming prevalence of their post-aspirated counterparts ($[p^h, t^h, k^h]$). Consider first Kingston's proposed explanation for the commonality of postaspirates. These involve the full silence of a stop, followed by a sudden onset of noise at release, which is most pronounced at the characteristic transient frequencies (around F2 for stops towards the back of the oral cavity; F3 for stops towards the front of the oral cavity) and continues until the periodic wave begins. The laryngeal abduction, which is responsible for the voiceless interval between stop and vowel, produces random noise across a broad portion of the sound spectrum. During [h] sounds, the shape of the supralaryngeal cavity is contextually determined by proximate supralaryngeal gestures. Consequently, even after the burst, the noise of the aspirate is more prominent at these vowels' characteristic formant frequencies. At the onset of modal phonation (plain voicing), the sound spectrum changes from noise to the quasi-periodicity that is characteristic of a regular glottal pulse.

In comparison to other CV sequences, 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. Because of its salience, Kingston suggests that stop release is a preferred site for the realization of linguistically significant articulatory events. Laryngeal articulations thus gravitate or 'bind' to this site so that

they may be realized with comparatively heightened acoustic salience, thus increasing the likelihood of unambiguous cueing to listeners.

Elaborating somewhat, an open glottis allows air to enter the oral cavity at a rapid rate. With a downstream closure, the oral cavity fills to capacity quite quickly. Typically, for post-aspirated stops, the glottal abduction is maximal around the transition from stop to vowel (Hirose, Lee & Ushijima 1974, Löfqvist 1980, Löfqvist & Yoshioka 1980, Yoshioka, Löfqvist & Hirose 1981). The pressure build-up behind the oral closure is thus released with a salient burst. Timing the maximal laryngeal abduction with the transition from stop closure to vowel thus results in maximal airflow during this critical interval. As increased particle flow at the sound sources (here, the larynx and the release site) correlates with increased acoustic energy, noise from both sources may be saliently encoded in the speech signal. Thus, as Kingston has noted, the release properties both depend on, and cue, the laryngeal state.

Apart from Ní Chasaide (1985) and Kingston (1990), there is very little experimental work which documents the phonetics of pre-aspirates. But as 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 abduction. On the contrary, because the mouth stays open for the vowel, after the glottis opens, any additional air flowing into the mouth immediately flows right out of it, and so no air pressure builds up in the oral cavity. Because no air pressure builds up, no event as salient as a burst occurs before the oral closure of the stop. Given the absence of a robust burst, the noise associated with 'h' sounds is not so saliently present in the signal.

It might seem unusual that vowel length and pre-aspiration (and prespirantization) are so intimately related both diachronically and synchronically, for, as I have noted, aspiration involves a wide open glottis whereas voicing involves approximated vocal folds, and also, pure aspiration involves an open oral cavity whereas a spirant involves approximated oral articulators. But as pre-aspirates are diachronically unstable, an oral constriction might evolve so that their noise characteristics are enhanced, thus resulting in a series of pre-spirants: $[^{h}p, ^{h}t, ^{h}k] \rightarrow [fp, ct, xk]$. In fact, we might partly attribute pre-spirantization to the observation that pre-consonantal gestures are often implemented more slowly - over a greater stretch of time - than pre-vocalic gestures. This extra duration could conceivably be a diachronic compensatory reaction to the absence of release cues: increasing the duration of the surviving cues may enhance the likelihood of acoustically encoding the contrastive features of the consonant. And with these gestures' slower velocity, the likelihood of implementing an oral constriction downstream from the open glottis of a pre-aspirate is increased, as the oral cavity is more gradually positioning itself for the ensuing closure. Alternatively, however, all traces of noise might disappear from the acoustic signal, and vowel length may survive: $[V^hp, V^ht, V^hk] \rightarrow [V:p, V:t, V:k]$. Neither of these diachronic

PRE-ASPIRATED STOPS

routes is the result of individual speakers' intentions. Instead, they may simply be the conventionalized result of the variation that is inherent in speech production.

In support of this approach, notice that there are no languages in the typological study in which homorganic spirant-stop clusters vary with [s]-stop clusters (*[sp, st, sk] ~ [fp, ct, xk]). If the diachronic route from s-stop clusters to the 'reverse affricate' may first pass through a stage of unstable pre-aspiration (as seems to have happened in Sanskrit, for example), then the absence of this pattern of variation may be accounted for as shown in (27).

(27) Observed variation and proposed diachrony



Since some internal sound changes have been argued to proceed from the variability inherent in speech production (Paul 1880, Martinet 1975, Ohala 1989, Janda & Joseph 2001), it follows that the form of immediate diachronic neighbors will be parallel to the forms found among synchronic variants. Consequently, as s-stop clusters vary with pre-aspirates, and pre-aspirates vary with 'reverse affricates' and/or vowel length, then it follows that these forms will also be found among diachronic neighbors, for example, $\{sk^{-h}k\}$, $\{{}^{h}k-xk-(:)k\}$. 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 at the synchronic level, for example, $\{sp-fp\}$, $\{\{sk-xk\}\}$. And indeed, this is exactly what our typological investigation has shown, as such patterns are never found.

4. CONCLUDING REMARKS

It is understandable that phonologists, engaged as they are in making crosslinguistic generalizations about sound patterning, sometimes simplify their descriptions of complex phenomena. In the case of so-called pre-aspirated stops I have shown in this paper that the simple cover-term 'pre-aspirate'

does not do the facts justice. The variability we observe among pre-aspirated stops is far greater than what we would expect if pre-aspirates were simply mirror-images of post-aspirates. Were pre-aspirates simple mirror-images of post-aspirates, they would rarely involve any significant downstream noise source, and would never be realized as a lengthening of the adjacent vowel. Indeed, genuine across-the-board pre-aspiration is almost never found, the reasons for its rarity and diachronic instability lying in its lack of phonetic salience. Instead, probably as a consequence of the variation inherent in speech production, these sounds typically come to involve oral stricture in some or all of their realizations. Upon the introduction of this added noise component, the salience of the pattern increases its likelihood of diachronic survival. In the absence of this downstream noise source, complete attrition of noise may evolve in the form of vowel length, or reduction to zero.

REFERENCES

Allen, William Sidney (1953). Phonetics in ancient India. London: Oxford University Press.

- Bloomfield, Leonard (1925). Notes on the Fox language. International Journal of American Linguistics 3. 219–232.
- Bloomfield, Leonard (1957). Eastern Ojibwa. Ann Arbor: University of Michigan Press.
- Borgstrøm, Carl H. J. (1940). *The dialects of the Outer Hebrides* (A linguistic survey of the dialects of Scotland, vol. 1; Norsk Tidsskrift for Sprogvidenskap, Supp. Bind 1). Oslo: Norwegian Universities Press.
- Borgstrøm, Carl H. J. (1941). *The dialects of Skye and Ross-shire* (A linguistic survey of the dialects of Scotland, vol. 2; Norsk Tidsskrift for Sprogvidenskap, Supp. Bind I). Oslo: Norwegian Universities Press.
- Docherty, Gerard J. & Foulkes, Paul (1999). Newcastle upon Tyne and Derby: instrumental phonetics and variationist studies. In Foulkes, Paul & Docherty, Gerard J. (eds.), *Urban voices*. London: Edward Arnold. 47–71.
- Dorian, Nancy C. (1978). East Sutherland Gaelic. Dublin : Dublin Institute for Advanced Studies.

Einarsson, Stefán (1927). Beiträge zur Phonetik der isländischen Sprache. Oslo: Brøgger.

- Engstrand, Olle (1987). Preaspiration and the voicing contrast in Lule Sami. *Phonetica* **44**. 103–116.
- Foster, Mary LeCron (1969). *The Tarascan language* (University of California Publications Linguistics **56**). Berkeley & Los Angeles: University of California Press.
- Fries, Ingegerd (1977). Lärobok i nutida isländska. Stockholm: Biblioteksförlaget.
- Fujimura, Osamu & Sawashima, Masayuki (1971). Consonant sequences and laryngeal control. Annual Bulletin of the Research Institute of Logopedics and Phoniatrics 5. 1–7.
- Goodwin, Buergel H. (1905). Det moderna isländska ljudsystemet. Några anmärkningar. *Svenska landsmål och svenskt folkliv* **86**. 99–113.
- Goodwin, Buergel H. (1908). Utakst till systematisk främstallning av det moderna isländska uttalet. Täxter ock grundlinjer till bruk vid undervisning i nyisländska, med särskild hänsyn till fornspråkets stadium i Sverige. *Svenska landsmål och svenskt folkliv* **89**. 77–115.
- Hirose, Hajime, Lee, C. Y. & Ushijima, T. (1974). Laryngeal control in Korean stop production. Journal of Phonetics 2. 145–152.
- Holmers, Nils M. (1949a). Goajiro (Arawak) I: phonology. International Journal of American Linguistics 15. 45–56.
- Holmers, Nils M. (1949b). Goajiro (Arawak) II: nouns and associated morphemes. *International Journal of American Linguistics* 15. 110–120.
- Horden, John (1881). A grammar of the Cree language as spoken by the Cree Indians of North America. London: Society for Promoting Christian Knowledge.

- Janda, Richard J. & Joseph, Brian D. (2001). Reconsidering the canons of sound change: towards a big bang theory. Presented at the International Conference on Historical Linguistics, Melbourne, Australia.
- Jones, William (revised by Michelson, Truman) (1910). Algonquian (Fox). In Boas, Franz (ed.), *Handbook of American Indian languages* (part 1). Washington: Government Printing Office. 735–874.
- Kingston, John (1985). The phonetics and phonology of the timing of oral and glottal events. Ph.D. dissertation, University of California at Berkeley.
- Kingston, John (1990). Articulatory binding. In Kingston, John & Beckman, Mary E. (eds.), *Papers in laboratory phonology* I: *between the grammar and physics of speech*. Cambridge: Cambridge University Press. 406–434.
- Kirk, Paul L. (1966). Proto-Mazatec phonology. Ph.D. dissertation, University of Washington. Ladefoged, Peter & Maddieson, Ian (1996). Sounds of the world's languages. Oxford: Blackwell.
- Liberman, Anatoly (1978). Pseudo-støds in Scandinavian languages. Orbis 27. 52-76.
- Liberman, Anatoly (1982). *The Scandinavian languages*. Minneapolis: University of Minnesota Press.
- Löfqvist, Anders (1980). Interarticulator programming in stop production. *Journal of Phonetics* **8**. 475–490.
- Löfqvist, Anders & Yoshioka, H. (1980). Laryngeal activity in Swedish obstruent clusters. *Journal of the Acoustical Society of America* **68(3)**. 792–801.
- Maddieson, Ian (1984). Patterns of sounds. Cambridge: Cambridge University Press.
- Martinet, André (1975, published 1988). The internal conditioning of phonological changes. *La Linguistique* **24**. 17–26.
- Ní Chasaide, Ailbhe (1985). Preaspiration in phonological stop contrasts. Ph.D. thesis, University College of North Wales, Bangor.
- Ní Chasaide, Ailbhe & Gobl, Christer (1993). Contextual varation of the vowel source as a function of adjacent consonants. *Language and Speech* **36**. 303–330.
- O Baoill, Dónall P. (1980). Preaspiration, epenthesis and vowel lengthening interrelated and of similar origin? *Celtica* **13**. 79–108.
- Oftedal, Magnus (1956). A linguistic survey of the Gaelic dialects of Scotland (Norsk Tidsskrift for Sprogvidenskap. Supplement. series). Oslo: H. Aachenhoug & Co.
- Ohala, John J. (1989). Sound change is drawn from a pool of synchronic variation. In Breivik, Leiv Egil & Jahr, Ernst Håkon (eds.), *Language change: contributions to the study of its causes*. Berlin: Mouton de Gruyter. 173–198.
- Parker, Steve (1994). Laryngeal codas in Chamicuro. International Journal of American Linguistics 60. 261–271.
- Paul, Hermann (1880). Principien der Sprachgeschichte. Halle: M. Niemeyer.
- Payne, David L. (1991). A classification of Maipuran (Arawakan) languages based on shared lexical retentions. In Derbyshire, Desmond C. & Pullum, Geoffrey K. (eds.), *Handbook of Amazonian languages* (vol. 3). Berlin: Mouton de Gruyter. 355–499.
- Pike, Kenneth L. & Pike, Eunice V. (1947). Immediate constituents of Mazateco syllables. International Journal of American Linguistics 13. 78–91.
- Ruhlen, Merritt (1975/6). A guide to the languages of the world. Language Universals Project, Stanford University.
- Sapir, Edward (1930). Southern Paiute, a Shoshonean language. *Proceedings of the American Academy of Arts and Sciences* **65**(1). 1–296.
- Silverman, Daniel (1995). Phasing and recoverability. Ph.D. dissertation, UCLA. (Published by Garland, 1997.)
- Steriade, Donca (1994). Complex onsets as single segments: the Mazateco pattern. In Cole, Jennifer & Kisseberth, Charles (eds.), *Perspectives in phonology*. Stanford, CA: CSLI Publications. 203–292.
- Steriade, Donca (1999). Alternatives to syllable-based accounts of consonantal phonotactics. In Fujimura, Osamu, Joseph, Brian D. & Palek, Bohumil (eds.), *Proceedings of the 1998 Linguistics and Phonetics Conference*. Prague: The Karolinum Press. 205–242.
- Thráinsson, Höskuldur (1978). On the phonology of Icelandic pre-aspiration. *Nordic Journal of Linguistics* 1. 3–54.

- Trubetzkoy, Nikolaj S. (1939). *Grundzüge der Phonologie*. Travaux du Cercle Linguistique de Prague VII. [English translation *Principles of Phonology*, Berkeley: University of California Press, 1969.]
- Whorf, Benjamin Lee (1946). The Hopi language, Toreva dialect. In Hoijer, Harry et al. (eds.), Linguistic structures of Native America (Viking Fund Publications in Anthropology 6). 158–183.
- Yoshioka, H., Löfqvist, Anders & Hirose, Hajime (1981). Laryngeal adjustments in the production of consonant clusters and geminates in American English. *Journal of the Acoustical Society of America* 70. 1615–1623.

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