J. Ohala “*The relation between phonetics and phonology*”, in: Hardcastle & Laver, “*Handbook of Phonetic Sciences*”, pp. 686-689

4.2 How can we explain the occurrence of common cross-language sound patterns?

At least since the work of Passy (1890) and Rousselot (1891) parallels have been noted between synchronic, non-distinctive, variation in pronunciation, which can be discovered in fine-gained instrumental study of speech, and diachronic variation discovered via reconstruction or by the direct evidence in ancient texts. Moreover, the synchronic variation in many cases is understandable by reference to known physical phonetic principles. From this one may conclude that (a) many sound changes arise first as non-distinctive synchronic variation and (b) that it is physical principles that determine the direction of this variability, including articulation (the topological geometry of the vocal organs as well as their inertia and elasticity), aerodynamics, how given vocal tract configurations give rise to sound, and auditory principles. A cognitive element, e.g., how listeners may err in “parsing” the events in the speech signal, is also important (Ohala 1992a, 1993). Although speaker-specific and culture-specific psychological or cultural factors play some role in sound change (certainly in the actual triggering of sound changes), phonetic factors are the most important factors and those most amenable to experimental study in determining cross-language universals or tendencies for sound patterning, i.e., patterns in phoneme inventories, in phonotactics, as well as in morphophonemic or allophonic variation.

Though the physical constraints shaping speech sound behavior are universal, their influence on languages is probabilistic, not absolute, because there are often ways that they can be overcome. Similarly, gravity is universal but individuals are capable of walking upright; occasionally, however, they lose their balance and stumble and then gravity asserts itself and they fall.

I will briefly present two examples of phonetically-explained sound patterns (see also Kawasaki 1986, 1992; Ohala 1983, 1985, 1989, 1990d, 1992a, 1993, 1994a, in press a, b, c, d; Ohala and Lorentz 1977; M. Ohala and J.J. Ohala 1991; Wright 1986).

4.2.1 The “bias” against voiced obstruents As is well known, there is a distinct “bias” against voiced obstruents in languages. Some languages, like Mandarin and Korean, have only voiceless stops and others, like English, which have both voiced and voiceless, show a lesser frequency of occurrence of voiced stops in running speech. Voicing in fricatives is even more infrequent than in stops. This pattern arises for the following reasons. Simplifying somewhat, vocal cord vibration has two requirements: first, the vocal cords must be lightly adducted, i.e., neither pressed against one another nor too far from the midline, and, second, there must be sufficient air flowing between the vocal cords. Assuming the first requirement is met, one of the principal factors influencing the second is the state of the supraglottal cavity. Obstruents, by definition, block the flow of air out of the vocal tract. During an obstruent the air accumulates in the air space between the point of constriction and the glottis; air pressure thus increases. Eventually the air pressure above the glottis will rise to approach that below the glottis. When the pressure differential across the glottis falls below a certain value (estimated at 1 to 2 cm. H_2O) the air flow will drop below the level necessary to maintain voicing. Vocal cord vibration will then stop. (See Ohala 1983, 1990c, 1994a.)

This is the principal reason for the bias against voiced obstruents. But there are many extensions and further elaborations of this principle.

The longer a stop closure is held, the more likely this constraint is to manifest itself. Thus voiced geminate stops often become devoiced, see Table 22.1.

Table 22.1 Geminate devoicing (Klingenheben 1927).

<u>*Original*</u>	<u>*Libanon-Neusyrischen*</u>	
n a g g ī b	**n a k k ī b**	*trocken*
m^{e} d a g g e l	**m d u k k e l**	*Lügner*
š a d d a r	**š a t t a r**	*schickte*
z a b b e n	**z a p p e n**	*verkaufte*

This aerodynamic constraint can be overcome (within limits) by enlarging the oral cavity during the obstruent closure in order to make more room for the accumulating air. Some enlargement happens passively due to the natural “give” or compliance of the vocal tract walls to impinging air pressure but even more enlargement can be done actively by lowering the tongue and jaw, letting the cheeks bulge out, raising the velum, lowering the larynx, etc. This factor must be responsible for the fact that the voiced implosives in Sindhi developed from geminate voiced stops, see Table 22.2. To maintain voicing during the long (geminate) stop closure the oral cavity volume was increased, including by lowering the larynx, and a sound change occurred when listeners took the cues for this active cavity enlargement as purposeful.

Table 22.2 Development of implosives in Sindhi (Varyani 1974).

<u>*Prakrit*</u>	<u>*Sindhi*</u>	
*** p a b b a**	**p a ɓ u ɳ i**	*lotus plant fruit*
g a d d a h a	**g a ɗ a h u**	*donkey*
-(g) g a m̥ ʈʰ i	**ɠ a ɳ ɖʰ i**	*knot*
bʰ a g g a	**bʰ aː ɠ u**	*fate*

However, the option of maintaining voicing by enlarging the oral cavity is less effective the further back the supraglottal closure is made because there is lesser surface area to yield to the impinging pressure and because there are few options for cavity enlargement. Thus Voiced uvular and velar stops, [ɢ], [g], therefore, are vulnerable; they may lose their voicing, their stop character, or both. This no doubt underlies the frequent absence of these sounds in languages which otherwise have one or more voiceless uvular or velar stops. See Table 22.3.

Table 22.3 Stop inventories showing absence of voiced velars.

Thai	**p**	**t**	**k**
	pʰ	**tʰ**	**kʰ**
	b	**d**	
Chontal	**p**	**t**	**k**
	b	**d**	
	p’	**t’**	**k’**

Southern (Nobiin) Nubian exhibits a morphophonemic pattern where both the influence of geminates and the influence of place of articulation are mani-fested. See Table 22.4. Here an inflectional process meaning ‘and’ adds the suffix [**ɔn**] to a noun stem and geminates the final consonant. But if this final consonant is voiced, the geminate that results is voiceless, unless it is articulated at the furthest forward place: labial.

Table 22.4 Morphophonemic variation in Nobiin Nubian (Bell 1971; Ohala and Riordan 1979).

Noun stem	*Stem + ‘and’*	
f ɑ b	**f ɑ bː ɔ n**	*father*
s ɛ g ɛ d	**s ɛ g ɛ tː ɔ n**	*scorpion*
k ɑ d͡ʒ	**k a t͡ʃː ɔ n**	*donkey*
m ʊ g	**m ʊ kː ɔ n**	*dog*

Statistics show that the bias against voicing in obstruents is even stronger in fricatives than in stops (Ohala 1983). Although this may at first glance seem puzzling because the fricatives, unlike stops, do involve some venting of the air accumulating behind the point of constriction, other factors are involved:

- Optimal voicing, as mentioned above, requires maximizing the $\Delta P_{transglottal} = P_{subglottal} - P_{oral}$.
- Optimal frication, on the other hand, requires maximizing $\Delta P_{transoral} = P_{oral} - P_{atmosphere}$.
- $P_{subglottal}$ and $P_{atmosphere}$ offer little or no opportunities for systematic, rapid, control.
- Therefore P_{oral} is the only parameter that can be controlled in order to optimize voicing and frication during voiced fricatives.
- But the one constraint would require keeping P_{oral} as low as possible and the other keeping it as high as possible. Obviously, it is not possible to do both simultaneously.

Thus to the extent that voiced fricatives have good frication, they are liable to be devoiced (and this is true of the sibilant fricatives [**z, ʒ**]) and to the extent that they maintain their voicing, they are liable to have little or no frication (and this is true of the “weak” fricatives such as [**β, v, ð, ɣ**]; see Pickett 1980:155).