Alveolar stops in American English, and the nature of allophony

Daniel Silverman
University of Illinois at Urbana-Champaign

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Department of Linguistics, University of Illinois at Urbana-Champaign

1. Introduction

Phonological alternations fall into two basic categories. Either an alternation is neutralizing (or near-neutralizing), or it is allophonic. Herein, I primarily investigate certain properties of allophonic alternation, with special reference to English.

There are at least two subtypes of allophony. First, we can speak of "true" allophony, which refers to an alternation in which one of the contextual variants is otherwise not present in the phone inventory. For example, in Corsican, voiced spirants alternate *only* with the voiced stops, with which they are unambiguously allophonic. We can also speak of "contextual" allophony, which refers to an alternation in which a contextual variant is otherwise present in the phone inventory, but only in other contexts, as an alternant with *another* value. For example, in the Southern Min tone circle, a 53 tone is contrastive in non-final position. In final position, 44 is the contextual reflex of non-final 53. 53 is also present in final position, but only as a variant of a 21 tone. And so 53 is never a neutralized value in Southern Min, but it is not exclusively in an allophonic relationship with only one value. It is always contextually allophonic, however.

Now, are patterns of alternation are merely random, or are there generalizations to be found from which predictions might be made regarding when an alternation should be allophonic versus (near-) neutralizing? The hypothesis I wish to explore in this paper is that allophonic patterns may be a consequence of linguistic function: certain acoustic or auditory cues which convey contrastive information are enhanced and/or modified in contexts where contrasts are otherwise vulnerable to neutralization. This is a *functional* approach if we agree that a major function of phonology is to achieve effective communication. The principle of what I term "contrast maintenance," then, is an *abstract* functional constraint: contrastive values (whatever their origin and whatever their mental status) are maintained. This issue has been investigated by others of course, including Martinet 1952, Kiparsky 1972, Liljencrantz and Lindblom 1972, and, in my own work, Silverman 1997.

An additional hypothesis is that neutralizing patterns may be a consequence of energy constraints. Neutralization may take place when insufficient energy is present in the relevant context of the speech signal (deriving from the speaker) for contrastive information to be effectively communicated (to the listener). This too is a functionally-based constraint, since a major constraint on effective communication is the availability of energy. In various guises, this constraint has been discussed by many others, including

Pius N. Tamanji and Kiyomi Kusumoto (eds.), NELS 28, 425-435

most recently Jun (1995), Steriade (1995), and Kirchner (in prep.). Energy availability then, is a *physical* functional constraint: it is a truism, of course, to state that energy for the speech signal is limited in its availability.

Given that neither of these two constraints—contrast maintenance and energy availability—can ever be in force fully independently of the other, we might hypothesize that there is a necessary interdependence between abstraction and physicality in order to properly account for patterns of alternation.

I also argue that unmarked values are typically phonetically *natural* values, while marked values are typically less phonetically natural. I provide evidence from English, and also Corsican, that these distinctions in phonetic naturalness carry over to contextually-conditioned alternations.

2. English

English alveolar stop contrasts along the laryngeal continuum possess several context-dependent manifestations, shown in 1. "Fortis" refers to the so-called voiceless stop ("/t/"). "Lenis" refers to the so-called voiced stop ("/d/").

(1) The English alveolar lenis-fortis distinction:

	lenis:			fortis:		
	form:	example:		form:	example:	
(a) word-initially:	t	'tɑk	dock	t^h	't^hɑ̆p	top
(b) syllable- and word-finally:	t d̥	'nɑt 'nɑd̥	nod	V̆t˥ V̆ˇt˥ V̆ʔ	'nɑ̆t˥ 'nɑ̆ᵍt˥ 'nɑ̆ʔ	knot
(c) stressed-syllable-initially:	d	ə'dɑ pt	adopt	t^h	ə't^hɑ̆ p	atop
(d) word-internal unstressed syllable-initially:	V̆ɾ ɾ	ɑɾ̩ɹ ɑ̆ɾ̩ɹ	odder (neutralized)	ɾ	'ɑ̆ɾ̩ɹ	otter
(e) following s:	form: t	example: stɑp˥ ;	stop (non-contrastive)			

Word-initially (1a), we see an aspiration contrast. The lenis stop is typically a plain voiceless stop, while the fortis stop is aspirated. Syllable and word finally (1b) the contrast is of a somewhat different nature. Here, the lenis stop is also typically realized as a plain voiceless (or devoiced) stop, while the fortis stop is normally realized with glottalization and/or unrelease, and a shorter vowel. Stressed syllable initially (1c) we see yet another manifestation of the contrast. Here, the lenis stop is voiced, while the fortis stop is voiceless aspirated. Word-internal unstressed syllable initially (1d), we observe complete or near-neutralization: both the lenis and fortis stops are tapped, with or without a vowel length distinction on the preceding vowel. Finally, following [s] (1e) there is no contrast between the fortis and lenis stop.

(Note that, contrary to standard labeling conventions, it is actually the lenis, the so-called "voiced" stop, which is unmarked; the fortis, so-called "voiceless" stop is marked. The patterning of the English so-called [-voice] or ∅voice stop is not parallel to the cross-linguistic norm for stops: its presence implies the presence of the truly unmarked norm, that is, the so-called voiced stop.)

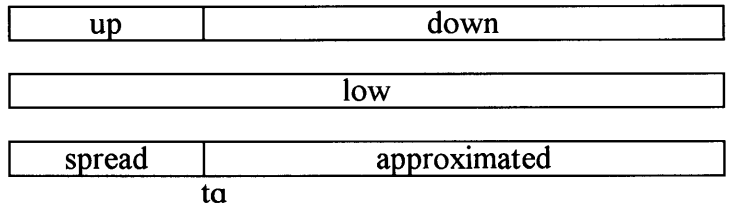
Synchronic alternations exist among the various forms presented in (1). In (2) are some examples.

(2) Synchronic alternations:

Lenis:	d - ɾ	**add**iction	**add**ict
	t/d̥ - ɾ	bu**d**	bu**dd**ing
	t - d	**d**o	re**d**o
Fortis:	V̆ˇt˥ - V̆ɾ	bu**tt**	bu**tt**ing
	t^h - ɾ	**a**tomic	**a**tom
	V̆ˇt˥ - t^h	dic**ta**te	dic**ta**torial

Consider in detail the word-initial contrast (1a). First, The *natural* laryngeal setting for word-initial stops is near-zero VOT, as there is an insufficient transglottal pressure drop to naturally implement vocal fold vibration until oral release (Westbury and Keating 1986, pace Rothenberg 1968). Westbury and Keating take their cue for "naturalness" from Trubetskoy's notion that "natural" contrastive values constitute "the least deviation from normal breathing" (1958:146). In (3) I provide a gestural score of the articulatory configuration over time (Browman and Goldstein 1986, 1989). Please be aware that this is merely a schematic of a typical realization.

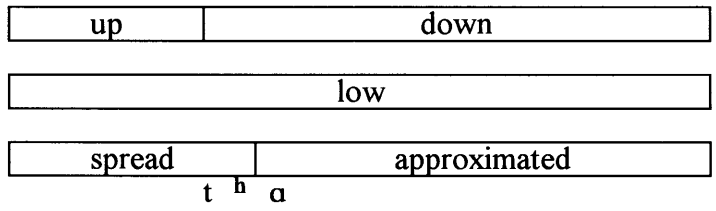
(3) Lenis stop:



Here, voicing is achieved at just around the stop release. The result is a voiceless, unaspirated stop, which is the cross-linguistic norm.

Now, If there is a laryngeal contrast among stops, what is its likely manifestation? A laryngeal contrast here may be effected by pushing toward late VOT (or aspiration). This is the English pattern, as portrayed in (4).

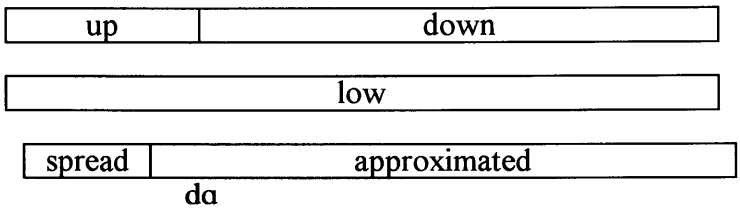
(4) Fortis stop:



Here, the spread glottis gesture is expanded beyond the stop release. The result is aspiration. Then, the vocal folds are approximated, and voicing kicks in for the vowel. Aspirates provide a robust contrast with plain stops, and so the contrast is maintained.

Alternatively, a laryngeal contrast here may be effected by pushing toward *early* VOT, as in Spanish, Dutch, and Japanese. This is a truly voiced, or pre-voiced stop.

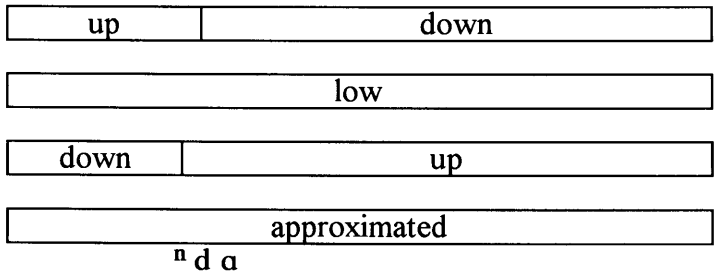
(5) Voiced stop:



The vocal folds are approximated during the stop closure itself, and voicing is implemented before stop release. This, of course, results in a fine and salient contrast with the plain stop.

A third realization of a contrast here may involve prenasalization, as in Chinantec, as schematized in (6).

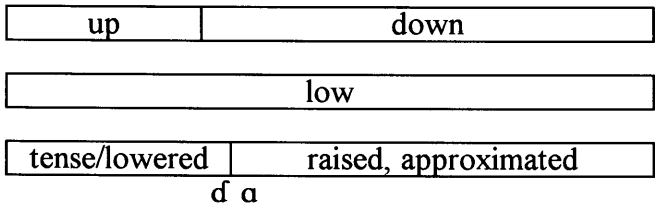
(6) Prenasalized stop:



Here, in order to ease the achievement of oral closure voicing, velic venting allows air to relatively freely cross the glottis.

Finally, there may be implosion as in Vietnamese, shown in (7). Here, active cavity expansion serves to increase the likelihood of closure voicing, thus enhancing the contrast between the two stop series.

(7) Imploded stop:



It is important to realize that these environment-specific manifestations achieve a contrast by accommodating to particular articulatorily natural constraints, by shifting from the natural laryngeal posture (for the unmarked pattern) to a somewhat less natural laryngeal posture (for the marked pattern); that is, either extend vocal fold spreading beyond release (resulting in aspiration), or extend voicing to precede release (as in prevoicing, prenasalization, implosion). Both of these laryngeal postures are aerodynamically unnatural, given the supralaryngeal state of affairs. And so the marked

pattern involves a push toward a less natural articulatory state. In this context—word-initially—sufficient energy is available to effectively implement these distinct realizations. The observed contrast can thus be motivated by comparing the natural, unmarked value ([t]) to the unnatural, marked value--[t^h], for English, or [d], [^{n}d], or [d̰].

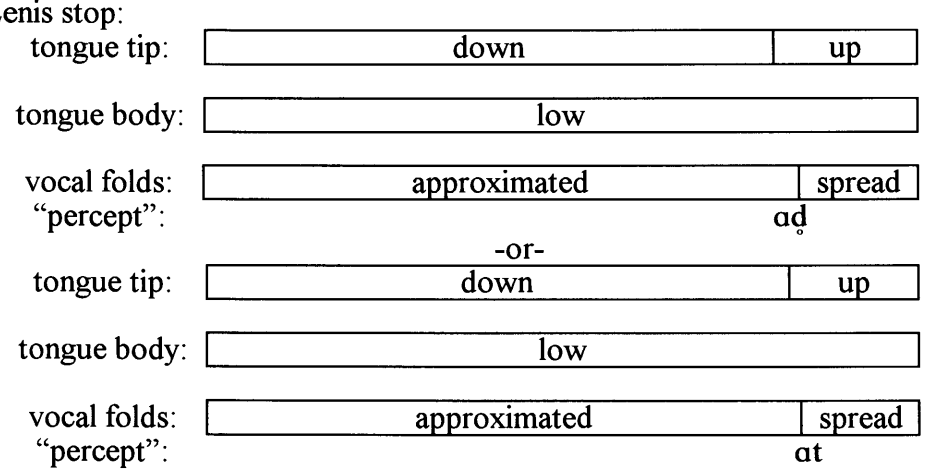
Note that nothing explanatory emerges by generating the respective values from some hypothesized lexical representations, that is, by changing (not temporally shifting) particular hypothesized distinctive feature values that cannot be functionally—or even formally—related to one another. So, in distinctive feature theory, an "underlying" [voice] value deletes word initially, and an "underlying" unspecified laryngeal value becomes [spread].

(8) [voice] → ∅
∅ → [spread]

That is all that can be said here. Nothing can functionally link the two fully distinct processes, and thus they are fully arbitrary with respect to each other.

Now consider syllable- and word-final position, where the contrast is one of plain or devoiced for the lenis stop, versus glottalized for the fortis stop, along with vowel shortening. The most common realizations of the lenis stop are schematized in (9).

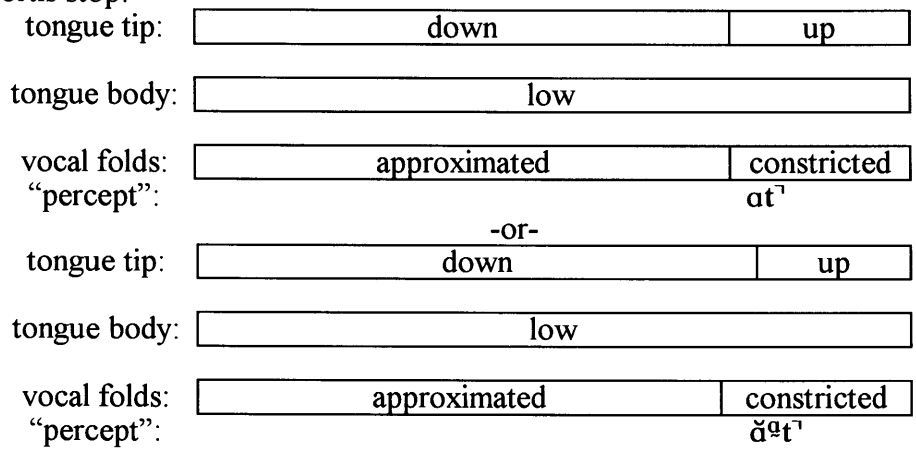
(9) Lenis stop:



Word-final and syllable-final stops are naturally voiceless. The natural laryngeal posture for syllable-and word-final stops is rather sudden dissipation of vibration, as the sealed oral cavity quickly fills to capacity, resulting in a rapid equalization of subglottal and supraglottal pressure (Westbury and Keating 1986). As indicated in the two similar scores in (9), vocal fold approximation ceases at or around the stop closure. This is thus the natural laryngeal configuration, which, not coincidentally of course, corresponds to the cross-linguistic norm for final stops, found in the English lenis series.

For the fortis stop, concomitant vowel shortening (/glottal constriction) may be implemented to enhance the contrast, as indicated in (10).

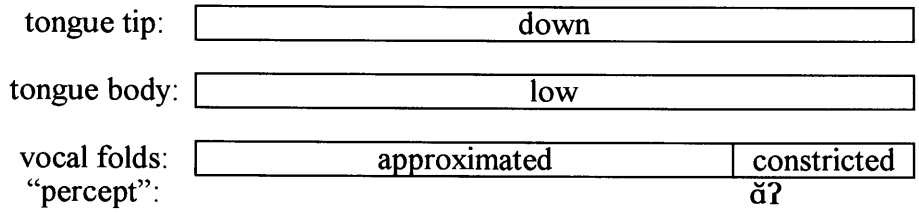
(10) Fortis stop:



It is quite possible that this vowel length distinction has historic origins. At some point, the present-day lenis stop may have been truly voiced in this context, which is usually accompanied by a longer vowel. Upon natural diachronic de-voicing, the vowel length distinction may have been retained, and even exaggerated, to preserve the otherwise jeopardized contrast.

Alternatively in this context, the glottal constriction can take the place of the oral occlusion, as in (11). Here, the tongue tip is down throughout. This configuration mimics the acoustic properties of a voiceless alveolar stop, that is, silence with less pronounced formant transitions than either labials or velars.

(11)



Here, the fortis alveolar stop again is less natural in articulatory configuration, and so again, this environment-specific manifestation maintains the contrast by accommodating to particular articulatorily natural constraints. The natural (unmarked) pattern involves voicelessness, and so the marked value normally involves a moderately less natural laryngeal posture.

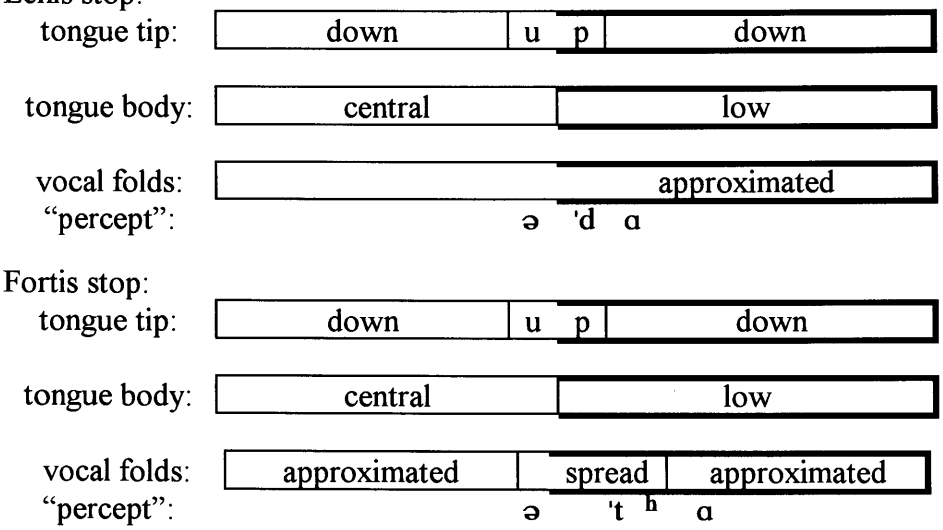
In distinctive theory, again, no functional link may be established between the two syllable- and word-final contrastive alternants. Possible generative feature-changing rules are given in 12.

(12) [voice] → ∅
∅ → [constricted]

Of course, re-characterizing the alternation with optimality-theoretic distinctive feature notation would offer no advantages, as optimality theory is equally incapable of capturing the functional basis for the alternation.

Stressed-syllable-initially, we have what might be regarded as an "embarrassment of riches" scenario: stressed syllables, with their increased energy, duration, and articulatory force, allow for maximally distinct values to be readily implemented. In the displays in (13), stressed domains are indicated with bold outlines. Energy availability is maximal here, so we have voicing versus aspiration, which are at opposite ends of the laryngeal continuum.

(13) Lenis stop:



But note again that the lenis value is the natural value, as voicing is natural for intervocalic stops. Here, the oral closure is typically short enough so that trans-glottal flow does not markedly dissipate. This is especially true for a tap (as opposed to a stop), which is sufficiently short in duration so as to be classified as a sonorant. In contrast, the fortis stop is unnatural, involving aspiration, which is never the most natural sort of stop.

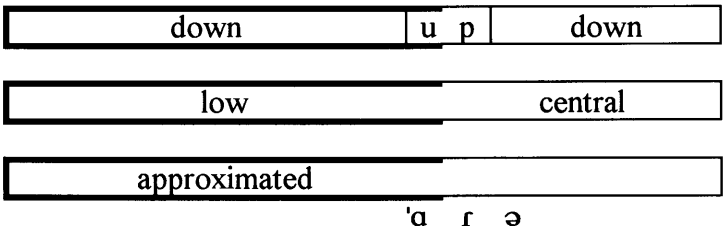
And again, distinctive feature theory would require a rule adding the feature spread in the case of the so-called voiceless stop, without any motivation, as in 14.

(14) ∅ → [spread]

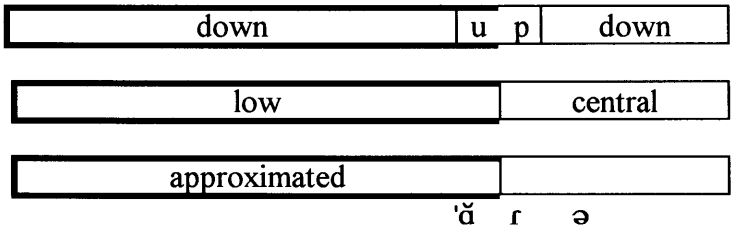
In sharp contrast, intervocalically before a *stressless* syllable is a particularly poor context for laryngeal contrasts to be maintained. While it is true that intervocalic position is excellent for maintaining oral place contrasts, in the context of a following stressless vowel, fewer contrasts are likely. And in the case of laryngeal contrasts, stresslessness tends to induce neutralization.

Now, as we have just observed, voicing is natural intervocalically. Moreover, stresslessness corresponds to a reduction of duration, energy and articulatory force, which establishes a natural environment for (obstruent) stops to turn into (sonorant) taps. Energy availability thus becomes a genuine issue in this context, and so the contrast is difficult to maintain. Not surprisingly, in such energy-deprived contexts, the contrast only barely survives (in vowel length on the *preceding* (*stressed*) vowel); in many dialects, the contrast is lost, and only the natural tap survives. Energy unavailability inhibits a push towards a less natural value for the purpose of maintaining the contrast.

(15) Lenis stop:



Fortis stop:



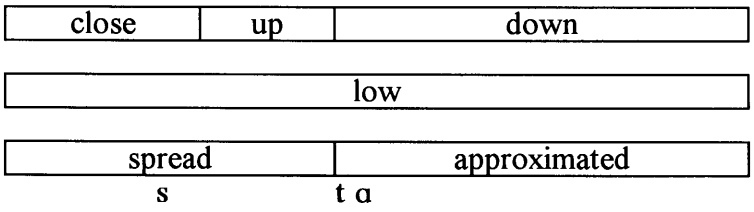
Within distinctive feature theory, we would require an arbitrary and "unnatural" rule which turns oral stops into sonorants.

(16) [-cont] → [+son]

How do such rules capture the functional origin of the alternations? My claim, of course, is that they do not.

Finally, after [s], the fortis-lenis distinction does not exist. Due to the laryngeal articulatory demands of the voiceless sibilant (sustained laryngeal spreading), energy availability becomes the overriding factor here. In (17) is a gestural display.

(17) No contrast:



In summary, consider the table in 18

(18) English alveolar stop alternation:

(a) word-initially:		**(b)** syllable- and word-finally:		**(c)** stressed-syllable-initially:		**(d)** word-internal unstressed syllable initially:		**(e)** preceding s:
t (natural)		t/d̥ (natural)		d (natural)	↘			
⇳		⇳		⇳		(V̆)ɾ (natural)		t (natural)
t^h (unnatural)		V̆t/ V̆ᵛ̃t/ V̆ʔ (unnatural)		t (unnatural)	↗			
Contrast maintenance		Contrast maintenance		Contrast maintenance		Creeping energy availability		Energy availability

*	ð/z (unnatural)		t (natural)	
	⇳		⇳	
	ɾ (natural)	*	t^h (unnatural)	

In cases (18a,b,c), given the sufficient energy availability in these contexts, the fortis-lenis contrast is readily maintained, accommodating to context-specific natural constraints on stop production. In these contexts, the lenis stop is implemented naturally, and sufficient energy may accommodate a push of the fortis stop to a somewhat less natural realization. In (18d,e) however, energy availability becomes an overriding (or almost overriding) factor. In these contexts, the contrast runs the risk of neutralization, as in (18d), or the contrast simply doesn't exist, as in (18e).

Note finally that in (18d), alternation with spirants would provide no functional gain, as ð and z are contrastive in these contexts (e.g., 'lather' vs. 'ladder', 'reason' vs. 'heathen'). Moreover, this contextual manifestation of the contrast would involve the unmarked, or natural lenis stop being realized in a marked fashion (as a spirant), while the marked, unnatural fortis stop would be implemented naturally, as a tap. This sort of contextual allophonic markedness reversal is thus correctly predicted unattested. Nothing in the distinctive feature theory, or, actually, any other theory of which I'm aware, has anything to say about such markedness relations.

3. Corsican and Southern Min

In Corsican (Dinnsen and Eckman 1977), as is rather common in Romance, we see a case of true allophony: there is a voiced-voiceless contrast in word-initial position, while intervocalically, the contrast is one of voiced stop-voiced spirant.

(19) Corsican:

# __ :		V __ V:
Voiceless stops:	⇔	Voiced stops:
peðe 'foot'		u beðe 'the foot'
tengu 'I have'		u dengu 'I have it'
sɑkːu 'bag'		u zɑkːu 'the bag'
⇳		⇳
Voiced stops:	⇔	Voiced fricatives:
bokːɑ 'mouth'		ɑ βokːɑ 'the mouth'
dente 'tooth'		u ðente 'the tooth'
golɑ 'throat'		diɣolɑ 'of throat'

Here, of course, intervocalic spirantization and word-initial voicing maintain the contrast, again, by shifting from a marked voiced stop to another marked value: fricatives, voiced or otherwise, are marked (and presumably involve more effort to properly implement) in comparison to stops; the presence of fricatives in a system implies the presence of stops. Moreover, here, unlike in English, the spirants exclusively alternate with the voiced stops; they do not contrast with them. Spirantization is thus non-neutralizing. So in Corsican, we see a truly allophonic alternation.

Finally, consider the Southern Min tone circle (e.g. Chen 1987). Here, Most sandhi forms are contextually allophonic, that is, non-neutralizing.

(20) Southern Min tone circle:

#		~ #
24	⇔	22
⇳		⇳
22	⇔	21
⇳		⇳
21	⇔	53
⇳		⇳
53	⇔	44
⇳		⇳
44	⇔	22

Only 22 is a (contextually) neutralized value, alternating with both 24 and 44 in the sandhi environment (non-final position). So all values are pushed to alternative realizations in the sandhi context, but almost all contrasts are maintained, regardless of position. I have nothing yet to say about the phonetic properties of tone here, which do not abide by any satisfactory notions of naturalness versus markedness, but a paleophonetic investigation may prove enlightening.

4. Summary and Conclusion

To summarize, allophony may be a consequence of contrast maintenance, given sufficient energy availability. This is an *abstract functional constraint* on phonological patterning. Moreover, neutralization may be a consequence of insufficient energy availability, which is rather uncontroversially characterizable as *a physical functional constraint*. Unmarked values are typically natural values, while marked values are

typically less natural. And these distinctions in naturalness seem to carry over to contextually-conditioned alternants. There thus seems to be a necessary interdependence between abstraction and physicality in order to properly account for patterns of alternation.

Finally, please observe that simply attributing a given alternation—allophonic or neutralizing—to either one of these functional forces results in a fully *non*-predictive theory. Instead, in an explanatory phonology we must investigate in detail the context-specific motivation for one force winning out over the other.

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Daniel Silverman
Department of Linguistics, UIUC
4088 FLB, MC-168
707 Mathews Avenue
Urbana, IL 61801-3625
USA

daniel@cogsci.uiuc.edu