CONTRAST AND LEXICON OPTIMIZATION

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Contrast is fundamental to all aspects of linguistic study. Yet this concept is somewhat difficult to pin down. In taxonomic phonology, discovery procedures were sought to determine contrastive segments by inspection of phonetic forms. A major contribution of generative phonology is that such discovery procedures are not, in fact, determinable, and that contrast can only be determined by the shape of the grammar as a whole. Our contention is that contrast is always relative to the environment. A contrast may exist generally but be neutralized or otherwise not realized in a particular set of environments. On the other hand, a contrast may seem to exist in a restricted set of environments and turn out not to be a real contrast in terms of the overall system. These considerations lead us to reevaluate the claims of recent theories which, like taxonomic phonology, attempt to derive language regularities primarily or exclusively from output phonetic representations.

To demonstrate the gradient nature of contrast, we can start with the clearest examples of contrast. In English, you find minimal pairs showing that the voiceless stops /p/, /t/, and /k/ contrast in many environments, as in (1).

(1)			/p/	/t/	/k/
	a.	*initial*	pin	tin	kin
	b.	*medial*	supple	subtle	suckle
	c.	*final*	hip	hit	hick

However, no contrast is possible between the labial and the velar stops in the second column of (2).

(2)		*contrast*	*no contrast*
	a.	apt	*app
	b.	act	*akp

At the other end of the scale are pairs of segments very nearly in complementary distribution or free variation, and so noncontrastive. A reasonably straightforward example again concerns the voiceless stops in English. In (1) /p/ and /t/ are both realized by an aspirated segment in initial position and by an unreleased segment in final position. Medially, /p/ is realized by a plain [p] and /t/ is realized by a flap [ɾ]. However, even here it is possible to construct minimal pairs showing a contrast between these segments, as in (3) (McCarthy & Prince 1993).

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(3) saw Ted [sɒtʰɛd]
sought Ed [sɒɾɛd]

According to the slogan proposed in taxonomic phonology, "Once a phoneme, always a phoneme," /p/ and /t/ are distinct phonemes since contrasts are found as in (1). However, this slogan also implies that aspirated *t* [tʰ] and flap [ɾ] are distinct phonemes, since they can contrast, as in (3). Most investigators in phonemic theory were reluctant to accept such a conclusion, and sought a variety of solutions in terms of "juncture phonemes" and the like. However, the problem is deeper than that. In fact, between the two extremes we have just discussed, there is a whole range of intermediate cases. We submit that contrast in some environments but not in others is the normal case, not the exception, and must be accommodated in any adequate theory of grammar.

A straightforward case of a fairly general contrast that is lacking in a specific environment is voicing in German obstruents, which are contrastive except in word-final position. Voicing contrasts in stops are shown in (4), while alternations are shown in (5).

(4) trat 'stepped' Draht 'wire'
[tʰʁɑt] [dʁɑt]

(5)

	nom.	*gen.*	
	Rat	Rates	'advice'
	[ʁɑt]	[ʁɑtəs]	
	Rad	Rades	'wheel'
	[ʁɑt]	[ʁɑdəs]	

Because /t/ and /d/ contrast in (4), phonemic theory requires them to be separate phonemes *everywhere,* and the morpheme for 'wheel' has two phonemic forms, or allomorphs. Capturing the relevant generalization within this theory requires setting up a third level, the morphophonemic level, distinct from the phonetic and phonemic levels. But this amounts to an admission that there is no *phonological* generalization.

(6)

Taxonomic analysis	'advice'		'wheel'	
morphophonemic level	//ʁɑt//	//ʁɑt + əs//	//ʁɑd//	//ʁɑd + əs//
phonemic level	/ʁɑt/	/ʁɑt + əs/	/ʁɑt/	/ʁɑd + əs/
phonetic level	[ʁɑt]	[ʁɑtəs]	[ʁɑt]	[ʁɑdəs]

Generative phonology returns the generalization to the phonology by setting up underlying representations that reflect the unpredictable aspects of each morpheme. In particular 'advice' has an underlying /t/ in morpheme-final position while 'wheel' has /d/ in that position. Phonetic [t] can be derived from underlying /t/ or /d/; but from the latter only by a rule that devoices obstruents in word-final position. A variant of the generative approach would allow /t/ to be underspecified.

(7)

Generative analysis	'advice'		'wheel'	
systematic phonemic level	/ʁɑt/	/ʁɑt + əs/	/ʁɑd/	/ʁɑd + əs/
systematic phonetic level	[ʁɑt]	[ʁɑtəs]	[ʁɑt]	[ʁɑdəs]

Devoicing rule: [–son] → [–voice] / ____#

An OT analysis of this case is essentially identical to the generative analysis, with the same phonemic forms but with a constraint instead of a rule.

The most interesting cases are those where there is generally no contrast, but an (apparent) contrast in certain environments. We will discuss four cases of this type. The first concerns vowel nasality in English, discussed by Malécot (1960) and Chomsky (1964). Malécot determined that the principal phonetic distinction between the pairs in (8a) does not reside in the presence or absence of a nasal consonant but in the nasal or oral character of the vowel. In (8b), however, where the vowel in question is followed by a voiced consonant, vowel nasality is entirely a byproduct of the following (phonetically realized) nasal consonant. His investigation included synthetic speech, tape-cutting experiments, and analysis of real speech.

(8)

a.	cap	[kæp]	camp	[kæ̃p]
	hit	[hɪt]	hint	[hĩt]
	buck	[bək]	bunk	[bə̃k]
	capper	['kæpəɹ]	camper	['kæ̃pəɹ]
	batter	['bæɾəɹ]	banter	['bæ̃ɾəɹ]
	tacker	['tækəɹ]	tanker	['tæ̃kəɹ]
b.	cad	[kæd]	canned	[kæ̃nd]
	rabble	['ɹæbəl]	ramble	['ɹæ̃mbəl]
	ladder	['læɾəɹ]	candor	['kæ̃ndəɹ]
	dagger	['dægəɹ]	anger	['æ̃ngəɹ]

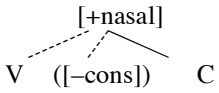
In phonemic theory, such minimal pairs require nasal vowels as distinctive segments of English, however much this jolts native speaker intuitions. However, as Chomsky points out, the fact that this contrast appears only when the vowel is followed immediately by a voiceless stop makes this case susceptible to an analysis with no underlying nasal vowels and two ordered rules, as illustrated in (9).

(9)

Underlying	/kæp/	/kæmp/	/kænd/
Vowel Nasalization	———	æ̃	æ̃
Nasal Consonant Deletion	———	Ø	———
Phonetic representation	[kæp]	[kæ̃p]	[kæ̃nd]

Rules:

Vowel Nasalization



Nasal Consonant Deletion

$$\begin{bmatrix} C \\ +nasal \end{bmatrix} \rightarrow \emptyset \,/\, [\ldots V \_\_\_\_ \begin{bmatrix} C \\ -voice \end{bmatrix} \ldots]_F$$

In discussing the question of vowel nasality in English in an OT framework, Hammond (1999) completely disregards examples such as (8a). He presents four constraints that essentially restrict nasal vowels to the position before phonetically realized nasal consonants, thus accounting for (8b) but not (8a). The rules in (9) apply in a counterbleeding order, creating an opaque derivation that generally causes problems for OT. These problems have the same fundamental cause as in phonemic theory; namely an output (phonetic) orientation. Phonemic theory would seem simply to accept the conclusion that vowel nasality is distinctive in English and let it go at that. OT has an option of invoking Sympathy Theory, essentially a roundabout way of letting intermediate stages of derivation in by the back door.

But OT might not take this option. An important adjunct of OT, though logically independent of the theory of constraint ranking, is Lexicon Optimization, stated by Prince & Smolensky (1993, 192) as in (10).

(10) *Lexicon Optimization (LO)*

> Suppose that several different inputs I_1, I_2, …, I_n, when parsed by a grammar G lead to corresponding outputs O_1, O_2, … O_n, all of which are realized by the same phonetic form Φ — these inputs are all phonetically equivalent with respect to G. Now one of these outputs must be the most harmonic, by virtue of incurring the least significant violation marks: suppose this optimal one is labelled O_k. Then the learner should choose, as the underlying form for Φ, the input I_k.

As Inkelas (1994) observes, LO has the effect of enforcing quite concrete input representations. While her particular focus was on underspecification, which is rejected by LO in general except in cases of alternations, the same effect is observed in cases like (8). LO requires underlying nasal vowels in English in words like *camp,* contradicting the intuitions of native speakers and failing to capture the generalization that such apparently contrastive nasal vowels occur only before voiceless consonants.

It is instructive to compare the English situation with French. Nasal vowels in French are not restricted to a small set of environments, and are generally felt to be distinctive by native speakers. There is some dispute as to whether nasal vowels are derived by rule in French or present underlyingly, but if they are derived by rule, at least in some cases, the case could be made that

the required rules are lexical, whereas in English the rules of (9) are postlexical. In any case, the assumptions of lexical phonology allow a difference between English and French to be expressed with respect to vowel nasality, whereas LO lumps these two languages together as both having underlying nasal vowels.

A second example from English concerns the shortened and raised diphthongs that appear before voiceless consonants in many dialects, as in (11a). When the distinction between voiced and voiceless consonants is neutralized (11b), the raised diphthong appears to be distinctive. Like vowel nasalization, this example is amenable to an analysis with two ordered rules in generative phonology, whereas both taxonomic phonemic theory and OT (assuming LO) would require underlying raised diphthongs.

(11) a.

ride	[ɹɑyd]	write	[ɹəyt]
Tiber	[ˈtʰɑybəɹ]	typer	[ˈtʰəypəɹ]

b.

ride	[ɹɑyd]	rider	[ˈɹɑyɾəɹ]
write	[ɹəyt]	writer	[ˈɹəyɾəɹ]

c. butter [ˈbəɾəɹ]

Rules

Diphthong Shortening

$$V \rightarrow \begin{bmatrix} -\text{low} \\ -\text{ATR} \end{bmatrix} \; / \; [\ldots \_\_\_\_ \; [-\text{cons}][-\text{voice}]\ldots]_{\omega}$$

Flapping

$$\begin{bmatrix} +\text{cor} \\ -\text{strid} \\ -\text{cont} \\ -\text{tense} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{cont} \\ +\text{son} \\ +\text{voice} \end{bmatrix} \; / \; [\ldots[-\text{cons}] \_\_\_\_ \; V \; \ldots \;]_{U}$$

In both examples in (11b) there is an alternation involving a stop and a flap, allowing the flap to be derived here, rather than underlying, according to LO. Presumably, LO would enforce an underlying flap in words like *butter* (11c). But the basic diphthong does not alternate with the raised one in either example of (11b). In *write, writer* we find only the raised diphthong and in *ride, rider* we find only the basic one. LO requires a raised diphthong in the underlying representation of both *write* and *writer*.

Our third example concerns the two *r*-sounds in Spanish, the trill [r] and the flap [ɾ], as analyzed by Harris (1983). These two segments contrast between vowels within words, as shown in (12).

(12) *Contrasting r-sounds between vowels in Spanish*

[r]			[ɾ]		
forro	[ˈforo]	‘lining’	foro	[ˈfoɾo]	‘forum’
perro	[ˈpɛro]	‘dog’	pero	[ˈpɛɾo]	‘but’

In other positions, the two sounds do not contrast. In word-initial position, and in syllable-initial position within a word after a consonant, the trill appears but not the flap (13a). In word-final position, in syllable-final position before a consonant, and after a consonant in the same syllable, the flap appears but not the trill (13b).

(13) a. *Trill, no flap*

Word initial

rojo	[ˈroxo]	‘red’
razón	[rɑˈson]	‘reason’

Syllable initial after a consonant

honra	[ˈonrɑ]	‘honour’
Enrique	[ɛnˈrike]	(name)
alrededor	[ɑlreð̞eˈð̞oɾ]	‘about’

b. *Flap, no trill*

Word final

dar	[ˈdɑɾ]	‘to give’
crecer	[krɛˈseɾ]	‘to grow’

Syllable final before a consonant

perla	[ˈpɛɾ.lɑ]	‘pearl’
fuerte	[ˈfwɛɾ.te]	‘strong’

After a consonant in the same syllable

prado	[ˈpɾɑð̞o]	‘meadow’
frío	[ˈfɾio]	‘cold’

The contrast in (12) forces a phonemic distinction to be made between the flap and the trill in all environments, according to taxonomic theory. In a generative analysis we might assume that the flap is underlying but not the trill and that the flap is converted to a trill by rule (14) (adapted from Harris 1983).

(14) *Trill*

$$\begin{bmatrix} +\text{cons} \\ +\text{son} \\ +\text{cont} \\ -\text{lat} \end{bmatrix} \rightarrow [+\text{HSP}] \; / \; \left\{ \begin{matrix} [+\text{cons}\}\$ \\ \# \end{matrix} \right\} \; \_\_\_$$

Harris notes that this rule may be marginally involved in alternations, although it is difficult to find convincing examples. He suggests the examples of (15), although the synchronic relations of the two columns may be open to question.

(15)	[r]		[ɾ]	
	rec+titud [rɛkti'tud]	'uprightness'	e+rec+ción [ɛɾɛk'syon]	'erection'
	rup+tura [rup'tuɾɑ]	'rupture'	e+rup+ción [ɛɾup'syon]	'eruption'
	rub+or [ru'β̞oɾ]	'blush'	e+rub+escente [ɛɾuβ̞ɛsɛnte]	'blushing'
	ro+er [ro'ɛɾ]	'to eat away'	e+ro+sión [ɛɾo'syon]	'erosion'
	rud+o ['ruð̞o]	'stupid'	e+rud+ición [ɛɾuð̞i'syon]	'erudition'

Going back to the examples in (12), do we need to acknowledge an underlying trill in the intervocalic context? Can we extend rule (14), which derives a trill in contexts where it does not contrast with flap, to contrastive contexts as well? Harris proposes that the trill between vowels is derived from a sequence of two flaps. It is not feasible to say that the trill is phonetically a sequence of flaps, since this would amount to the claim that there is a sequence of two flaps in syllable-initial position at the beginning of words or after a consonant (16), which would violate well motivated syllable structure constraints in Spanish.

(16)	rojo	['roxo]	*['ɾɾoxo]	'red'
	honra	['onrɑ]	*['onɾɾɑ]	'honour'

Neither [ɾɾ] nor [nɾ] is a possible onset cluster, nor is [nɾ] a possible syllable-final cluster. Phonetically, we have a single segment, trill [r], in (16), derived from an underlying flap /ɾ/ by rule (14).

Harris notes that there is no distinction phonetically between a trill and a sequence consisting of a flap followed by a trill; that is, the latter is converted into a trill only and the phrases in (17) are identical with respect to the *r*-sounds.

(17)	salí rápido	[sɑ'liˈrɑpiˌð̞o]	'I left rapidly'
	salir rápido	[sɑ'liˈrɑpiˌð̞o]	'to leave rapidly'
	gamba rara	['gɑmbɑ'rɑɾɑ]	'strange shrimp'
	ámbar rara	['ɑmbɑ'rɑɾɑ]	'strange amber'

To account for this, Harris proposes a rule of Flap Deletion (18).

(18) *Flap Deletion*
ɾ → Ø / ____ (#) r

Given rules (14) and (18), the apparently contrastive trill in words like *forro* 'lining' is derived as in (19). For comparison we give the derivation of *onra* 'honour,' where the trill is in a noncontrastive position.

(19)	underlying	/foɾɾo/	/onɾɑ/
	(14)	foɾro	onrɑ
	(18)	foro	————
	phonetic	[foro]	[onrɑ]

Harris points out that there is no reason not to expect underlying representations containing a sequence of two flaps, which would be an unexplained gap if the phonetic trill had to be analyzed as an underlying trill /r/ distinct from the underlying flap /ɾ/. The flap regularly occurs in syllable-final position before a variety of consonants, as in (20).

(20)	arpa	['ɑɾpɑ]	'harp'
	árbol	['ɑɾbol]	'tree'
	arte	['ɑɾte]	'art'
	sarna	['sɑɾnɑ]	'scabies'
	Carlos	['kɑɾlos]	(name)
	marcha	['mɑɾčɑ]	'departure'
	arco	['ɑɾko]	'bow'

It also occurs in syllable-initial position between vowels, as in (21). The flap occurs underlyingly in syllable-initial position after a consonant and word-initially (13a). It would be surprising if no underlying representations existed with two consecutive flaps, one that can be syllable final and one that can be syllable initial, in conformity with the principles of Spanish syllabification.

Harris's analysis explains main stress placement in (21c,d), which involves flap and trill. Main stress in Spanish can appear on the antepenultimate syllable only if the penultimate syllable is light, that is, ends in a simple vowel (not a diphthong), as in (21a) The hypothetical words in (21b), where the penultimate syllable ends in a consonant, cannot be stressed on the antepenult. In (21c) antepenultimate stress is possible when the penultimate syllable is open before a flap, while in (21d) such stress is impossible in hypothetical words with a trill in this position.

(21)	a.	teléfono	[tɛ'lɛfono]	'telephone'
		número	['numɛɾo]	'number'
	b.	*teléfosno	[tɛ'lɛfosno]	
		*númelro	['numɛlɾo]	
	c.	cámara	['kɑmɑɾɑ]	'chamber'
		víbora	['biβ̞oɾɑ]	'viper'
	d.	*cámarra	['kɑmɑrɑ]	
		*víborra	['biβ̞oɾɑ]	

(21c, d) are parallel to (21a, b) if, at the point where stress is assigned, the trill in intervocalic position in (21d) is repesented as a sequence of two flaps. Since the penultimate syllable is closed by a flap, antepenultimate stress is prevented.

Harris's analysis also explains the irregular future tense of the verb *querer* 'to want.' Regular verbs form the future tense by adding person-number endings to the infinitive, as in (22a). Certain irregular verbs lose the vowel of the infinitive in the future, such as *poder* 'to be able' (22b), whose future stem is suppletive /podɾ/, rather than /podɛɾ/. We can similarly analyze the future stem of *querer* as suppletive /kərɾ/, with a sequence of two flaps which surface as an intervocalic trill (compare the infinitive /kɛɾɛɾ/), thus avoiding an otherwise unattested suppletive future /kɛr/.

(22)	a.	comer	[koˈmɛɾ]	'to eat'
		como	[ˈkomo]	'I eat'
		comeré	[komɛˈɾe]	'I will eat'
	b.	poder	[poˈð̞ɛɾ]	'to be able'
		puedo	[ˈpweð̞o]	'I can'
		podré	[poˈdɾe]	'I will be able'
	c.	querer	[kɛˈɾɛɾ]	'to want'
		quiero	[ˈkyɛɾo]	'I want'
		querré	[kɛˈre]	'I will want'

A fourth example comes from Modern Icelandic. In Icelandic, velar stops are palatalized before front unround vowels, as in (23). Under LO, the stops are unspecified for place. (Data is from Árnason 1978). The vowel spelled /æ/, phonetically a low back rising diphthong [ɑi], is assumed to be an underlying low front vowel /æ/.)

(23)	a.	kemur	[cʰɛːmʏr]	'comes' (3sg)
		(koma	[kʰɔːmɑ]	'to come')
	b.	geta	[ʝ̊ɛːtʰɑ]	'to be able to'
		(gat	[gɑːtʰ]	'could' (3 sg))
	c.	sekir	[sɛːcʰɪr]	'guilty' (m.pl.nom.)
		(sekar	[sɛːkʰɑr]	'guilty'(f pl nom))
	d.	gæti	[ʝ̊ɑiːtʰɪ]	'he could' (subjunctive)
		(gátum	[gɑuːtʰʏm]	'we could' (indicative))
	e.	kýr	[cʰiːr]	'cow' (nom sg)
		(kú	[kʰuː]	'cow' (acc/dat sg))

Patalal stops also appear before front unround vowels in nonalternating examples, as in (24).

(24)	a.	kíkir	[cʰiːcʰɪr]	'field glass'
	b.	kista	[cʰɪstɑ]	'chest'

c.	gæfa	[ʲɟaiːvɑ]	‘good luck’
d.	Gísli	[ʲɟislɪ]	(proper name)
e.	kær	[cʰɑiːr]	‘dear’
f.	gera	[ʲɟɛːrɑ]	‘to do’
	(gerði (preterite); gerður (past participle))		
g.	kenna	[cʰɛnːɑ]	‘to teach’
	(kenndi (preterite); kenndur (past participle))		

Under LO, the initial stops in (24) are underlying palatals. The minimal pairs in (25) (from Árnason 1978), with palatal stops in nonpalatalizing environments, would seem to support the claim that palatal stops are phonemic.

(25)	a.	kjör	[cʰœːr]	‘election’
		kör	[kʰœːr]	‘old age’
	b.	kjara	[cʰɑːrɑ]	‘lot’ (gen.pl.)
		Kara	[kʰɑːrɑ]	(proper name, fem.)
	c.	gjarna	[ʲɟɑrd̥nɑ]	‘willingly’
		garna	[ɡ̊ɑrd̥nɑ]	‘intestines’ (gen.pl.)

However, the phonetically palatal stops in *kjör*, *kjara*, and *gjarna* (25) can alternatively be analyzed as underlying sequences of velar stop plus palatal glide /y/. Velar stops palatalize before stem-forming *-j,* as in (26). (Geminate stem-final *g* in *leggja* is regular, as well as fricativization of the velar stop before an obstruent.)

(26)	a.	vek-j-a	[vɛːcʰɑ]	‘to awaken’
		(vak-ti	[vɑxtɪ]	(preterite sg))
		(cf. vaka ‘to be awake’)		
	b.	legg-j-a	[lɛʲɟːɑ]	‘to lay’
		(lagði	[lɑɣðɪ]	(preterite sg))

Stem-forming *-j* forms present stems, as in (27).

(27)	a.	tel-j-a ‘to count’	
		(tal-di ‘counted’ (pret sg)	tal-inn (past participle))
	b.	sit-j-a ‘to sit’	
		sat ‘sat’ (pret sg)	set-inn (past participle)

Allowing underlying sequences of velar stop plus /y/ (phonetically realized as palatal stops) fills a distributional gap, since /y/ otherwise occurs after labial and coronal stops, as in (28) (Árnason 1978).

(28)	a.	/py/	pjatla	[pʰyɑʰtlɑ]	‘patch’
	b.	/by/	bjartur	[b̥yɑr̥d̥ʏr]	‘bright’
	c.	/ty/	tjald	[tʰyɑld̥]	‘tent’
	d.	/dy/	djarfur	[d̥yɑrvʏr]	‘daring’

e.	/ky/	kjaftur	[cʰɑfʧʏr]	‘snout’
f.	/gy/	gjalla	[ʃɑʤlɑ]	‘yell’

With this analysis, we can avoid postulating suppletive infinitive stems in (29), where velar stops appear in the past, and palatal stops in the present, and consider all the stems in the paradigm to begin with a velar stop, while the infinitive has a *-j-* added in the onset.

(29)	a.	kjósa	[cʰouːsɑ]	‘to choose’
		kaus	[kʰœys]	‘chose’ (pret sg)
		kosinn	[kʰɔːsɪn]	(past participle)
	b.	gjósa	[ʃouːsɑ]	‘to gush’
		gaus	[ɣœyːs]	‘gushed’ (pret sg)
		gosinn	[ɣɔːsɪn]	(past participle)
	c.	gjalda	[ʃɑlʤɑ]	‘to pay’
		galt	[ɣɑlt]	‘paid’ (pret sg)
		goldinn	(past part)	

In this analysis, palatalization applies within stems as well as before endings, and the nonalternating instances of palatal stops are derived from velar stops (unspecified for place) in a palatalizing environment.

Evidence from acquisition may provide support for analyzing palatal stops as underlying sequences of velar stop plus palatal glide. Guðfinnsson (1964), cited in Orešnik (1977), reports that children sometimes produced velar stops instead of palatal stops in palatalizing environments, in the words in (30).

(30)	a.	gengið	‘went’ (past participle neut)
	b.	kyngja	‘to swallow’
	c.	gefa	‘to give’
	d.	ekki	‘not’
	e.	kindurnar	‘sheep’ (def pl)
	f.	ákefð	‘eagerness’

Guðfinnsson also found that children vacillated between velar and palatal stops in stems before the suffix *-elsi* in (31). Velar stops are regularly palatalized before this suffix.

(31)	a.	reykelsi	‘incense’	(reykur ‘smoke’)
	b.	fangelsi	‘prison’	(fanga ‘to capture’)

Since these were reading tests, there may have been interference from spelling—although most of the words in (30) are very common. Nevertheless, this may suggest that these children had not internalized these words with underlying palatal stops. More acquisition studies are needed.

Conclusion

LO enforces concrete inputs in a constraint-based grammar, because faithfulness constraints are violated less to the extent that inputs resemble outputs. In this respect it resembles previous restrictions on the abstractness of underlying representations, such as Kiparsky's (1968, 130) alternation condition (32).

(32) One of the effects of restricting phonology like this is to enter nonalterating forms in the lexicon in roughly their autonomous phonemic representations. That is, if a form appears in a constant shape, its underlying representation is that shape, except for what can be attributed to low-level, automatic phonetic processes. These can be defined as processes which do not cause neutralization of distinct representations. For example, the vowel shift of English, or the loss of final /g/ in *sing,* are low-level automatic phonetic processes, since the underlying form is in each case recoverable from the phonetic form.

Inkelas (1994) shows that LO requires full specification of nonalternating information in inputs; underspecification is excluded except in cases of alternation. She refers to such low-level automatic phonetic processes in a footnote (p. 15) (33).

(33) A natural question is whether even allophonic, "low-level" nonalternating structure, such as aspiration in English, should be prespecified. I have no answer at present other than to observe that there might be some general, inviolable constraint against the presence of such information in the lexical…component of the grammar.

It is clear from her discussion, however, that LO *does* require (pre)specification of such low-level information. There are three reasons to reject such a constraint. First, OT generally does not allow constraints on inputs. Furthermore, aspiration is distinctive in some languages like Hindi and Thai, so such a constraint could not be completely general or inviolable. Third, even such "low-level" processes may be involved in alternations, such as (34).

(34) atom [ˈærəm]
atomic [əˈtʰɒmɪk]

In cases such as (34) aspiration and flapping could be unspecified, but it would still need to be specified in nonalternating words like *Ted,* or *Adam*. We need to ask what the criteria are for "low-level" processes. In a rule-based grammar it is possible to determine which segments (or underspecified units) need to be present in underlying representations; rules producing other segments are low level. In a constraint-based grammar that assumes LO, all phonetic detail not involved in alternations is forced into the input representations. Under these conditions it is not possible to determine from input representations which

segments or features are contrastive in a given language. Languages exhibit regularities, some of which cannot be determined by inspecting minimal pairs in isolation. Some language regularities appear in underlying and intermediate representations. Like taxonomic phonology, OT attempts to determine all regularities from outputs, forcing much that is not distinctive into inputs. If one of the tasks of a grammar is to express contrasts, this would appear to be an incorrect prediction.

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