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A panchronic study of aspirated fricatives, with new evidence from Pumi

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ABSTRACT

Aspirated fricatives are typologically uncommon sounds, only found in a handful of languages. This paper studies the diachronic pathways leading to the creation of aspirated fricatives. A review of the literature brings out seven such historical pathways. An eighth, heretofore unreported pattern of change is revealed by Shuiluo Pumi, a Sino-Tibetan language spoken in China.

These diachronic data have non-trivial implications for phonological modelling as well as for the synchronic typology of sound patterns.

First, they provide new evidence for the debate concerning the definition of the feature [+spread glottis].

Second, they explain some of the typological properties of aspirated fricatives, in particular the absence of aspirated fricatives in consonant clusters and the rarity of non-coronal aspirated fricatives.

1. Introduction

Aspirated fricatives are typologically uncommon sounds. In Maddieson's (1984) UPSID database, only one aspirated fricative is mentioned [s^{h}], and it is present in only three of the languages included in that survey. A review of the literature reveals a small number of additional examples. Most languages with a contrast between unaspirated and aspirated fricatives are found in Asia. Of all language families, it is in Sino-Tibetan that these sounds are least uncommon. They are found in Burmese (UPSID), Tibetan languages (Sun, 1986, fieldwork by the author), Sgaw Karen (UPSID), Bai (Xi and Li, 1997; Wang, 2006) and three languages of the Qiangic branch: Zhaba (Gong, 2007), Rtau/Horpa (Duoerji, 1998; Sun, 2000) and Pumi (fieldwork by the author). Outside of Sino-Tibetan, neighbouring languages such as Shan (Kra-Dai; Edmondson, 2008:197), Yanghao (Hmong-Mien; Wang, 1985:13–15) and Korean also have aspirated fricatives. The presence of aspirated fricatives in Asia is probably at least in part an areal development, as many of these languages (Tibetan, Zhaba, Pumi, Bai on the one hand and Burmese/Shan on the other) are spoken in contiguous zones.

These obstruents are also widespread among Oto-Manguean languages, especially Mazatec (Pike and Pike, 1947; Kirk, 1966; see however Silverman and Blankenship, 1995, cf. section 2), Mazahua (Knapp, 1996) as well as Ixcatec and Amuzgo (data from Rensch, 1976).

Outside of these areas, only isolated cases have been reported: Ofo (Siouan; de Reuse, 1981; Rankin, 1988), Chumashan (Klar, 1977:13–15) and one variety of !Xũ (Köhler, 1981). Iroquoian languages have surface aspirated fricatives (see section

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3.6). Moreover, one proto-language has been reconstructed with aspirated fricatives: Late Middle Chinese (Pulleyblank, 1984:63–69, see sections 2 and 3.3).

In any case, aspirated fricatives are notoriously unstable sounds. In Burmese, for instance, the younger generation of speakers tends to lose the contrast, the aspirated /s^h/ merging with /s/ (Wheatley, 2003:199). Similarly, the hypothetical contrast between *f and *f^h reconstructed for Late Middle Chinese has not left a single trace in any modern Chinese language.

The rarity and instability of the aspiration contrast in fricatives raises the issue of how such a typologically unusual contrast could have arisen in the first place in the few languages where it does constitute a synchronic reality, and how the mechanisms of historical change that created these sounds fit with what is known about their phonetics and phonology.

This paper is a contribution to the typology of sound changes (see for instance Martinet, 1955; Labov, 1994), a field that has been aptly called 'Panchronic Phonology' (Hagège and Haudricourt, 1978; Mazaudon and Michailovsky, 2007). The aim of this field is to classify attested patterns of phonetic change and extract general laws and pathways of evolution. This endeavour has three main objectives.

First, understanding the attested patterns of sound change is helpful to constrain the reconstruction of proto-languages, as it can help to determine which evolutions are likely and which are not.

Second, important insights relevant to phonological theory can be gained from historical phonology: sound changes are no less important to theoretical modeling than synchronic alternations.

Third, in the framework of Evolutionary Phonology (see Blevins, 2004; Smith and Salmons, 2008), the typology of sound changes can be put to use to explain cross-linguistically recurrent synchronic sound patterns.

Since aspirated fricatives have not been discussed in the literature on either Panchronic Phonology or Evolutionary Phonology cited above, this paper is the first attempt at a general survey of the phonetic pathways leading to the creation of these sounds.

Our paper is divided into four parts. First, we discuss the nature of aspirated fricatives from both a phonetic and a phonological point of view, and study synchronic typological properties of these sounds. Second, we provide an overview of the literature concerning phonetic changes leading to aspirated fricatives in various language families. Third, we adduce first-hand data from a Pumi dialect showing another path of phonetic changes creating aspirated fricatives. Fourth, we propose an interpretation of these data in terms of phonological features, and show that despite their diversity, most are really variants of the same type of change. Additionally, we show how these sound changes can explain several typological properties of aspirated fricatives.

2. Aspirated fricatives: typological properties

Several typological generalizations can be derived from the attested examples of aspirated fricatives throughout the languages mentioned in section 1.

From a phonological point of view, it is important to stress the fact that not all surface aspirated fricatives have the same phonological status in the languages under scrutiny. Four situations are observed:

First, the most common situation is that aspirated fricatives are phonemes, contrasting with their non-aspirated counterpart (in most cases a voiced counterpart also exists).

Second, in Iroquioan, aspirated fricatives are just the outcome of the cluster /s/ + /h/. They should be analyzed as a combination of two phonemes.

Third, in Korean, the aspirated [s^h] only contrasts with the tense fricative [s*]: there is no simple non-aspirated fricative in this language; as a result the status of aspiration in Korean is controversial (see sections 3.1 and 5.1.2).

Fourth, Mazatec was first described as having a contrast of aspiration on fricatives (Pike and Pike, 1947), but more recent research has shown that aspiration (or rather breathiness) is a feature of the vowels in this language, and probably also in other Oto-Manguean languages as well (Silverman and Blankenship, 1995:83–84; Golston and Kehrein, 1998).

Apart from Korean, all languages with aspirated fricatives also have the corresponding unaspirated one in their phonological inventory.

All attested languages that have aspirated fricatives have s^h; and when a language only has one (Burmese, Shan, Korean) it is always s^h. The same implicational relationship seems to be true for unaspirated fricatives (Maddieson, 1984) and is probably due to the greater perceptual salience of sibilant fricatives.

Non-strident aspirated fricatives are rarer. f^h is only found in three languages, only two languages have a contrast between x and x^h (Heqing Bai, Xi and Li, 1997 and Cone Tibetan, personal fieldwork) and no language has a contrast between χ and χ^h or θ and θ^h. All languages with x^h also have at least two sibilant aspirated fricatives.

Late Middle Chinese would seem to be a counterexample to these generalizations: it is reconstructed with only the aspirated fricative *f^h. There is no evidence for a contrast between f and f^h in any contemporary Chinese language, but the existence of this consonant is generally accepted by specialists of Chinese historical phonology for philological reasons: it appears in Chinese rhyme tables. However, a reconstruction *pf^h for this phoneme would not go against any known fact about Chinese Historical phonology. Reconstructed languages are less reliable than attested languages as evidence to falsify typological generalizations, as reconstructions are hypotheses subject to revision.

Table 1
Attested examples of aspirated fricatives contrasting with their non-aspirated counterparts.

Aspirated fricative	Examples
f^h	Ofo, Yanghao, Heqing Bai
s^h	all
$ɬ^h$, $ɬ^{jh}$	Yanghao
$ɕ^h$	Shuiluo Pumi, Heqing Bai, Zhaba, Cone Tibetan
$ʂ^h$	Shuiluo Pumi, Zhaba, Cone Tibetan
$ʃ^h$	Dikundu !Xũ, Chumashan, Puxi Horpa, Mazahua, Ixcatec
$ç^h$	Puxi Horpa
x^h	Heqing Bai, Cone Tibetan
$z^{ɦ}$, $ʒ^{ɦ}$	Dikundu !Xũ

Table 2
Attested inventories of aspirated fricatives.

Inventory of aspirated fricatives	Languages
s^h $ʃ^h$	Chumashan, perhaps some Oto-Manguean languages (see above)
f^h s^h	Ofo
s^h $ɕ^h$ $ç^h$	Puxi Rtau/Horpa
s^h $ɕ^h$ x^h	several varieties of Eastern Tibetan languages
s^h $ɕ^h$ $ʂ^h$	Zhaba, Shuiluo Pumi
s^h $ɕ^h$ $ʂ^h$ x^h	Cone Tibetan, Geshizha Rtau/Horpa
f^h s^h $ɕ^h$ $ʂ^h$	Heqing Bai
s^h $ʃ^h$ $z^{ɦ}$ $ʒ^{ɦ}$	Dikundu !Xũ
f^h s^h $ɬ^h$ $ɬ^{jh}$ $ɕ^h$	Yanghao

The only reported instance of voiced aspirated fricatives is in a dialect of !Xũ: all other languages only have unvoiced ones. Some scholars have claimed that all languages with a contrast between aspirated and non-aspirated fricatives also had a series of voiced fricatives (for instance, Jansen, 2004:56), but this claim is falsified by Korean and Ofo, which have no voiced fricatives.

Table 1 summarizes the existing aspirated fricatives and indicates all the languages in which they are attested.

The language with the highest number of aspirated fricatives is Yanghao, which boasts as many as five: f^h, $ɬ^h$, s^h, $ɬ^{jh}$ and $ɕ^h$ (additionally, the velar x^h is mentioned, but as it does not contrast with an unaspirated counterpart, we do not include it in this count). The attested inventories are the following (not including languages with only s^h) (Table 2).

From these inventories, the following implicational hierarchies can be proposed:

(1) a. $s^h > \{ɕ^h, ʂ^h, ʃ^h\} > \{ç^h, x^h, ɬ^h, ɬ^{jh}\}$

b. $s^h > f^h$

c. unvoiced aspirated fricatives > voiced aspirated fricatives

f^h is not on a par with $\{ɕ^h, ʂ^h, ʃ^h\}$ (sibilant aspirated fricatives other than s^h), because there is no attested language with only s^h, f^h and one of $\{ç^h, x^h, ɬ^h\}$. Another important feature of aspirated fricatives is that they rarely occur in initial clusters: the only languages with aspirated fricatives in clusters are the Rtau languages.

Some of the generalizations set out in this section will receive explanations as we go through the historical origins of aspirated fricatives in the next sections.

3. The origin of aspirated fricatives in typological perspective

Of the languages mentioned in the introduction that have an aspiration contrast on fricatives, not all have been studied in detail from the point of view of historical linguistics; therefore, only a subset of these languages will be discussed in the present paper.

There are seven mechanisms leading to the creation of aspirated fricatives attested in the literature. First, cluster simplification in Korean and Tibetan. Second, preservation of aspiration after change from affricates to fricatives in Burmese. Third, mutation of the cluster p^hj- in Tibetan languages. Fourth, development of plain fricatives from affricates and of aspirated fricatives from former plain fricatives in Shan. Fifth, fricativization of an aspirated sonorant. Sixth, fusion with a laryngeal element in Ofo and Iroquoian. Seventh, obstruent dissimilation in Chumashan.

3.1. Korean and Tibetan: cluster simplification and aspiration contrast in fricatives

In Korean and Tibetan, initial clusters of the type *stop+fricative* became unaspirated fricatives, while simple fricatives became aspirated. Let us first examine data from Amdo Tibetan (Sun, 1986) and then Middle Korean.

Table 3
Fricatives in Old Tibetan and Amdo.

Old Tibetan	Mdzod-dge	Cone	meaning
(mda) gzu	zɤ	(ndæ) ɤə̀	bow
gzig	zɤg	not attested	leopard
gsum [ksum]	sɤm	sə̃	three
so	s^{h}o	s^{h}ɔ́	tooth
zos	so	sɔ̀	eat (imperative)
ɕar	ɕ^{h}ær	x^{h}ǽr	east
ɕubs [ɕups]	ɕ^{h}ɤb	x^{h}ú́	sheath

Table 4
Fricatives in Middle and Modern Korean.

Middle Korean	Modern Korean	meaning
psi H	ssi	seed
psol H	ssal	rice
psu-ta H-H	ssuta	use
sal H	sal [s^{h}aɾ]	arrow
say R	say [s^{h}ɛ]	bird

In Amdo, Khams and many outlier Tibetan languages, all aspirated fricatives without exception come from simple initial fricatives, whereas unaspirated fricatives have two origins: either unvoiced fricatives in a *stop+fricative* cluster or simple voiced fricatives (Sun, 1986:110, 120–123). As pointed out by Sun, a complex chain shift took place:

(2) s- > s^{h}-
gs-/bs- > s-
z- > s-
gs-/bs- > z

The following data taken from Sun's monograph (slightly adapted to fit IPA) illustrate these sound changes in a variety of Amdo Tibetan. We provide additional data from Cone Tibetan,[1] which illustrate the same chain shift (Table 3).Although in its detail the situation in Mdzod-dge Tibetan is quite complex,[2] the basic mechanism described here is clearly attested, and valid for other Tibetan languages.

In the dialects that have aspirated fricatives, we may encounter sporadic cases of aspirated fricatives having a different origin, especially in grammatical morphemes. For instance, Haller (2004:39) reports that the reflex of the Tibetan directional adverb *tshur* 'towards oneself' is *s^{h}ər* instead of expected *ts^{h}ər. Cone Tibetan has a special rule p^{h}j- > ɕ^{h}- which will be analyzed in more detail in section 3.7.

Korean is not entirely similar to Tibetan, as in this language the contrast is between a tense unaspirated fricative spelled ss- and lax aspirated fricative spelled s-. The tense fricative comes mainly from the cluster ps- (Martin, 1992:43–45), while plain s- initials in Middle Korean correspond to phonetically aspirated s^{h}- in modern Korean (Table 4).[3]

While the contrast between tense and lax involves several acoustic dimensions and has no equivalent in Amdo Tibetan, aspiration is nevertheless one of the most important acoustic clues that distinguishes tense from lax fricatives in Korean (Kagaya, 1974).[4] In loanwords from English, the tense fricative ss- is used to correspond to English s, not the aspirated one (Davis and Cho, 2006).

In these two languages, initial *stop+fricative* clusters invariably became unaspirated simple fricatives, while simple fricatives became aspirated. In both languages, this change in the fricatives is actually paralleled by a general change affecting the unaspirated stops. In Old Tibetan, there were originally only two series of stops (Li, 1933; Hill, 2007): the contrast between voiceless unaspirated and aspirated became phonemic only at a later period. In Tibetan dialects that lost ancient clusters, unaspirated stops correspond to Old Tibetan *stop+stop* or *s,r,l+stop* clusters, while aspirated stops

[1] This language is spoken in Cone (Zhuoni 卓尼) county, Gansu, China. The data comes from a field trip by the author in October/November 2010.
[2] The Old Tibetan initial ɕ- has two reflexes, ɕ^{h}- and x-; Sun explains it as an ongoing sound change, which has not yet spread to the whole vocabulary. In other Amdo dialects such as Themchen (Haller, 2004:40; 322), we also find various reflexes for Old Tibetan ɕ- (ç- vs. ɕ-), but their lexical distribution is entirely different from the one described by Sun in Mdzod-dge. There seem to be no reason to postulate different initials in proto-Tibetan: these irregular correspondences are due to dialect mixture. In any case, these are not counterexamples to the general phonetic law that Old Tibetan simple initials become aspirated in Amdo. In Cone Tibetan, all alveolo-palatals become velars (see also section 3.3).
[3] The Middle Korean data were provided to me by Anton Antonov (cited from Nam, 2007).
[4] However, the analysis of Korean fricatives is debated. Kim et al. (2010:147–148) find that both /s/ and tense /ss/ have aspiration. Aspiration is longer in /s/ than in its tense counterpart /ss/, but the airflow of non-tense /s/ is considerably lower than for corresponding aspirated stops and affricates. Kim et al. (2010:158) conclude from their acoustic and physiological data that both fricatives are [−spread glottis].

Table 5
Development of velar fricatives in Cone Tibetan.

Old Tibetan	Proto-Cone	Cone
ɕ-	*ɕ^{h}-	x^{h}-
ʗɕ-	*ɕ-	x-
ʑ-	*ɕ-	x-
ʗʑ-	*ʑ-	ɤ-

correspond to Old Tibetan *nasal+stop* or simple initials. In Korean, the situation is not entirely similar, but *stop+stop* clusters became tense stops (which have no aspiration) while simple initial stops became slightly aspirated in initial position (though they are realized as voiced stops in intervocalic position).[5]

3.2. Burmese: chain shift from affricate to fricative

Burmese offers a model of evolution that is radically different from Tibetan and Korean. In Old Burmese, there were only two series of stops (voiceless unaspirated and aspirated) and one series of fricatives, whereas we find three series (voiceless unaspirated, aspirated and voiced) for both stops and fricatives in modern Burmese. The voiced series results from sandhi phenomena, and need not be of concern here.

A complex chain shift occurred between Middle Burmese (15th century) and Modern Burmese:

(3) s > [t̪^{θ}]
c [ts] > [s]
ch [ts^{h}] > [s^{h}]
kr-, ky- > [tɕ]
khr, khy > [tɕ^{h}]

After OB s- became a dental affricate, alveolar affricates took its place and became alveolar fricatives. However, the aspiration contrast was maintained, and the OB aspirated affricate became an aspirated fricative.

A similar evolution has been described for the Yanghao language of the Hmong-Mien family (Wang, 1979; Niederer, 1998:72, 259–270). The reconstruction is Wang's (1979) proto-Hmong-Mien.

(4) *nts- > s-
*nts^{h}-, *ts^{h}- > s^{h}-
*ntʂ- > ɕ-
*ntʂ^{h}- > ɕ^{h}-

Interestingly, Yanghao also presents the Shan-type evolution that will be discussed in the next subsection.

A third example is the sporadic change ts^{h}- > s^{h}- in some Amdo Tibetan dialects mentioned in section 3.1.

3.3. Stop+palatal glide to alveolo-palatal fricative

Aspirated fricatives have many origins in Tibetan languages: we have already discussed two of them in sections 3.1 and 3.2. Another type is sporadically attested in Amdo Tibetan (Sun, 1986:123–124, 191), and is fully regular in Cone Tibetan.

In Cone Tibetan,[6] as mentioned in section 3.1, alveolo-palatal fricatives became velars (Tables 5 and 6).However, new alveolo-palatal fricatives were created after this change from the labial stop+j clusters: p^{h}j- > ɕ^{h}- and bj- > ɕ- respectively. Table 6 illustrates the chain shifts *ɕ^{h}- > x^{h}- / *p^{h}j- > ɕ^{h}- and *ɕ- > x- / *bj- > ɕ-:

It is crucial in interpreting this sound change to notice that they never went through an affricate stage:

(5) p^{h}j- > tɕ^{h}- > ɕ^{h}-
bj- > tɕ- > ɕ-

If the evolution as presented in (5) were true, this type of change would be a mere variant of the Burmese type presented in section 3.2. However, the hypothesis in (5), though possible in principle, is refuted in Cone Tibetan by the fact that Old Tibetan alveolo-palatal affricates tɕ^{h}- and tɕ- remain affricates and do not change to fricatives.

A different path must be posited:

[5] There is also in Korean a third series of strongly aspirated stops, which do not become voiced in intervocalic position.
[6] This placename is pronounced [tɕɔnɛ́] locally.

Table 6
Velar and alveolo-palatal fricatives in Cone Tibetan and their origin in Old Tibetan.

Old Tibetan	Proto-Cone	Cone Tibetan	meaning
ɕig	*ɕʰí	xʰí	louse
bɕad	*ɕé	xé	to talk
gʑus	*ʑì:	ɣì:	to melt (tr)
pʰjis	*pʰjí:	ɕʰí:	to wipe (past)
pʰjugpo	*pʰjəkkɔ́	ɕʰəkkɔ́	rich
pʰje	*pʰjɛ́	ɕʰɛ́	flour
*bji loŋ	*pjì lù:	ɕì lù:	mole "blind mouse"

(6) $p^hj- > p\text{ɕ}^h- > \text{ɕ}^h-$
$bj- > p\text{ɕ}- > \text{ɕ}-$

The hypothesized *f and *fʰ of Late Middle Chinese (Pulleyblank, 1984:63–69), if they truly existed, would be a variant of the sound change observed in Cone Tibetan, as they come from Early Middle Chinese *pj- and *pʰj- respectively.

This type of change presents some common features with the frication of aspirated sonorants described in section 3.5.

3.4. Shan: mixed development

The development of aspirated fricatives found in Shan (a Southwestern Tai language spoken in Burma) superficially looks similar to the Burmese one as ancient affricates change to s-, but is in fact quite distinct. As Edmondson (2008:197) explains, the following chain shift took place in Shan:

(7) $*s/z > s^{\text{fi}}-$
$*t\text{ɕ}-/dz- > s-$

The chain shift in this language is different from Burmese, as the ancient non-aspirated fricatives became aspirated, and the non-aspirated affricates become non-aspirated fricatives. However, the two changes are compatible, as the Hmong-Mien language Yanghao mentioned above has both. In addition to the changes (4) described in section 3.2, the following ones are also attested:

(8) $*s- > s^h-$
$*\text{ʂ}- > \text{ɕ}^h-$

Combined with *nts- > s- and *ntʂ- > ɕ-, these changes belong to the same type as those observed in Shan.

3.5. Fricativization of aspirated sonorants

Aspirated sonorants [r̥], [j̥] and [w̥] are prone to change to fricatives, and in some languages they even become aspirated fricatives. Two cases are attested.

The first occurs in Cone Tibetan. In this language, the rare initial /ʂʰ/ is attested in the word *ʂʰè:* "coarse" which comes from Old Tibetan *hral* (other instances of /ʂʰ/ have no known etymology). By contrast, Cone /ʂ/ comes from the Old Tibetan clusters sr- and spr-, as in 'cloud' *ʂɪ̃:* from *sprin*. The change spr- > ʂ- must have occurred before the fricativization of hr- (probably realized as [r̥] in Old Tibetan), otherwise hr- would have merged with it.

Second, proto-Mazatec has been reconstructed by Kirk (1966:95) with two aspirated fricatives *sʰ- and *ʃʰ-. However, their distribution is strikingly different. While *sʰ- is reflected as sʰ- in five out of the twelve dialects investigated by Kirk, *ʃʰ- appears as ʃʰ- in only one of them (Chiquihuitlán Mazatec); it is reflected as h- in all other varieties. Strangely, in Chiquihuitlán Mazatec, the reflex *sʰ- is the non-aspirated s- (Table 7).

If proto-Mazatec had two aspirated fricatives, we would expected both to develop in a parallel way at least in some languages, but they do not appear as such in any Mazatec dialect.

An alternative interpretation of Kirk's data is that his *ʃʰ- was not an aspirated fricative, but a voiceless glide *j̥-, or a preaspirated *hj-. Although Kirk (1966:177) also reconstructs *hj- in proto-Mazatec (written *hy- in his system), this onset is

Table 7
Aspirated fricatives in proto-Mazatec.

proto-Mazatec (Kirk, 1966)	Mazatlan	Chiquihuitlán	Jalapa
*sʰ-	tsʰ-	s-	sʰ-
*ʃʰ-	h-	ʃʰ-	h-

Table 8
Comparison of unaspirated f and s in Ofo to s and x in other languages. For Biloxi and Ofo, the page number in Dorsey and Swanton (1912) is indicated in the 'Ref' column.

meaning	Biloxi	Ref	Ofo	Ref	Tutelo
night	†pəsí <psí, pŭs, pŭsi, pûsí>	247b	†upó:fi <upō′fi, ū-pō′fi>	331b	†osi: <usī, osī>
chase	†nõxe <noxĕ′, nóxĕ>	237a	†nõse <nu$^{n'}$sĕ>	327a	

Table 9
Ofo fh-.

meaning	Biloxi	Ref	Ofo	Ref	Tutelo
armpit	tuksĭ′	281b	†tą́f^{h}e <tą́fhe>	329b	
arrow	ãksi′	177a	†ã́f^{h}i <ó^{n}fhi>	328a	†mã:ksi: <māñksīi>
leg, thigh			†tʃəf^{h}a-hi <tcąfhahi>	329a	†jeksa: <yeksā>
one			†núf-ha <nû′fha, nû′fhá>	327a	†nõsa ''<noñsa>

only attested by one example, and is not a threat to our idea. Recent sources on Chiquihuitlán Mazatec (Jamieson, 1996) actually have a cluster transcribed as jy- (a spelling which could represent either [hj], [xj] or [j̊]) in the set of words transcribed with ʃ^{h}- in Kirk's data (for instance, 'hawk' is *jya* in Jamieson, 1996, and ʃ^{h}*a* <šhá> in Kirk). As for proto-Mazatec *s^{h}- on the other hand, although Kirk's reconstruction should be revised in line with more recent findings on Mazatec phonology (Silverman and Blankenship, 1995), there is no compelling reason to doubt the existence of at least surface aspirated fricatives in this proto-language. It would imply that in some varieties *s^{h}- changed to the corresponding affricate ts^{h}- instead of a simple unaspirated fricative, a development not attested elsewhere but not entirely implausible. The ultimate origin of this *s^{h}- (or ∗sV̤) is not fully clear in spite of Rensch's (1976) attempt at reconstructing proto-Oto-Manguean.

The pronunciation ʃ^{h}- found in Kirk's data is therefore either a feature of some varieties of Chiquihuitlán Mazatec or an artifact of transcription. In any case, even if some dialects do have an aspirated fricative contrasting with simple ʃ-, it is clear that this fricative cannot be reconstructed for proto-Mazatec: the reconstruction ∗j̊- or *hj- better accounts for the data. In Mazatec dialects other than Chiquihuitlán, *hj- simply merged with *h-.[7]

These two sound changes, though they may appear to be of an entirely different nature, belong to the same type: an aspirated fricative is created from an aspirated sonorant in a language that already has a corresponding unvoiced unaspirated fricative (ʂ- in the case of aspirated r̥- > ʂ^{h}- and ʃ-, ç- or ɕ- in the case of j̊- > ɕ^{h}-/ʃ^{h}-/ç^{h}). In both Cone Tibetan and Mazatec, this sound change occured in a language which already had aspirated fricatives. A possible, though non-attested development as far as we know, would be the hypothetical change w̥- > f^{h}- in a language that already has a phoneme f-.

3.6. Ofo: fusion of fricatives and laryngeal elements

Ofo was a Siouan language belonging to the Ohio Valley subgroup, alongside Biloxi and Tutelo (Swanton, 1909; Dorsey and Swanton, 1912; Rankin, 2004). The cognate sets and reconstructions cited here come from Carter et al.'s unpublished Siouan Comparative Dictionary. The Biloxi comparative data are quoted from Dorsey and Swanton (1912) and the Tutelo ones from Hale (1883) and Frachtenberg (1913). The original forms as found in those sources are indicated between quotation marks and the normalized forms from Carter et al. (slightly adapted to fit IPA) are presented with a † symbol before them.

Ofo is quite unusual among Siouan languages in having a contrast between plain unvoiced and aspirated fricatives s / s^{h} and f / f^{h} (de Reuse, 1981; Rankin, 1988).[8] The unaspirated fricatives f and s respectively come from *s and *x, as the following comparisons with Tutelo and Biloxi show (Table 8).

The origin of the aspirated fricative is not straightforward in all cases, but the examples in Tables 9 and 10 illustrate some robust correspondences with other Siouan languages.

Ofo f^{h}- regularly corresponds to clusters such as ks- in other Siouan languages. Rankin (1988) explains it as the result of a series of sound changes:

(9) *C + s > *hs > *s^{h} > f^{h}

In a few other cases, such as the last example of the table, f^{h}- seems to come from the fusion of *s- with a subsequent *h-:

[7] The preaspirated hj- still present in other Mazatec dialects has a different origin: for instance, in Jalapa Mazatec (Silverman, 1997:238), preaspirated hj- (transcribed in narrow IPA transcription *ʰ͡ʃʲ-*) occurs in words such as *ʰ͡ʃʲu -*| 'peace', a word found in cognate set #53 in Kirk (1966) *ʃ^{h}iú 'quiet', which we would rather reconstruct as *hjiu. In other words, while *hj- and *h̥- merged in Jalapa Mazatec, a new hj- emerged from the initial h- followed by a diphthong with -i- as the first element.

[8] Hidatsa, another Siouan language, seems to have aspirated fricatives (in fact fricative+h clusters) in intervocalic position, but there is some uncertainty as to their phonetic nature (Boyle, 2007:30–31).

Table 10
Ofo s^h-.

	Proto- Dhegiha	Quapaw	Biloxi	Ref	ofo	Ref
to hear	*nãxʔó́	nõxʔó́	†nãxe <naxĕ′, náxe>	231b	†nas^{h}é <nashĕ′>	326b
old	*waxʔó	waxʔó	†xohí <xohí>	222a	†s^{h}óhi <shóhi>	329a

(10) *s+h > *s^h > f^h

The numeral "one" in Ofo here has the same suffix –ha as in numeral "two" (Ofo †núp^ha <nū′p-ha>, Swanton, 1909:485).

The aspirated s^h- is more difficult to study, as Swanton's orthography seems to be sometimes ambiguous, s^h- being using to represent both the aspirated fricative and the postalveolar fricative. Comparison with Biloxi and Tutelo offers little insight here, but adducing evidence from Mississipi Valley Siouan languages such as Quapaw (data quoted from Carter et al. coming from Rankin's fieldwork), it appears that Ofo s^h- corresponds to the group xʔ- in Dhegiha, Chiwere/Winnebago and Dakotan.

We can therefore postulate the following sound change in Ofo:

(8) *xʔ > s^h-

All three origins of aspirated fricatives in Ofo have a common feature which was not found in the previous languages: they involve at some stage a sequence *fricative+glottal; the aspiration evolved out of that glottal element.

Outside of Ofo, this type of evolution is quite common, also found in the Chumashan and Iroquoian families.[9]

As in Ofo, one of the origins for aspirated fricatives in Chumashan language (a second origin for these consonants will be studied in section 3.6) comes from the fusion of sibilants with the phoneme /h/ at morpheme boundaries. The following data from Ineseño Chumash illustrate this rule (Applegate, 1972:123):

(11) ʃi$ʃ^h$alala
s-iʃ-halala
3-DU-quarrel
'They are quarreling.'

Northern Iroquoian languages present a similar case. Although these languages do not have aspirated fricative phonemes, they allow initial clusters, including the combination /s/+/h/, which is realized phonetically as an aspirated fricative [s^h] (see for instance Oneida in Abbott, 2006:8, a reference with sound files).

3.7. Chumashan: dissimilation to aspirates

Chumashan languages were formerly spoken in California, but became extinct in the 1960s. The family as a whole is mainly attested through the field notes of J.P. Harrington, which are fortunately phonetically reliable. On the basis of these data, Klar (1977) has proposed a reconstruction of proto-Chumashan.

All attested Chumashan languages (Ineseño, Barbareño, Ventureño, Obispeño, Cruzeño and perhaps also Purisimeño) all have a three series of stops (p p^h p') and fricatives (s s^h s'). Ineseño and Barbareño have three groups of fricatives, alveolar, postalveolar and velar, but only the first two have aspirated counterparts: there are /s^h/ and /$ʃ^h$/ phonemes, but no */x^h/ (Klar, 1977:11–13). Proto-Chumashan, however, is reconstructed without aspirated phonemes at all, as Klar (1977:14) argues that the aspirated stops and fricatives come from the dissimilation of obstruents at morpheme boundaries, as illustrated in the two following examples from Ineseño:

(12) s^hi'nay
s-si'nay
3-put.away
'He puts it away' (Applegate, 1972:19)

(13) $ʃ^h$ilit$ʃ^h$oʔ
s-sili-t$ʃ^h$oʔ
3-DESIDERATIVE-stop
'He wants to stop' (Mithun, 1999:391)

[9] Outside of Ofo, Wang (2006) has argued that the aspirated fricatives *s^h- and *$ɕ^h$- in his reconstructed proto-Bai (based on aspirated fricatives in some Bai dialects) come from earlier clusters *Cə-s- and *sk-. The only way a change such as *sk- > s^h- is possible would be through a series of stages *sk- > *sx- > *sh- > *s^h-, the last three stages of which are identical to one of the origins of the Ofo aspirated fricatives. The analysis of the Bai data requires further confirmation, but a detailed study would lie beyond the scope of this paper.

Table 11
Regular correspondences of etyma without clusters in the Lanping dialect.

Ref. in Lu (2001)	gloss	Shuiluo	Mudiqing	Lanping	place
685	to win	kô	qû	$t^həkó$	velar
213	head	$k^huə̂$	qhə̂	$q^hó$	
8	rain	guí	guí	guí	
131	hawk	tʂiě	tʂeě	tʂà	retroflex
638	to cut	$tʂ^hî$	$tʂ^hî$	nə $tʂ^hí$	
777	to shake	dʐuǐ	dʐuǐ	dʐuì	
876	clean	ʂą̄	ʂą̄	ʂǫ́ né	
109	sheep	zą́	zą́	ʒą́u	
619	to weave	tɕě	tɕě	nətɕá	alveolo-palatal
660	to dry in the sun	$tɕ^hǐ$	$tɕ^hě$	$t^hə$ $tʃ^hɛ̀$	
138	fish	dzə̂	dzə̂	dʒə́	
151	louse	ɕî	ɕî	ʃí	
595	to sleep	zə̌	zə̌	nə́ ʒə́	
252	liver	tsyî	tsyê	tsyɛ̀	dental
253	lung	$ts^huə̌$	$ts^huɤ̌$	$ts^hỳ$	
546	to eat	dzə̂	dzə̂	dzə́	
116	leopard	syî	syî	syí	
218	face	zû	zô	ziɯ́	

Aspirated fricative have another origin in sibilant+h clusters (see (9) in section 3.4). They seem to be quite rare morpheme-internally (Applegate, 1972:11), but examples can be found such as the native name of the Ineseño language *s^{h}amala*.

3.8. Concluding remarks

In this section, We have reviewed the previous literature and found the existence of at least seven distinct types of attested origins for aspirated fricatives. The data presented here is uncontroversial, except perhaps for the discussion in section 3.5 where we present some original data from Tibetan and a new analysis of existing proto-Mazatec reconstructions.

The next section will present an eighth type of evolution leading to aspirated fricatives in a dialect of the Pumi language (Sino-Tibetan).

4. New evidence from Pumi dialects

Pumi dialects are spoken across the two provinces of Sichuan and Yunnan in China. These languages belong to the Qiangic subbranch of the Sino-Tibetan family, which also includes Rgyalrong, Lavrung, Horpa, Queyu, Qiang, Zhaba, Muya and Tangut.[10] Three varieties will be discussed in the present paper: the Lanping dialect from Yunnan (Lu, 2001),[11] which preserves consonant clusters, and the Northern dialects of Mudiqing (Yunnan, Ninglang county)[12] and Shuiluo (Sichuan, Muli county), which have lost almost all clusters. The data from the latter two dialects were collected by the author during two field trips in August 2008 and February/March 2009 in the areas where they are respectively spoken.

4.1. Simple initials

Etyma that have simple initials in Lanping Pumi have similar initials in the Northern dialects, as can be observed from the following table. In the first table, we show etyma that present almost identical consonants in the three dialects. For each place of articulation, the examples are set out in the following order: voiceless unaspirated stop/affricate, aspirated stop/affricate, voiced stop/affricate, unvoiced fricative and voiced fricative (Table 11).

The data in this table strongly suggest that most if not all of these consonants should be reconstructed for proto-Pumi. A few examples present irregular correspondences between the three dialects; we find diverging places of articulation:

908	sour	tɕú	tʂú	tʃú
384	salt	$tɕ^hǐ$	$ts^hǐ$	$ts^hì$

[10] Other languages such as Guiqiong, Ersu, Shixing and Namuyi which are classified as Qiangic by Sun, 2001 probably do not belong to this group.
[11] We have replaced Lu (2001)'s tone marks by grave (low tone) and acute (high tone) accents. The tones of the Mudiqing and Shuiluo dialects are likewise transcribed using Africanist tone marks: á high tone, â falling tone, ǎ rising tone. Note that in Mudiqing Pumi, there is no phonological contrast between uvulars and velars, but we keep the distinction in our transcription.
[12] The dialects studied by Matisoff (1997) and Ding (2003) are closer to the Mudiqing type.

Table 12
Etyma with *s+velar* stop clusters in Lanping.

Ref. in Lu (2001)	gloss	Shuiluo	Mudiqing	Lanping
622	to sell	ɕî̯	kǐ	skí
562	to take	ɕî̯	kě	də skiɛ́
191	garlic	xə̂	kə̂	skɯ́
632	to cook	xô	qû	sqó
425	cork	xuɛ̂	kuî	skǿ
281	mad	xɑ̃mɑ̃		sqɑ̃u mí
261	feces	xɛ̂ i	qɛ̂ i	sqá
715	to run after	xiɛ́	kí	skié
722	to cry	xuɛ́ i	quɛ́ i	squá
734	to fear	xiɜ̌	kiɤ̌	skiɛ̀
765	to turn	xú		nəskiú
422	key	xî	$k^hî$	$sk^hí$
121	otter	xí̯	tɕê	$sk^hɛ́$
41	smoke	xiŭ	$mɐ̯ k^həu$	$sk^hiɯ́$
251	heart	xuɜ̌	$k^huɤ̌$	$sk^hɛ́$
370	leggings	xiã tʂə́	$k^həu$ dzŭ	$sk^hiɑ̃u$ tʂhə
105	horse	ɤuǐ	guě	sgʮɛ̀
946	nine	ɤiə̂	gû	sgiɯ́
831	high	ɤuǐ	guɛ́	sgʮɛ́
146	ant	bə́ ɤió	bə́ go	bý sgiè
200	grass	ɤiɑ̌	gɑ̌	sgiɑ̂u
724	to like	ɤiɛ́	giɐ́	sgiɑ́

4.2. *s+velar clusters*

In etyma that have a cluster of the type *s+stop* in the Lanping dialect, however, we find entirely different correspondences. We will present these correspondences in two tables, Table 7 including etyma with velars, and Table 8 including those with retroflex, alveolo-palatal and dental initials. Etyma with labial initial do not present such correspondences, as we shall see in Table 10. Note that there is no phonemic contrast between uvulars and velars in either Mudiqing or Lanping (Table 12).Some of the clusters in Table 7 are ancient, as we find similar clusters in more conservative languages of the Qiangic group, such as Rgyalrong languages. In the Japhug variety of Rgyalrong, the cognates of Lanping Pumi *skú* "garlic" and *sqó* "to cook" are *ɕku* and *sqa* respectively.[13] In other examples, the s- probably comes from an ancient presyllable corresponding to Japhug tɤ/tɯ- for instance "smoke" *tɤkʰɯ*, "feces" *tɯqe*. Finally, Pumi seems to have undergone tremendous phonetic changes in some clusters, such as sgy- which regularly corresponds to Japhug mbr- (proto-Japhug *mr-) in the homophonous etyma "horse" *mbro* (<*mraŋ) and "high" *mbro* (<*mraŋ).

Etyma that have the clusters sk-, skh- and sg- in the Lanping dialect have the corresponding simple stop initial in Mudiqing, apart from one exception: 'otter', where we find an alveolo-palatal affricate tɕ-. In Shuiluo Pumi, on the other hand, these etyma have mostly velar fricatives: x- corresponding to sk- and skh- and the voiced ɤ- corresponding to sg-. We only find two exceptions, 'to sell' and 'to take', where an alveolo-palatal fricative is found instead of a velar fricative. In these two examples, palatalisation of the velar into an alveolo-palatal took place. This palatalisation occurs only when the main vowel is –i or –ĩ in Shuiluo Pumi, and the initial comes from proto-Pumi *sk-, not *sk^h- ("key" and "otter" do not have the same palatalisation).

None of the exceptions found in either Mudiqing or Shuiluo can be accounted for by any straightforward rule. Admittedly, these are all cases of palatalisation occurring when the Lanping form has either a front vowel or a -i- medial. However, this is not a satisfying explanation, as other etyma with front vowel and/or -i- medial in Lanping do not have the same correspondences (for instance 'to run after' and 'to fear').

Whatever the reason for these palatalisations, we can safely propose that the clusters found in Lanping should be reconstructed for proto-Pumi, and that these clusters evolved differently in Mudiqing and Shuiluo. In the former, the s- was lost without trace, and the stop remained. In the latter, it induced lenition of the stop, causing it to change into a fricative. We will see that a similar explanation can be proposed for other initials.

One of the words in Table 7 is a Tibetan loanword: 'to like', which comes from Tibetan *dga*[14] The presence of loanwords among etyma belonging to these correspondence sets shows that the lenition does not predate the first contact between Pumi and Tibetan speakers.

[13] The Japhug forms cited in this paragraph are taken from Jacques (2004). A more comprehensive study of Pumi historical phonology, based on comparison with Rgyalrong and other Qiangic languages is underway.

[14] The correspondence -iɛ:-iɐ:-iɑ reflects a pre-Pumi *-ak rather than *-a: we find the same correspondence with etyma like 'pig' (Shuiluo *tsiɛ̌*, Lanping *phʑa*^{2}), a cognate of Tibetan *phag*. The verb 'to like' was therefore borrowed after the loss of the final stop, and cannot be a cognate, otherwise a different correspondence would be expected.

Table 13
Etyma with *s+coronal* affricates/stop clusters in Lanping.

Ref. in Lu (2001)	gloss	Shuiluo	Mudiqing	Lanping
673	to hide	ʂû	tʂŭ	thə̀ stʃú
357	nest	ʂuâ	tʂuɔ̂	stʃuá
581	to jump	ʂə̂	tɕə̂	tə́ stʃə́
642	to stab	ʂ^{h}uɛ̌ i	tʂ^{h}uɛ̌	xə́ stʃ^{h}à
259	saliva	ʐa̰	dʐɐ̌	sdʒà
235	nail	ʐɛ̰	dʐɛ̌	sdʒá
770	to leak	ʐə̌	dʐə̌	k^{h}ə́ sdʒə̀
612	to chop	ɕɛ̂	tɕê	t^{h}ə̀ stʃɑ́
415	horse whip	dʐuɜ ɕɛ́	bɹə tɕɤ́	bʐə̀ stʃɑ́
418	saddle	ɕî		stʃɛ́ tʂ^{h}ő
568	to twist	ɕúwá	tɕú	nə̀ stʃɯ́
616	to feed	ɕ^{h}ɛ̌	tɕ^{h}ĭ	thə́ stʃhɛ́
647	to scoop	ɕ^{h}ə̰	tʂ^{h}ə̰	
166	pine	ɕ^{h}ĩibő	tɕ^{h}ĩ sɛ̃	stʃ^{h}ɛ̀ sbő
582	to stand	ɕ^{h}ɤ̌	tɕ^{h}ə̂	nə̀ stʃə́
553	to swallow	ʑĭ	diɛ̃	k^{h}ə̀ sdʒɛ́
15	hail	ʑĭ	dʐɛ̂	sdʒɛ́
368	trousers	ʑə̌	dʐə̌	sdʒə́
852	light	ʑĭ	dʐɛ̌	sdʒɛ̀
228	beard	a ső	a tió	à stiáu
1063	pulse	siɛ́		sèi stié
341	pillar	sɛ́	tɛ̀	stá
674	to choose	s^{h}ɛ́	t^{h}í	t^{h}ə́ st^{h}ié
279	deaf	za bə̌	də bə̌	sdə̀ bə̀
6	cloud	zə rĩ́	də rĩ́	sdĩ́

For this word, only the first syllable for zə- / də- of the Shuiluo and Mudiqing forms is to be compared with the Lanping form. The second syllable -rĩ́ has a different origin.

4.3. *[s+coronal] clusters*

With coronal initials, we find a similar situation: etyma in *s+coronal affricate/stop* in Lanping have corresponding affricates or stops in Mudiqing,[15] whereas they invariably correspond to fricatives in Shuiluo.[16] These correspondences can be understood here too in terms of lenition caused by a prefixed consonant. The contrast between retroflex and alveolo-palatal found in northern Pumi dialects seems to have been neutralized in Lanping after s-, where all the corresponding initials are postalveolar affricates.

The correspondence of a simple fricative to a cluster *s+affricate* could appear to be a case of prefix pre-emption (Matisoff, 2003:153), whereby a prefixal consonant displaces the initial consonant of the root. However, this alternative explanation seems to be weaker than an analysis in terms of lenition. First, a process of lenition must be postulated anyway for clusters with velars, and since the same process can explain the data in Table 8, there is no need for an alternative hypothesis. Second, had the prefixal consonant displaced the affricate, we would not expect it to have preserved the place of articulation and the aspiration of that affricate (Table 13).

For the dentals, we find many exceptions to the correspondences s:t:st and z:d:sd illustrated in the table above. The correspondences t:t:st and d:d:sd are actually well attested, as the following examples show (Table 14).

We may need to reconstruct two distinct proto-initials for proto-Pumi to account for these two sets of correspondences. A possibility would be to reconstruct two types of clusters, one without schwa *st- which would result in the correspondence s:t:st and another one with an intervening schwa *sət- that would yield the correspondence t:t:st.[17] Because of the schwa in *sət-, the stop is not in direct contact with the s- and does not undergo lenition. In this regard, it is interesting to note that in a document from 1903 recording a Pumi dialect spoken in Muli, not far from Shuiluo, the numeral 'ten' was transcribed as <Casse-ti> by a French explorer, a transcription implying a pronunciation *[kasti] or *[kastĩ]. This means that the simplification of these clusters in Mudiqing-type dialects is a relatively recent phenomenon (Michaud and Jacques, 2010).

Etyma with *s+labial stop* never present any sign of lenition in Shuiluo Pumi, as the following examples will show (Table 15).

This is the opposite of the situation found in Amdo Tibetan, where only clusters involving labials undergo lenition, or the Laze language,[18] where proto-Naish *S+velar stop and *S+labial stop undergo lenition, but the coronal stop does not (Jacques and Michaud, in press).

[15] The only exception is the verb 'to swallow' where we find a dental stop corresponding to an affricate in Lanping.
[16] In the examples 'to jump', 'to leak' and 'to scoop', Mudiqing and Shuiluo dialects have initials with diverging places of articulation.
[17] We find a contrast of this type in Japhug Rgyalrong, as in the minimal pair *spa* "to be able" and *sɯpa* "to consider".
[18] This language, investigated by Alexis Michaud, is spoken in Muli, Sichuan, and belongs to the Naish branch of Sino-Tibetan.

Table 14
The correspondence t:t:st.

Ref. in Lu (2001)	gloss	Shuiluo	Mudiqing	Lanping
542	to see	tô	tô	stó
676	to nail	tă	tă	xə̀ stá
844	straight	tú	tú	stú
947	ten	kɜ́ tī́	qá tiẽ	qá stiɛ̃́
694	to ask	dú duɜ́	dɑ́ duə	xə̀ sduə̀

Table 15
s+labial stop clusters.

Ref. in Lu (2001)	gloss	Shuiluo	Mudiqing	Lanping
855	soft	pû	pə̂	spú tí
205	leaf	pă	pɔ̌	sʊ'spa'
657	to patch	pʰiɛ̌	pʰĭ	xə̀ spʰɛ̂
11	ice	bu bɔ̌	bə bŏ	sbù sbɔ̃̀
675	to pile up	bú	bó	xə̀ sbú

Table 16
Proto-Pumi **s+stop* clusters.

Proto-Pumi	Shuiluo	Mudiqing	Lanping
*sk-	x-	k-	sk-
*skʰ-	x-	kʰ-	skʰ-
*sg-	ɤ-	g-	sg-
*stʂ-	ʂ-	tʂ-	stʃ-
*stʂʰ-	ʂʰ-	tʂʰ-	stʃʰ-
*sdʐ-	ʐ-	dʐ-	sdʒ-
*stɕ-	ɕ-	tɕ-	stʃ-
*stɕʰ-	ɕʰ-	tɕʰ-	stʃʰ-
*sdʑ-	ʑ-	dʑ-	sdʒ-
*st-	s-	t-	st-
*stʰ-	sʰ-	tʰ-	stʰ-
*sd-	z-	d-	sd-
*sət-	t-	t-	st-
*səd-	d-	d-	sd-
*sp-	p	p	sp-
*spʰ-	pʰ-	pʰ-	spʰ-
*sb-	b	b	sb-

4.4. Lenition and the creation of aspirated fricatives

If we exclude the few exceptions mentioned above, which mostly concern unexplainable cases of palatalization, the correspondences between the three dialects can be summarized in the following table. We propose a proto-Pumi reconstruction for all such clusters (Table 16).

The reconstruction proposed here differs little from the Lanping dialect, except for the fact that this dialect has merged retroflex and alveolo-palatal initials, and lost the difference between fused and non-fused clusters *st- /*sd- and *sət- /*səd-, a contrast which is preserved in the Shuiluo dialect.

As we mentioned above, in Shuiluo Pumi the lenition caused by the *s- changed stops or affricates into fricatives of the corresponding place of articulation and degree of voicing/aspiration. In particular, clusters of the type *s+aspirated stop/affricate became aspirated fricatives, except for the velar *skʰ- which merged with *sk- as x- in this dialect. Following this phonetic change, Shuiluo Pumi now boasts as many as three distinct aspirated fricatives sʰ-, ɕʰ- and ʂʰ-, more than modern Burmese or Ofo (which only had sʰ- and fʰ-), but still less than Yanghao or Cone Tibetan.

The aspirated fricatives found in Shuiluo Pumi are not only unusually varied in place of articulation, they came into being by an entirely different path of phonetic development from any other attested language.

From an areal point of view, it is relevant to notice that Shuiluo Pumi is in contact with a variety of Khams Tibetan that also has aspirated fricatives (Chirkova, in press), though these fricatives, as in Amdo Tibetan, have an entirely different diachronic origin. Whether this areal influence could have in some way triggered the creation of these aspirated fricatives in Pumi lies beyond the scope of this paper.

Table 17
Attested origins of aspiration contrasts on fricatives.

	Aspirated fricatives	Unaspirated fricatives	Languages
A	*s- > s^h-	*Cs- > s-	Amdo, Khams, Cone Tibetan
B	*s- > s^h-	*ts- > s-	Shan, Yanghao
C	*sts^h- > s^h-	*sts-, *s- > s-	Shuiluo Pumi
D	*ts^h- > s^h-	*ts- > s-	Burmese, Yanghao
E	*C^hj- > $ɕ^h$-	*Cj- > ɕ-	Cone Tibetan
F	*r̥- > $ʂ^h$- / *j̥- > $ʃ^h$-	*ʂ- > ʂ- / *ʃ- > ʃ	Cone Tibetan, Chiquihuitlán Mazatec
G	*s + h- > s^h-	*s- > s-	Ofo, Chumash
H	*s + s- > s^h-	*s- > s-	Chumash

5. Interpretation of the attested changes

The case studies reviewed in sections 3 and 4 show that as many as eight distinct processes creating aspirated fricatives are attested among various languages. This great variety, as well as the limited number of examples for each particular type of phonetic change, prompts the question whether a useful typology can be drawn out of these sound changes, and whether they explain anything about the synchronic typology of aspirated fricatives presented in section 2.

In this section, we will first show, using feature theory, that the eight types of phonetic changes studied above can in fact be reduced to three, and then show what historical phonology has to say about the synchronic distribution of aspirated fricatives.

5.1. An interpretation in terms of feature theory

Here are the eight origins of aspirated fricatives, presented in schematic fashion: in Table 17, we replace all places of articulation by alveolars to simplify the analysis, since the place of articulation is only marginally relevant to most of these changes except for E and F.

These eight types of change can be divided into three groups:

(1) A and B, where aspiration appears on fricatives and simple fricatives are created from clusters or affricates.
(2) C, D, E and H, where aspiration is preserved from the proto-languages, but a fricative is created due to various processes.
(3) G and H, where aspirated fricatives result from the fusion of two segments.

The interpretation of these changes crucially depends on how one analyses aspiration in one's theoretical framework. In this section, we will give a brief account of the competing theories that exist regarding aspiration, and then analyze one by one how the data from the three categories of aspirated fricatives can be explained using these theories.

5.1.1. The phonological and phonetic nature of aspiration in fricatives

Competing theories have been proposed in the phonological literature to account for aspiration.

Earlier research has proposed to equate aspiration with VOT, but this approach has been shown to be problematic (Vaux and Samuels, 2005:406), as it cannot account for instance for the existence of aspiration contrasts in coda position.

The most usual definition of aspiration is an articulatory one: the feature [spread glottis] (Kim, 1970; Halle and Stevens, 1971). Two competing theories exist concerning the exact interpretation of this feature; Kim's original idea was that [spread glottis] depended on the size of glottal opening (the Glottal width theory), while others such as Löfqvist (1980) have argued that the aspiration contrast depended on the relative timing of laryngeal and oral gestures (the Glottal Timing theory).

For stops, the aspiration contrast generally correlates with the opening of the glottis: voiced and voiceless unaspirated stops are pronounced with a smaller glottal opening (while the glottal opening gesture starts at implosion),[19] while aspirated stops are pronounced with a spread glottis. Concerning fricatives, however, the situation is different: plain unvoiced fricatives are pronounced with an open glottis (Stevens, 1991), a fact which, together with much evidence from phonological alternations and historical phonology in various languages, has led Vaux (1998) to suggest that voiceless fricatives are normally [+spread glottis], like aspirated stops.

In languages that have the contrast of aspiration on fricatives, plain unvoiced fricatives would have to be analyzed as [−spread glottis] in spite of the fact that their glottis is spread, as the duration of glottis spreading is less than that of aspirated fricatives. This is confirmed by the existence of an aspiration dissimilation rule in Ofo involving aspirated fricatives, which de Reuse (1981) has aptly compared to Grassmann's law:

[19] This is not true however, in clusters where a stop is found between two fricatives or between another stop and a fricative: Ridouane et al. (in press) show that in Tashlhiyt, some unaspirated stops are pronounced with a spread glottis in clusters of this type, as the segments in bold in a word like [t**kk**s**t**stt] "you took it off".

(13) *oskaf^{h}ã* 'white egret' < *ósk^{h}a* 'crane' + *af^{h}á̃* "white'
apés^{h}ihi 'smoke' < *ap^{h}é* - 'fire' + *tə-s^{h}íhi* 'burn'

This alternation shows that the dissimilation occurs when an aspirated stop is followed by an aspirated fricative in the next syllable, while no such dissimilation occurs when a non-aspirated stop follows. s^{h}- and f^{h}- therefore share with aspirated stops the value [+spread glottis], while s- and f- are aligned with unaspirated stops in having the value [−spread glottis].[20]

Such an analysis implies that the same sound can receive different feature specification in different languages: a [+spread glottis] fricative would be aspirated in languages with a contrast between aspirated fricatives and non-aspirated fricatives and would be non-aspirated in languages without this contrast. This brings the question whether this definition of [spread glottis] is the best way to describe aspiration with fricatives, and whether another possibility should not be considered.

Redouane et al. (to appear) propose an alternative analysis of the feature [spread glottis]. According to them, a purely articulatory definition of [spread glottis] based on the glottal configuration cannot account well for many phenomena, especially the fact that unaspirated stops can be pronounced with an open glottis in some languages. They argue for a definition of [+spread glottis] that includes both articulatory and acoustic attributes:

(14) a) Presence of a glottal noise source (i.e. spread glottis)
b) Presence of aspiration noise

According to this definition, aspirated fricatives are clearly [+spread glottis], but unaspirated ones would be [−spread glottis].

The contrast between plain and aspirated fricatives has not yet been investigated from an articulatory point of view. The only language for which aerodynamic data are available is Korean (Kim et al., 2010), but the nature of the contrast between the two fricatives in this language is complex and typologically unusual, as aspirated fricatives are opposed to tense fricatives, without a plain counterpart. It is the only language in our sample to present such a contrast, and it cannot therefore be taken as basis for a general model. A detailed aerodynamic analysis of aspirated fricatives in a language with a contrast between plain unvoiced, aspirated (and voiced) fricatives such as Amdo Tibetan would be needed to describe the nature of aspiration in fricatives, but this study would go beyond the scope of the present paper. In this article, we will only provide preliminary hypotheses and some limited acoustic data from Cone Tibetan to be tested against further studies.

Friction and aspiration are basically two types of turbulent sound (noise), differing by the place where the noise is realized: at the glottis for aspiration, and in the supraglottal cavity for friction. For both friction and aspiration to be produced, flow of air caused by a difference between upstream and downstream pressure is necessary, intraoral pressure for friction and subglottal pressure for aspiration (Ohala and Solé, 2010:40).

The aspiration contrast on unvoiced fricatives for CV syllables can be described in terms of three overlapping articulatory gestures: constriction, upstream/downstream pressure adjustment and voice (beginning of the vowel). Differing in timing between constriction and upstream pressure adjustment in three stages could explain the difference between the two types of fricatives.

(1) In both aspirated and non-aspirated fricatives, friction starts with a combination of increased intraoral pressure and oral constriction. The glottis is spread.
(2) In non-aspirated fricatives, upstream pressure drops simultaneously with (or prior to) the release of the constriction, just before the beginning of the vowel. By contrast, in aspirated fricatives, there is a time lag between the release of the constriction and the drop of upstream pressure: the constriction is released while upstream pressure from the lungs is maintained.[21] The oral constriction having been released, the upstream pressure causes aspiration.
(3) Glottal adjustment (initiation of voicing for the vowel).

One element of explanation for the rarity of aspirated fricatives may reside in their articulatory complexity: they require a type of coordination between supraglottal constriction, subglottal pressure and glottal configuration that is at odds with the tendency towards economy in speech production. Another element to explain their rarity is possibly of perceptual nature; we can speculate that aspiration is more difficult to perceive in fricatives than in stops, though psychoacoustic tests would be needed to prove or disprove this idea.

In Figs. 1 and 2, we present a quasi-minimal pair in Cone Tibetan between *su^{121}* "cattle" (Old Tibetan *zog*) and *s^{h}u^{13}* "a kind of basket" (Old Tibetan *slebo*). On the signal in Fig. 2, we observe a peak in amplitude followed by a decrease before the beginning of the vowel (marked by an arrow). This peak is probably the effect of an abrupt release of constriction and intraoral pressure, causing an increase of airflow, after which intraoral pressure drops sharply. The decrease in amplitude following the peak, observed on all instances of aspirated fricatives in this language, is due to the fact that fricatives

[20] On the other hand, in Greek and Sanskrit unaspirated s- does not trigger Grassmann's law, a fact that sheds doubts on the idea that /s/ is [+spread glottis] in these languages.
[21] This hypothesis follows Silverman (1997:80): 'In those rare instances of aspirated fricatives, aspiration usually both co-occurs with the fricative (in order to maintain constriction) and is maintained upon oral release (in order to saliently encode the contrastive aspiration).'

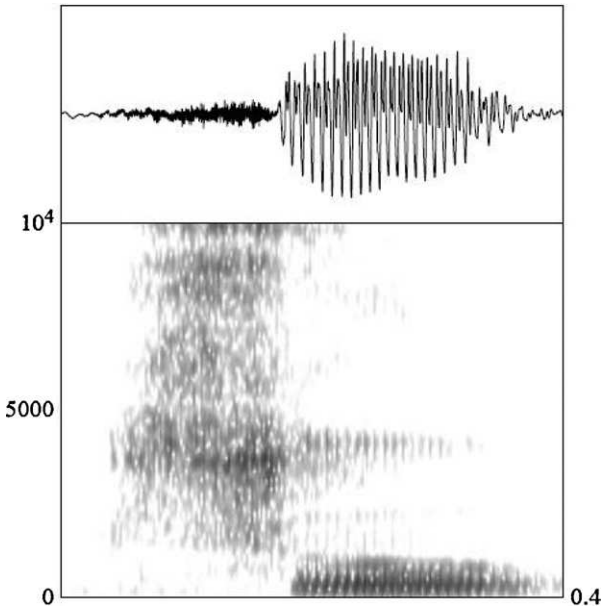


Fig. 1. Cone Tibetan sù "cattle".

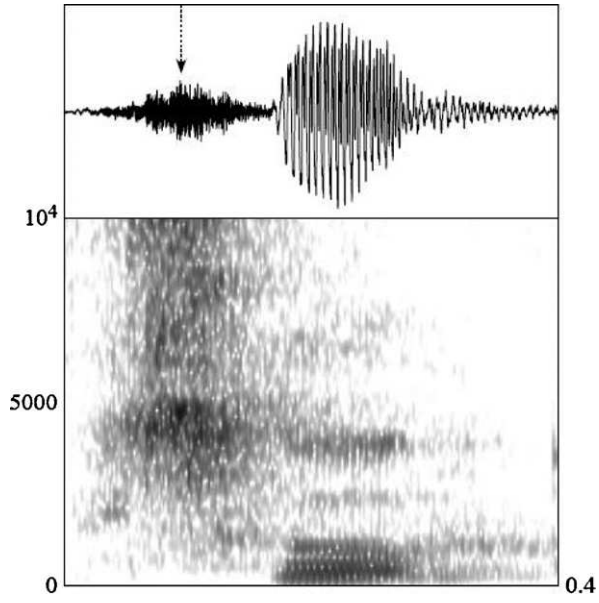


Fig. 2. Cone Tibetan s^{h}ù: "a kind of basket".

(especially sibilants) have a more intense noise than aspiration. If the part of the fricative before the arrow is deleted, the resulting signal sounds like an aspirated [t^{h}].

In the following discussion, we will compare how well the two analyses of the feature [spread glottis], can account for the data presented in sections 3 and 4.

As mentioned in the beginning of this section, the eight types of changes can be divided into three: aspiration of unaspirated fricatives, fricativization of aspirated onset and fusion of two segments.

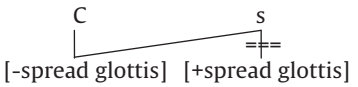
5.1.2. Aspiration of unaspirated fricatives

The changes A and B from Table 17 have in common the fact that ancient (unaspirated) fricatives develop aspiration, causing a chain shift whereby non-aspirated fricatives are derived from either consonant clusters or affricates. Using Vaux's definition of [spread glottis], type A and B changes can be easily explained.

In type A (Tibetan), the simple fricative s- > s^h- remains [+spread glottis]. In a language without aspirated fricatives like Old Tibetan or Middle Korean, [s] is underspecified for [spread glottis] since there is no contrast, and the default value is [+spread glottis] as we have seen above. In a language with contrastive aspirated fricatives such as Amdo Tibetan or Modern Korean, [+spread glottis] corresponds to [s^h], while [s] is in fact [−spread glottis]. Although both s- (in Old Tibetan /Middle Korean) and s^h- (in the modern languages) share the value [+spread glottis], a phonological change nonetheless happened, as in the first case the value [+spread glottis] is just the default value of the underspecified feature, whereas in the second case it is a fully specified [+spread glottis].

The development of phonetic aspiration can be understood as the indirect result of the spread of the [−spread glottis] feature from the preceding stops in *Cs- > s-: the feature [+spread glottis] is delinked from the fricative in these clusters:

(15)



When the cluster Cs- simplifies to s-, the only remaining contrastive feature between ancient *Cs- and ancient *s- is the feature [spread glottis]: the phonetic realisation of this feature then changes in the case of ancient *s-, which develops aspiration to preserve the contrast.

In type B (Shan), as in type A, we observe a change s- > s^h-. The same interpretation as above can be proposed. The difference lies in the fact that the gap in the system (the unaspirated [s]) is filled not by a Cs- cluster, but by an affricate ts- > s-. In terms of feature theory, this can be analyzed as a change [−continuant] > [+continuant], the value of [spread glottis] (or [aspiration]) remaining the same.

Using Ridouane et al.'s definition of [spread glottis], the A and B changes have to be described in an entirely different way. The fundamental problem is why aspiration would spontaneously develop in non-aspirated fricatives, if non-aspirated fricatives are analyzed as [−spread glottis].

In Tibetan dialects that have aspirated fricatives, the Old Tibetan Cs- clusters have either simplified to s-, or the preceding stop has changed to a fricative or even a preaspiration; the stops are never preserved as such in any of these dialects. In most Amdo dialects, we observe the following changes[22]:

(16) gs- > xs- > ^{h}s-
bs- > ɸs-

We may hypothesize a stage, before the development of aspirated fricatives, when simple initial s- contrasted with preaspirated s-, or with a double fricative cluster. The development of aspiration in simple s- might have been a reaction to maximize the contrast with ^{h}s-, as the two onsets were in danger of merging.

Such an explanation is not available however for Korean, where the non-aspirated fricative [s*] is a tense fricative. However, as mentioned before, the status of aspiration in Korean differs from that of other languages with aspirated fricatives. In the stop system of Korean, we find tense stops /t*/, mildly aspirated stops /t/ (realized as voiced in intervocalic position without any aspiration) and strongly aspirated stops /t^h/. Kim et al. (2010) find that the aspiration in non-tense fricatives corresponds more to the mildly aspirated stops than to the strongly aspirated one; besides, aspiration disappears in intervocalic position. They argue that /s/ is [−spread glottis] in Korean. The presence of aspiration in /s/ in Korean is the result of a systemic change in which all non-aspirated obstruents developed aspiration, probably as a way to maximize the contrast with the corresponding intensives.[23]

In this conception of the feature [spread glottis], the Tibetan and Korean data would not even be classified as a common type of change. A still different explanation would have to be proposed for the Shan type evolution s- > s^h- / tɕ- > s-, but we cannot find a functional explanation to motivate this change.

5.1.3. Fricativisation of aspirated onset

Types C, D, E and F differ from types A and B in that aspiration is not created, it is instead preserved from the older stage of the language. These pathways involve the change of an aspirated stop/affricate/sonorant (or a cluster including an aspirated segment) into a fricative. Since the aspiration does not undergo any modification, these four changes can be described equally well by assuming either Vaux's or Ridouane's definitions of [+spread glottis].

In type C (Burmese), the changes ts^h- > s^h- and ts- > s- only have to do with the feature [continuant], changing from the value [−continuant] > [+continuant]. This is an extension of a rule already found in type B.

Type D (Pumi) is in some way similar to type B: the main difference is that the change [−continuant] > [+continuant] is triggered by lenition of the initial consonant due to the presence of a preconsonant s- in a former stage of the language,

[22] b- and g- are the only stops allowed in this position. There was no contrast of voicing in preinitial stops, and gs- / bs- should be interpreted as *[ks] and *[ps-] in a phonetic reconstruction of Old Tibetan.

[23] Evidence from Chinese loanwords and from Chinese transcription of Korean shows that mildly aspirated stops in Korean used to be non-aspirated.

whereas in type B the change of the feature [continuant] is spontaneous. This type of lenition is widely attested throughout languages of South-East Asia (Michaud, 2009).

In types E and F, an aspirated sonorant becomes aspirated fricative. E differs from F in that in the former, both fricatives come from similar clusters ($p^hj- > ɕ^h-$, $pj- > ɕ-$), while in the latter, the aspirated fricative and its non-aspirated counterpart have entirely different origins ($hj- > ʃ^h-$). As mentioned in section 3.5, type F only occurs in languages that already had the corresponding non-aspirated fricative in their phonological system **and** other aspirated fricatives before the change took place.

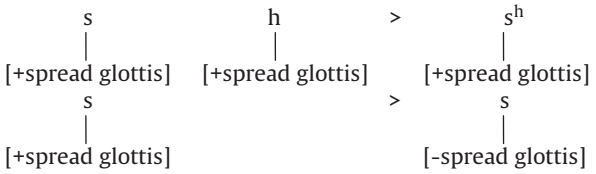
5.1.4. Fusion of two segments

Types G and H considerably differ from the five previous types of change. Aspirated fricatives here result from the fusion of a fricative with another element.

In type G (Ofo), aspirated fricatives come from the fusion of a fricative with a laryngeal element /h/. Since Ofo itself involves many phonetic changes, we will discuss here a simplified change s + h > s^h-, which is attested as such in Chumashan.

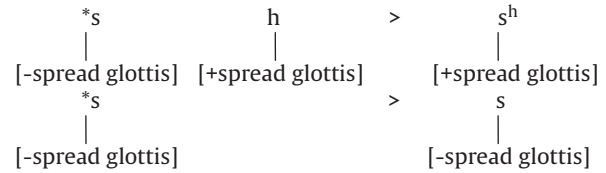
If we adopt Vaux's analysis of [spread glottis], the changes from proto-Chumashan to attested Chumashan can be represented as follows:

(17)



These evolutions do not allow an elegant analysis if we assume that the default value of the fricatives was [+spread glottis] in proto-Chumashan: one is compelled to suppose that in order to preserve the contrast between the two, the simple fricative changed its [spread glottis] value from + to −. In order to explain this change in a more satisfactory way, we would have to assume that the default values of fricatives in proto-Chumashan was [−spread glottis] instead:

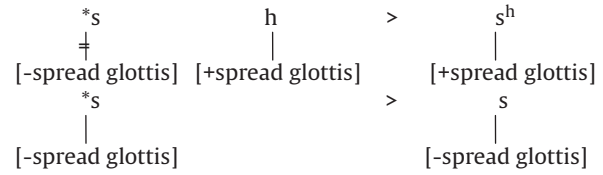
(18)



The possibility that languages differ as to the default value of the feature [spread glottis] on fricatives has been mentioned by Vaux (1998:508); he suggests for instance that, although in most languages the default value for fricatives is [+spread glottis], some may also have [−spread glottis] (he cites Chinese as one example of the latter type). This explanation makes the prediction that type A-F changes occur in languages where the default value for fricatives is [+spread glottis], while change H occurs in languages where it is [−spread glottis].

However, this would be basically equivalent with an analysis in terms of Ridouane's definition of [+spread glottis]:

(19)



The laryngeal fricative is analyzed as being [+aspirated] due to the presence of aspiration frication. This simpler analysis is more satisfying than the previous one in terms of [spread glottis].

Type H (Chumashan) involves the change s+s > s^h-. It is part of a more general process in which all geminate unvoiced and unaspirated obstruents, including stops, become aspirated (Applegate, 1972:121). Another rule seems to be related to (16). According to Appleyard (1972:138–139), unvoiced affricates followed by /s/ become aspirated affricates:

(20) ts+s > ts^h-

Table 18
Combined patterns of pathways leading to the creation of aspirated fricatives.

Type of change	Pattern	Example language
A, D, E	1,2	Amdo Tibetan
A, E, F	1,2	Cone Tibetan
B, D	1,2	Yanghao
G, H	3,4	Chumashan

Since Chumashan has aspirated fricatives, the simple /s/ must be analyzed as [-spread glottis] even in Vaux's theory, so one cannot propose that the aspiration is due to the [+spread glottis] feature of the /s/ being debuccalized. It should be described instead as a rule of obstruent dissimilation.

5.1.5. Concluding remarks

The eight types of changes reviewed in sections 3 and 4 can be reduced to four main patterns.

- Pattern 1 (types A and B) involves the spontaneous creation of aspiration on unaspirated fricatives. This pattern could provide some supporting evidence for Vaux (1998)'s theory that unaspirated fricatives are inherently [+spread glottis], but alternative analyses are also possible.
- Pattern 2 (C to F) is the preservation of aspiration, while a former aspirated stop, affricate or sonorant is being fricativized.
- Pattern 3 (G) involves the fusion of a fricative and a laryngeal. This type of change is analyzed in a simpler way using the Ridouane et al.'s definition of [+spread glottis].
- Pattern 4 (H) is the effect of a rule whereby all geminate obstruents merge to become a single aspirated segment.

Some languages attest more than one type of change, but not all combinations are attested (Table 18).

The available data show that languages have aspirated fricatives coming either from Pattern or from Pattern 3/4 but we find no attestation of any language whose aspirated fricatives would come from both 1 and 3 for instance.

An explanation for this mutual incompatibility is probably the fact that patterns 1/2 only occur in languages that previously had phonemic aspiration, while patterns 3/4 are only found in languages that are reconstructed without a series of aspirated stops.

5.2. Historical phonology and synchronic typology

Blevins (2004:192–198) argues that two main reasons can explain why some sound patterns are uncommon: either that no or few diachronic pathways can lead to their creation, or that sound change can easily eliminate them. In this section, based on these insights, we will propose an interpretation for three typological facts about aspirated fricatives: their overall rarity, their absence in consonant clusters, and the even greater rarity of non-coronal aspirated fricatives.

First, as mentioned in the introduction, contrastive aspiration on fricatives is extremely rare in the world's languages. However, given the variety of attested diachronic pathways creating aspirated fricatives described in sections 3 and 4, their cross-linguistic rarity is arguably not due to a dearth of possible origins; the reason is rather to be sought in the difficulty in maintaining this contrast. The contemporary Burmese example, where s^h- and s- merge as s-, illustrates the fact that the aspiration contrast tends to be lost in fricatives leaving only the non-aspirated form.

Second, aspirated fricatives almost never occur in consonant clusters. Of the eight attested origins of aspirated fricatives, we have seen that six (A, D, E, F, G and H) involve a loss of consonant clusters. The development of aspirated fricatives is one of the many possible responses to preserve phonemic contrasts after loss of clusters. This observation gives us now a way to explain the absence of clusters involving aspirated fricatives mentioned in section 2. Although it is not impossible in principle that an aspiration contrast could appear with fricatives in a cluster (for instance, a hypothetical example $ts^hr- > s^hr-$ with a type C evolution), the chances that both a cluster could be preserved and aspiration created are very slim since most of the phonetic evolutions leading to the creation of aspirated fricatives involve a loss of clusters. The only known case of aspirated fricatives in clusters is in the Horpa/Rtau languages (Sun, 2000), where verbal stem alternation involves systematic aspiration polarity (Table 19).

Table 19
Aspiration polarity in Rtau (Sun, 2000:223).

	Base stem	Aorist stem
to split open	*fqrə*	*fq^{h}rə*
to go	*ɕə*	*ɕ^{h}ə*
to raise	*xsu*	*xs^{h}u*
to complete	*st^{h}a*	*sta*
to put inside	*ŋk^{h}ə*	*ŋkə*

This type of alternation, which would belong to our type G (even if aspiration is partly a suprasegmental feature in this language), can create aspirated fricatives even when the base stem already had a cluster, as in the word *xsʰu* above. There are also base stems with aspirated fricatives in Rtau languages, but their diachronic origin is not yet known.

Third, non-coronal aspirated fricatives are even rarer than coronal ones. We proposed the following implicational hierarchies in section 2:

(21) a. $s^h > \{ɕ^h, ʂ^h, ʃ^h\} > \{ç^h, x^h, ɬ^h\}$

b. $s^h > f^h$

c. unvoiced aspirated fricatives > voiced aspirated fricatives

These hierarchies are also generally observed tendencies in the distribution of corresponding non-aspirated fricatives and affricates.

Out of the eight pathways creating aspirated fricatives, two (C and D) involve a change from affricate to fricative, and all others except E and F involve fricatives. It has been observed that non-coronal affricates contrasting with plain stops are extremely rare, and that voiced ones are even rarer (De Lacy, 2002:496). These tendencies are not surprising in view of the greater salience of sibilant fricatives.

Given the fact that affricates are often involved in the phonetic pathways leading to aspirated fricatives, it is not surprising that we find the same skewed distribution of non-coronal places of articulation for both types of sounds. x^h- and f^h- can only be directly generated by pathways A, D, G or H (possibly also F in the case of f^h, though no example is attested). The only way they could be generated by another pathway would be through a second sound change involving a shift in place of articulation as in Cone Tibetan.

However, in the case of x- / x^h-, the rarity of possible origins is not the only reason for the extreme rarity of this contrast. In Shuiluo Pumi, such a contrast would be predicted by the general mechanism of lenition: we would expect the following changes to have taken place:

*sk^h- > x^h-

*sk- > x-

However, we have seen that *sk^h- and *sk- merge as x-: the aspiration could not be preserved with velar fricatives, though it cannot be excluded that in a former stage, Shuiluo Pumi did have such a contrast. Similarly, in Chumashan, the obstruent dissimilation rule described in section 3.7 does not apply to velar fricatives.

These examples show that the development of a x- / x^h- contrast tends to be avoided in languages that develop an aspiration contrast in fricatives on other places of articulation. This shows that the rarity of this contrast is not only due to its limited possible origins: it is acoustic, as aspiration and friction are less distinct for velars than at other places of articulation: velars fricatives have more energy in the lower range of the spectrum than other fricatives, and resemble aspiration. Even when such a contrast is created, it tends to be eliminated by phonological change; the tendency for the aspiration contrast in fricatives to be lost mentioned above is stronger with velars than with coronals.

6. Conclusion

This paper has two contributions to make to the typology of phonetic changes and one to phonological theory.

First, it describes all the attested evolutionary pathways creating aspirated fricatives in a range of languages, presents new data on Cone Tibetan to illustrate several types of changes, and documents a previously undescribed type of evolution in Shuiluo Pumi. This piece of research fills a gap in the literature on the evolution of consonantal systems (ranging from Martinet, 1955 to Blevins, 2004), where aspirated fricatives are never mentioned. The findings of this article will be of interest to reconstruct the origin of aspirated fricatives in other languages such as Bai, !Xũ, Rtau or Oto-Manguean where it has not yet been elucidated: we expect other cases of aspirated fricatives to fit into the four main patterns analyzed in this article.

Second, the Pumi comparative data presented in this paper exemplify a process of initial consonant lenition found elsewhere in many languages of East Asia (Jacques and Michaud, in press) and linked with monosyllabicization (Michaud, 2009); Shuiluo Pumi is remarkable in that all places of articulation undergo lenition except labial stops. In all other languages which present lenition, such as Tibetan or Laze, the reverse situation is attested: the labial stops are the one that tend to be more prone to lenition that the other places of articulation.

Third, the sound changes studied here provide evidence in the debate regarding the definition of the feature [+spread glottis] across languages and the nature of the aspiration contrast in fricatives.

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