Systemic markedness in sibilant inventories

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A survey of place contrasts among sibilant fricatives, building on Padgett & Zygis (2007), Zygis & Padgett (2010), reveals systematic gaps and restrictions (1). Each row in (1) represents an inventory contrasting the sibilant places indicated with check marks ([s] dental/alveolar, [ɕ] alveolopalatal, [ʃ] palato-alveolar, and [ʂ] retroflex), and indicates whether that inventory is attested.

(1)

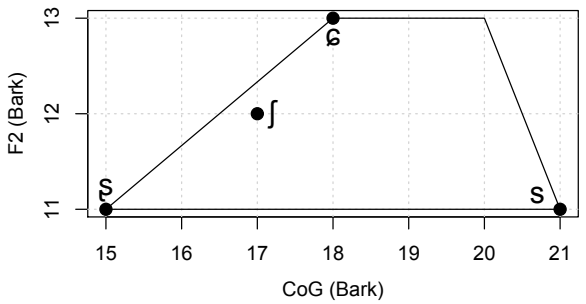
s	ɕ	ʃ	ʂ	attested?	remarks/examples
✓	✓			(yes)	Only with palatalization contrasts, e.g. Japanese
✓		✓		yes	English, French, German, Khasi, Malay, Aymara
✓			✓	yes	Mazatec, Papago, Czech dialects, Slovene dialects
✓	✓		✓	yes	Mandarin, Polish, Telugu, Malayalam, Naxi
✓		✓	✓	yes	Burushaski, Hmong, Jacaltec, Tulu, Acoma
✓	✓	✓		no	-
✓	✓	✓	✓	yes	NW Caucasian

(Maddieson (2004) reports that Chuvash and Tehuelche have [s, ɕ, ʃ] inventories. In fact these languages contrast [s, ʃ] plus non-sibilant fricatives (Kruger 1961, Adelaar & Muysken 2004)).

This typology cannot be accounted for in terms of fixed rankings of standard markedness constraints because different implicational universals hold in inventories with two vs. three sibilant places:

- All languages with three sibilant places include retroflex [ʂ], which suggests *ʃ, *ɕ >> *ʂ, but languages with two sibilant places can contain any of the non-anterior sibilants, implying no fixed ranking among *ʃ, *ɕ, *ʂ.
- Alveolopalatal [ɕ] only occurs as the second sibilant place where it patterns as the palatalized counterpart of [s] in a broader set of palatalization contrasts (e.g. [p, pʲ], [k, kʲ]) as in Japanese (Padgett & Zygis 2007). We might try to account for this generalization by universally ranking *ɕ above constraints against other palatalized consonants, but this restriction does not apply to languages with three sibilant places, e.g. Polish and Malayalam both have [ɕ], but only Polish has other palatalization contrasts.

The dependence of the markedness of individual sibilants on the overall system of contrasts follows from an analysis based on constraints that penalize perceptually indistinct contrasts (Flemming 2017). The distinctiveness of a contrast between two sibilants is modeled as the weighted Euclidian distance, d_{ij}, between the sounds in the perceptual space below:



$$d_{ij} = \sqrt{(1-a)\left(CoG_i - CoG_j\right)^2 + a\left(F2_i - F2_j\right)^2}$$

where $0 < a < 1$ models allocation of attention between the two dimensions (Nosofsky 1986). The value of a varies across languages.

The primary dimensions are F2 adjacent to the sibilant and Center of Gravity (CoG) of the fricative spectrum.

The locations of the basic sibilant types are based on published studies of Polish, Mandarin, Russian and English sibilants, and the lines demarcate the space of possible sibilants. CoG is lowest with retroflexes and retroflexion is articulatorily incompatible with a high front tongue body constriction (Hamann 2003) so the lowest CoG sibilants cannot have high F2. Anterior [s] can be palatalized with minimal reduction in CoG (e.g. Kochetov 2017), so a range of F2 values are compatible with high CoG in sibilants.

The typology of sibilant inventories arises from different rankings of constraints that penalize contrasts between sounds that are separated by less than *d* in the perceptual space (MINDIST = *d*), articulatory effort constraints, and a constraint that prefers larger inventories of contrasts (MAXIMIZE CONTRASTS) (Flemming 2017), together with variation in the value of *a*.

The number of contrasts depends on the ranking of MINDIST and MAXCONTRASTS (2, 3). For example, with $a = 0.4$, only two places can be distinguished if MINDIST = 3 >> MAXCONTRASTS (2), while the reverse ranking allows three places.

For values of $a < 0.87$, the maximally distinct contrasts are [s, ʂ] for two places and [s, ɕ, ʂ] for three, so these inventories are derived if MINDIST constraints rank high enough (2, 3). However, inventories containing [ʃ] are preferred by articulatory constraints, which follow the fixed ranking *ʂ/ɕ >> *ʃ >> *s (where *ʂ/ɕ penalizes all sibilants other than [s, ʃ]). So [s, ʃ] would win in (2) if *ʂ/ɕ >> MINDIST = 3.5, and [s, ʃ, ʂ] would win in (3) if *ʂ/ɕ >> MINDIST = 2. The unattested inventory [s, ɕ, ʃ] (3b) cannot be derived because it is harmonically bounded by [s, ʃ, ʂ] (3c), since the latter inventory is better dispersed (for all values of *a*) and tied with respect to articulatory constraints.

(2)

	$a = 0.4$	MINDIST = 2.5	MINDIST = 3	MAX CONTRASTS	MINDIST = 3.5	*ʂ/ɕ	*ʃ
a.	s ʃ			2	*!		*
b.	☞ s ʂ			2		*	
c.	s ɕ		*!	2	*	*	
d.	s ɕ ʂ		*!*	3	**	**	

(3)

	$a = 0.4$	MINDIST = 1.5	MAX CONTRASTS	MINDIST = 2	MINDIST = 2.5	*ʂ/ɕ	*ʃ
a.	☞ s ɕ ʂ		3			**	
b.	s ɕ ʃ	*!	3	*	*	*	*
c.	s ʃ ʂ		3	*!	*	*	*

The last attested inventory [s, ɕ] can only be derived if $a > 0.87$: the higher weight on F2 transitions makes [s, ɕ] more distinct than [s, ʂ]. High weight on F2 transitions makes all palatalization contrasts more distinct, so under these conditions other palatalization contrasts are selected also. But with three sibilant places, the maximally dispersed contrasts are [s, ɕ, ʂ] for all values of *a*, so the association between occurrence of [ɕ] and other palatalization contrasts only applies to languages with two sibilant places.

Summary: Two mechanisms account for the dependence of the attestation of individual sibilants on the overall system of contrasts: (i) Distinctiveness constraints – different sibilants yield maximally distinct contrasts when trying to fit 2 vs. 3 sounds into the available perceptual space. (ii) The perceptual distinctiveness of differences on a phonetic dimension can vary across languages, affecting the markedness of all contrasts that rely on that dimension.

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