FOOT, WORD, AND LARYNGEAL FEATURES IN ENGLISH AND ICELANDIC

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1. Introduction

The relation between phonetics and phonology has long been controversial. While it is generally agreed that phonology must be based on phonetics, linguists differ on the extent to which nonphonetic constructs are available to phonology, whether it is more abstract, nonphonetically realized underlying representations or abstract organizational structure. An extreme view on the one hand is expressed by Bybee (2001), who rejects abstract representations and claims that words are listed in phonetic form, including fine phonetic detail, and that such listing is necessarily highly redundant. See (1) and the similar sentiments by Ohala in (2).

(1) "Mental representations of linguistic objects have the same properties as mental representations of other objects…Generalizations over forms are not separate from the stored representations of forms but emerge directly from them…there is no 'rule/list separation'" (Bybee 2001, 7).

(2) "For the sake of explaining natural sound patterns there are advantages to representations using phonetic primitives—advantages not found in other currently popular phonological representations" (Ohala 1990, 267).

On the other hand, compare the statements in (3) and (4).

(3) "…phonology is not necessarily natural…and there is no reason to expect that all of its constructs should have simple physical parameters" Ladefoged (1990, 403).

(4) Hale & Reiss (2000, 162) "believe that phonology consists of a set of formal properties…that are modality independent and thus not based on phonetic substance. Failure to appreciate this goal has resulted in rampant 'substance abuse' in the phonological community."

As a first approximation, we list (5) some of the properties that may differentiate phonological from phonetic studies (based on Myers 2000).

Laryngeal features are a good testing ground for distinguishing phonological from phonetic phenomena. These features include designations for

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voicing, aspiration, glottalization, implosion, and tone. An influential proposal for laryngeal features is found in Halle & Stevens (1971), which we give in (6).[1]

(5)	Phonology	Phonetic
	Sensitivity to prosodic categories	no
	sensitivity of morphological categories	no
	categorial	gradient
	sensitivity to morpheme boundaries	no
	sensitivity to lexical exceptions	no
	no	sensitivity to gradient factors (e.g., F_0 of preceding high tone in downdrift
	no	sensitivity to speech rate
	no	sensitivity to "careful" vs fast speech
	no	sensitivity to anatomical differences among speakers
	arbitrary rules	no
	may have different/several phonetic correlates	has phonetic "cause"

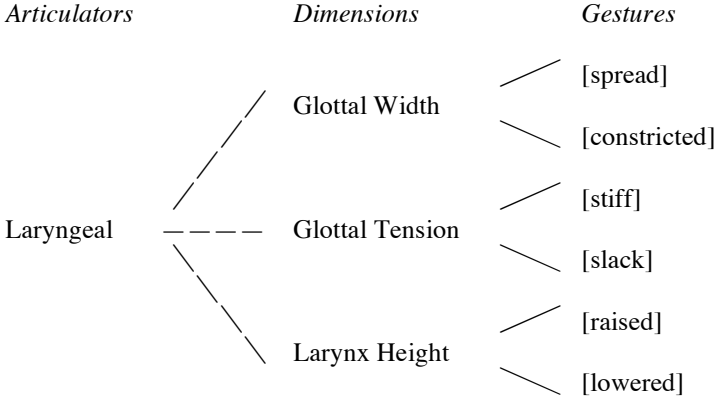
(6) *Distinctive features for glottal state*

	1	2	3	4	5	6	7	8	9
obstruents	b$_1$	b	p	p*	b^h b̤	p^h	ɓ	ʔb	p’
glides	w, y				fi	h, ẉ, y̤		ʡ	ʔ, ʔw, ʔy
vowels	V (mid tone)	V̀ (low tone)	V́ (high tone)	voiceless vowels ḁ	breathy vowels a̤			creaky voice vowels a̰	glottalized vowels aʔ
spread glottis	–	–	–	+	+	+	–	–	–
constricted glottis	–	–	–	–	–	–	+	+	+
stiff vocal folds	–	–	+	–	–	+	–	–	+
slack vocal folds	–	+	–	–	+	–	–	+	–

[1]The symbol b$_1$ represents a lax voiceless stop as in Danish; the symbol p* represents the moderately aspirated stop of Korean; the symbol ʔb represents a preglottalized b (no examples given in Halle & Stevens).

Avery & Idsardi (2001) propose a modification of this scheme, where the laryngeal articulator is regarded as having three dimensions, each of which is associated with two gestures. We give their geometry of laryngeal configurations in (7). They claim that only dimensions are relevant to phonological distinctions, not gestures.

(7)



The first question is whether this proposal is sufficient to make all the required distinctions that are observed in different languages. Under their proposal English and Spanish differ in the distinctive features for stops. In English, it is GW, which is realized as aspiration, in contrast with an unmarked stop, realized as unvoiced but unaspirated. In Spanish, it is GT, distinguishing a fully voiced stop from one that is unvoiced but unaspirated. Languages like Thai and Hindi make use of both GT and GW, distinguishing voiceless aspirated from voiceless unaspirated stops, with Hindi exhibiting also a voiced aspirated stop. K'ekchi distinguishes voiceless glottalized from plain voiceless, while Hawaiian has no laryngeal distinctions. We give their feature scheme for the stops in these languages in (8), from Iverson & Salmons (2003, 46). Empty brackets [] in the first column represent the laryngeally unmarked phonemic type.

(8)

	/p~b̰]	/b/	/pʰ/	/p'/	/bʰ/
Hawaiian	[ ]				
K'ekchi	[ ]			LH	
Spanish	[ ]	GT			
English	[ ]		GW		
Thai	[ ]	GT	GW		
Hindi	[ ]	GT	GW		GT,GW

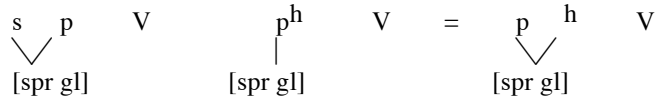
Additional contrasts are captured with other combinations. I&S (1995, 383) suggest some features for Beja, which contrasts ejectives and voiced implosives,

in addition to the contrasts found in Hindi. We have modified this minimally to conform to Avery & Idsardi's representations.[2]

(9)	Beja	/p/	/b/	/pʰ/	/bʰ/	/p'/	/ɓ/
		[ ]	GT	GW	GT,GW	LH	GT,LH

Iverson & Salmons (1995), referring to Kim (1970), suggest that phonetic aspiration is present before a vowel in initial position but is suppressed after [s] in a cluster in English because the [spr gl] feature is shared between the fricative and the stop, as in (10). The [spr gl] (or GW) is realized as aspiration in the singleton, but runs out, as it were, before stop release in the cluster.

(10) a. *Cluster* b. *Singleton*



The criteria that we suggest for underlying features include the following:

(11) a. Consistence: the same feature difference is underlying in all positions
b. Pattern congruity: all obstruents have the same underlying feature distinction
c. Patterns of assimilation

Iverson & Salmons suggest that fricatives, as well as stops, contrast in aspiration (SG) in English (and Germanic generally, except Dutch). Their argument is that this allows a unified treatment of stop deaspiration after fricatives, and sonorant devoicing after stops and fricatives. They claim that both of these represent a sharing of [SG] by the two segments involved, as in (10). However, fricatives do not contrast phonetically in aspiration in English, though such a contrast exists in Burmese (for example):

(12) *Burmese fricatives (Ladefoged and Maddieson 1996, p. 179)*

Voiced:	zà	'lace'
Voiceless unaspirated:	sà	'to be hungry'
Voiceless aspirated:	sʰà	'letter'

In Burmese aspirated fricatives contrast with unaspirated. They cannot be analyzed as clusters. Clusters are very restricted in Burmese; /sʰ/ is represented by a single symbol in the orthography.

Vaux (1998) discusses some possible phonological evidence for [+spread] as the distinctive feature for voiceless fricatives in the New Julfa

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[2]Iverson & Salmons (1995) give [constricted glottis, voice] for either /b̰/ (creaky voice) or /ɓ/; it is not clear which is intended for Beja.

dialect of Armenian. This dialect has a four-way laryngeal contrast in the stops and affricates, like the Hindi stops in (8). Fricatives show only a two-way contrast, that would traditionally be referred to as voiced and voiceless. The future prefix, underlying /k/, added to the present subjunctive, assimilates in voicing and aspiration to a following consonant, as in (13) (Vaux 1998, 498).

(13)	*underlying*	*phonetic*	*gloss*
a.	k-ert^{h}-a-m	kert^{h}am	'I will go'
b.	k-bzz-a-m	gəbəzzam	'I will buzz'
c.	k-l-am	gəlam	'I will cry'
d.	k-zɾ-a-m	gəzəɾam	'I will bray'
e.	k-t^{h}oʁ-n-ie-m	k^{h}ət^{h}oʁniem	'I will allow'
f.	k-savor-ie-m	k^{h}əsavoriem	'I will grow accustomed to'
g.	k-b^{h}ier-ie-m	g^{h}əb^{h}ierriem	'I will carry'

Vaux attributes this assimilation to the spreading of the laryngeal node, dominating both [spread glottis] and [stiff vocal folds] (in Avery & Idsardi's terms, GW and GT). This assimilation rule is followed by a rule that inserts schwa after unsyllabified consonants. This pattern of assimilation raises some questions. One is what is the difference between 'sharing' a feature as in (10), where the shared [spr gl] prevents aspiration of the stop after [s], and 'spreading' of the laryngeal node in (13), which results in aspiration in two places in (13e). A second question arises with respect to the inserted vowel, which would seem to be necessary for the spread aspiration to be realized, at least when a fricative follows, as in (13f).

The evidence presented by I&S and Vaux for underlying aspiration for English stops and fricatives seems inconclusive. So we suggest that the distinction in English is the feature [voice] (or GT), the same as Spanish, for both stops and fricatives and that aspiration ([spread], GW) is not distinctive in either language. The realization of the two values is different in the two languages by language-particular phonetic implementation (which is also systematic).

2. Aspiration in English not directly dependent on stress.

Iverson & Salmons (1995, 378) claim that the degree of aspiration in English correlates with the degree of stress. They cite Kim's (1970) pioneering work on laryngeal phonetics, in which he claims that

(14) "it seems to be safe to assume that aspiration is nothing but a function of the glottal opening at the time of release" (Kim 1970, 111).

Iverson & Salmons identify the location of aspiration in English as the beginning of a stress foot. We claim that this insight is basically correct, but with a revised conception of the foot, defined as in (16). Unstressed syllables are

Chomsky adjoined to an adjacent foot, such as the initial syllables of *terrain, potato,* in (15).

(15)

time	[t^h]ime	terrain	[t^h]errain
typhoon	[t^h]yphoon	potato	[p^h]otato

(16) Foot (definition): a prosodic unit consisting of one or more syllables, of which one (and only one) is stressed.

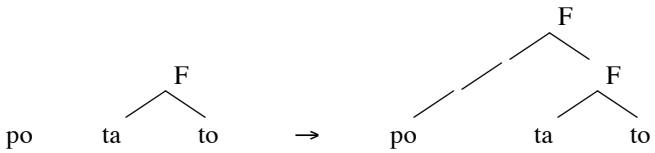
There are also cases where aspiration appears at the beginning of word-internal unstressed syllables, as in (17).

(17)

òppor[t^h]unístic	àbra[k^h]adábra
mìli[t^h]arístic	Mèdi[t^h]erránean

We follow Withgott (1982) in assuming that, when two unstressed syllables arise between stressed syllables (say, as a result of destressing), they are adjoined one to each side. This accounts for aspiration in (17). Chomsky-adjunction is illustrated in (18) with *potato*.

(18)



3. Aspiration is not distinctive in English

Lisker and Abramson (1964) propose voice onset time as an acoustic measure that correlates with aspiration. They justify this by pointing out that the noise heard as aspiration occurs during the period of voicelessness between the release of the stop and the start of voicing of the following vowel, as in (19).

(19) "Aspiration…is regarded simply as a large delay in voice onset." (Lisker and Abramson 1964, p. 387).

"…the feature of aspiration is directly related to the timing of voice onset…" (Lisker and Abramson 1967, p. 15).

Kim (1970) proposes that the voicing delay after voiceless stops is due to the narrowing of the glottis before voicing starts, as in (20).

(20) "…the length of aspiration or voicing lag appears to be equal to the time it takes for the open glottis to close for the vibration of the following vowel." (Kim 1970, p. 109)

In a cineradiograhic study of Korean stops, Kim measured both voice onset time and glottal opening for each type of stop. Korean stops are distinctive for 3 degrees of aspiration, as in (21). Voice onset times for each phoneme are given in (21). Note that the three degrees of aspiration are widely separated by voice onset time. Note also that all the consonants have a positive voice onset time, including the unaspirated voiceless stops. That is, even for unaspirated stops, voicing does not begin immediately upon the stop release, but there is a period of voicelessness — though small — between the release and the start of voicing.

(21) Voiceless stops in Korean: 3 distinctive degrees of aspiration (Kim 1970, p. 108)

Unaspirated	/p'ali/	'washer'	/t'al/	'daughter'	/k'ali/	'villain'
Slightly aspirated	/pal/	'leg'	/tal/	'moon'	/kali/	'stack'
Heavily aspirated	/p^{h}al/	'arm'	/t^{h}al/	'mistake'	/k^{h}al/	'knife'

		Voice onset time
Unaspirated	(/p'/, /t'/, /k'/)	10 msec
Slightly aspirated	(/p/, /t/, /k/)	35 msec
Heavily aspirated	(/p^{h}/, /t^{h}/, /k^{h}/)	90 msec

Voiceless unaspirated stops of Puerto Rican Spanish—a Romance language—also have a small voice delay of 0–55 msec (average 14msec) (Lisker and Abramson 1964, 392).

Kim's measurements of glottal opening of stops in Korean (22) show a direct correlation with voice onset time as measured in (21). Notice that the glottis is never completely closed, even for unaspirated stops.

(22) Voiceless stops in Korean: approximate degree of glottal opening (in millimetres) (Kim 1970, p.110)

Unaspirated		*Slightly aspirated*		*Heavily aspirated*	
/p'/	1 mm	/p/	3.5 mm	/p^{h}/	10 mm
/t'/	2 mm	/t/	3.5 mm	/t^{h}/	9.5 mm
/k'/	1 mm	/k/	3 mm	/k^{h}/	10 mm

Lisker et al. (1969) did a transillumination study of the larynx in connected speech in English, which measured the light being transmitted through the glottis as it opened. The amount of light transmitted correlates directly with the degree of opening of the glottis. In the example sentence in (23), the three stops at the beginning of stressed syllables—/p/ in *put*, /t/ in *tape*, and /t/ in *tube*—show successively larger glottal openings, corresponding to the increase in stress. Main sentence stress is on *tube*, which has the largest glottal opening. The unstressed /p/ in *tape* preceding the unstressed vowel of *around* has a very small glottal opening. We suggest that the /p/ in *tape* is unaspirated or only slightly aspirated.

(23) Don't 'put a dirty 'tape around the 'tube. (Lisker et al. 1969, 1545)
[p]

Lisker and Abramson (1964, 1967) measured average voice onset time for stressed initial stops in isolated words in English (24). The voiced stops divide into two discontinuous groups, some with negative voice onset time, and some with positive voice onset time. The ranges of the voiced and voiceless stops in each homorganic pair do not overlap. Lisker and Abramson conclude that (the measure of) voice onset time serves to distinguish each homorganic pair — /b/ from /p/, /d/ from /t/, and /g/ from /k/.

(24) Stressed initial stops in isolated words in English
Mean voice onset time in msec. (Lisker and Abramson (1967), p. 6)

	/b/		/p/	/d/		/t/	/g/		/k/
Average	–101	1	58	–102	5	70	–88	21	80
Number	17	51	102	13	63	116	13	53	84

	/b/	/p/	/d/	/t/
Range:	–130:–20 / 0:5	20:120	–155:–40 / 0:25	30:105

/g/	/k/	
–150:–60 / 0:35	50:135	(Lisker and Abramson 1964, p. 394)

Lisker and Abramson (1967) measured voice onset time for stops in sentence contexts in English (25). They included stressed and unstressed voiced and voiceless stops in initial and non-initial position. They broke down the measurements into values for stressed and unstressed stops. They found first, that unstressed /p, t, k/ tend to have shorter delays in voice onset than do stressed /p, t, k/. Second, those voiced stops with positive voice onset time tend to have longer delays in voice onset in unstressed than in stressed position. Consequently, the voiceless and voiced stops are less clearly separated when unstressed than when stressed. The ranges show overlap in both stressed and unstressed position for voiceless stops and those voiced stops with positive values, indicating that the voicing lag does not clearly separate voiced from voiceless stops. They note, however, that they did not include in the chart the many ("nearly all", p. 18) instances of non-initial /b, d, g/ that are voiced throughout. We might conclude that in sentences, voiced and voiceless stops are generally distinguished by voicing rather than by voicing lag or "aspiration."

(25) Stressed and unstressed stops in sentences (English)
Mean voice onset time in msec. (Lisker and Abramson (1967), pp. 12-14)
(Initial versus non-initial position did not make a significant difference.)

		General		Stressed		Unstressed	
/p/	Average	34		35		34	
	Range	15:75		15:70		15:80	
	Number	168		130		38	
/b/	Average	–61	10	–62	10	–50	10
	Range	–130:–20 / 0:35		–130:–20 / 0:35		–50:–50 / 0:30	
	Number	20	50	19	36	1	14
/t/	Average	45		48		40	
	Range	10:120		15:90		15:120	
	Number	165		96		69	
/d/	Average	–50	12	–49	10	–55	15
	Range	–80:–15 / 0:20		–80:–15 / 0:20		–55:–55 / 0:20	
	Number	8	57	7	34	1	23
/k/	Average	53		55		45	
	Range	20:85		20:80		20:80	
	Number	144		123		21	
/g/	Average	–73	20	–77	20	–66	21
	Range	–160:–10 / 0:40		–160:–30 / 0:40		–110:–30/ 0:40	
	Number	12	40	8	24	4	16

We conclude that aspiration in English is categorial (phonological) in foot-initial position. In phonetic implementation there may be some aspiration in other positions. This is gradient and phonetic, not phonological. Voiceless and voiced stops may be distinguished by aspiration in foot-initial position in isolated words, but in running sentences, they are generally distinguished by other cues, such as the unbroken voicing of voiced stops between vowels.

In Icelandic, by contrast, stops are distinctive for aspiration, and are always voiceless (26).

(26) a. panna [pʰanːa] ‘pan’
banna [panːa] ‘forbid’

b. tala [tʰaːla] ‘speak’
dala [taːla] ‘valley (gen pl)’

c. kaldur [kʰaltʏr] ‘cold’
galdur [kaltʏr] ‘magic’

Unaspirated stops are always voiceless, even between vowels (27).

(27) a. Icelandic *aldur* [ɑltʏr] ‘age’; compare English *alder* [ɔldɚ]
b. Icelandic *Líbanon* [liːpɑnɔn]; compare English *Lebanon* [lɛbənɑn] (Bérkov (1962))
c. Icelandic *túba* [tʰuːpɑ]; compare English *tuba* (Rögnvaldsson 1989, p. 29)
d. Icelandic *sígaretta* [siːkɑrɛhtɑ]; compare English *cigarette* (Rögnvaldsson 1989, p. 29)

In the southern dialect, aspirated stops neutralize with unaspirated stops in non–word-initial position (28). Both are voiceless unaspirated in this context.

(28) a.	Southern (Reykjavík)		b.	Northern (harðmæli)	
	api	[ˈɑːpɪ]		[ˈɑːpʰɪ]	‘ape’
	hata	[ˈhɑːtɑ]		[ˈhɑːtʰɑ]	‘to hate’
	loka	[ˈlɔːkɑ]		[ˈlɔːkʰɑ]	‘to close’
	gata	[ˈkɑːtɑ]		[ˈkɑːtʰɑ]	‘street’
	sápa	[ˈsauːpa]		[ˈsauːpʰa]	‘soap’
	taka	[ˈtʰɑːkɑ]		[ˈtʰɑːkʰɑ]	‘take’

4. Sonorant Devoicing

Kim observed (1970, 114) that, in a syllable-initial cluster of /s/ plus a voiceless stop, the glottis is open to the same degree as for a syllable-initial stop alone, but that, by the time /p/ is released the glottis has narrowed so that the voicing for the following vowel begins immediately after /sp/ instead of after a lag as after /p/. This provides a phonetic explanation for the lack of aspiration in /s/ plus stop clusters. Our phonological interpretation is that voiceless stops after /s/ in such cases are not foot initial, so they fail to aspirate for the same reason as voiceless stops in other foot-internal positions, as in (29).

(29)				
sting	s[t]ing	satyr	sa[ɾ]yr
abstain	abs[t]ain	hospital	hospi[ɾ]al
after	af[t]er	night owl	nigh[ɾ] owl

Iverson & Salmons interpret this autosegmentally as a single gesture [spread glottis] as in (10) above.

I&S claim that sonorant devoicing also falls under this generalization. Sonorants are devoiced after voiceless stops in (30) (I&S 1995, 373; their transcriptions).

(30) plan [pl̥æ̃n] crow [kɹ̥o]

Iverson & Salmons treat this phenomenon in the same way as aspiration; that is, with a sharing of the feature [spread glottis] within the cluster. However, devoicing of sonorants is fairly clear after stops in the same syllable, whether or not the stop is aspirated. Sonorants are devoiced after unaspirated stops in (31).

(31)

apricot	ap[ɹ̥]icot	Islip	Is[l̥]ip
acclimate	acc[l̥]imate	Cremona	C[ɹ̥]emona

Lehiste (1964, 77) provides a spectrogram of *hatred* which shows voiceless *r* following *t*. But there is no devoicing of sonorants that follow a voiceless stop in another syllable, as in (32).

(32)

Atlas	At[l]as	nice[n]ess	nice[l]y

This is because *tl* is not an acceptable onset in English, so /t/ and /l/ are necessarily in different syllables in *Atlas*. In *niceness* and *nicely*, the *s* and the sonorant are in separate syllables, assuming that resyllabification does not apply to Level II derived words.

After fricatives, devoicing is not so apparent. Iverson & Salmons (1995, 373) also transcribe devoiced sonorants following fricatives in (33).

(33)

slip	[s̥lɪp]	shrimp	[ʃɹ̥ɪ̃mp]
sneeze	[sn̥iz]	fleet	[fl̥it]

Preliminary phonetic investigation of these and similar words suggests that sonorants are not devoiced reliably after voiceless fricatives (at least not to the extent that they are devoiced after voiceless stops.) We found for one speaker (M) that nasals are devoiced after /s/, but not for the other speaker (J).

A number of published spectrograms show voiced sonorants following /θ/, /f/, and /s/ in fricative-sonorant onset clusters, for example, *three* (Ladefoged 1982, 187), *fly, free* (Potter et al. 1966 p. 265, p. 257), and *smoke, snow, small, sleep* (Potter et al. 1966, p. 196, p. 196, p. 239, p. 257).

Iverson & Salmons (1995) consider the deaspiration of stops by a preceding *s,* as in (10a), as indicating that fricatives are phonologically [+spread]. But Kim (1970) describes this deaspiration as an instance of coarticulation, analogous to the lip rounding found on onset consonants preceding a round vowel in Russian (34).

(34) Cf. Kim 1970, fn. 10, p. 113: "in syllables of the type *stu, ntu, dnu,* etc. of Russian, the lip protrusion began practically simultaneously with the beginning of the first consonant. What makes the string realized in a serial order is…not a separate and direct instruction for each segment from the speech center…but a sort of reflex mechanism connecting several movements…"

Kim notes that the glottal widening during /s/ in anticipation of /p/ is possible since /s/, being voiceless, does not need the glottis to be closed. That is, the articulation of /s/ is "compatible" with a widening of the glottis. The deaspiration in (10a) would not be possible if /s/ were incompatible with glottal widening. However, the fact that /s/ facilitates coarticulation in this way does

not justify assigning it a phonological feature [+spread]. In view of the evidence that fricatives may not devoice following sonorants, we conclude that fricatives in English are not phonologically [+spread] (or GW). If devoicing of sonorants after fricatives is phonetic implementation rather than a phonological rule, then it is interesting that it appears to be sensitive to syllable boundaries, as in (32). On the other hand, we propose that sonorant devoicing after stops is phonological and is triggered by a feature denoting voicelessness.

References

Avery, Peter & William Idsardi (2001) "Laryngeal dimensions, completion and enhancement," in T. Alan Hall (ed.) *Distinctive Feature Theory,* Berlin: De Gruyter, 41–71.

Bérkov, V.P. (1962) *Íslenzk-Rússnesk Orðabók,* Moscow.

Burton-Roberts, Noel, Philip Carr & Gerard Docherty (2000) *Phonological Knowledge: Conceptual and Empirical Issues*. Oxford: Oxford University Press.

Bybee, Joan (2001) *Phonology and Language Use,* Cambridge, UK: Cambridge University Press.

Hale, Mark & Charles Reiss (2000) "Phonology as cognition," in Noel Burton-Roberts, Philip Carr, & Gerard Docherty (eds.) (2000).

Halle, Morris & Kenneth Stevens (1971) "A note on laryngeal features," *MIT Quarterly Progress Report* 101, 198–212.

Iverson, Gregory K. and Joseph C. Salmons (1995) "Aspiration and laryngeal representation in Germanic," *Phonology* 12: 3, 369–396.

——— (2003) "Laryngeal enhancement in early Germanic," *Phonology* 20, 43–74.

Kim, Chin-Wu (1970) "A theory of aspiration," *Phonetica* 21, 107–116.

Ladefoged, Peter (1982) *A Course in Phonetics* (second edition), New York: Harcourt, Brace, Jovanovich.

Ladefoged, Peter (1990) "On dividing phonetics and phonology: comment on the papers by Clements and by Browman and Goldstein," in John Kingston and Mary E. Beckman (eds.) *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech,* 398–405.

Ladefoged, Peter and Ian Maddieson (1996) *The Sounds of the World's Languages*, Blackwell Publishers, Cambridge, MA.

Lehiste, Ilse (1964) *Acoustical Characteristics of Selected English Consonants,* The Hague: Mouton.

Lisker, Leigh and Arthur S. Abramson (1964) "A cross-language study of voicing in initial stops: acoustical measurements," *Word* 20: 384–422.

Lisker, Leigh and Arthur S. Abramson (1967) "Some effects of context on voice onset time in English stops," *Language and Speech* 10: 1–28.

Lisker, Leigh, Arthur S. Abramson, Franklin S. Cooper, and Malcolm H. Schvey (1969) "Transillumination of the larynx in running speech," *Journal of the Acoustical Society of America* 45, 1544–1546.

Myers, Scott (2000) "Boundary disputes: The distinction between phonetic and phonological sound patterns," in Noel Burton-Roberts, Philip Carr, & Gerard Docherty (eds.) (2000).

Ohala, John J. (1990) “The phonetics and phonology of aspects of assimilation,” in John Kingston & Mary Beckman (eds.) *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech,* Cambridge, UK: Cambridge University Press.

Potter, Ralph K., George A. Kopp, & Harriet Green Kopp (1966) *Visible Speech,* New York: Dover.

Rögnvaldsson, Eiríkur (1989) *Íslensk Hljóðfræði*, Málvisindastofnun Háskóla Íslands, Reykjavík.

Vaux, Bert (1998) “The laryngeal specifications of fricatives,” *Linguistic Inquiry* 29, 497–511.

Withgott, Mary Margaret (1982) *Segmental Evidence for Phonological Constituents,* Ph.D. dissertation, University of Texas, Austin.