2 Analyzing laryngeal contrasts[1]

2.1 Background to laryngeal properties and phenomena

Consonants can be characterized along three dimensions: place of articulation (referring to where the air passing through the vocal tract during the articulation of the consonant is blocked), manner of articulation (describing the degree of the obstruction) and **laryngeal property** (the quality of the consonant determined by the states of the vocal folds in the larynx)—see the table in (1).[2]

(1)

				Place of articulation							
				bilab.	labio-dent.	dent.	alv.	post-alv.	pal.	vel.	glot.
Manner of articulation	obstr.	stops/plosives		p b			t d			k g	[ʔ]
		fricatives			f v	θ ð	s z	ʃ ʒ			h
		affricates						ʧ ʤ			
	son.	nasals		m			n			ŋ	
		approx.	liquids				l	r			
			glides	w					j	(w)	

About half of the world's languages contrast **two series of obstruents** differing in their laryngeal properties, e.g., [p] and [b]. This "voiced–voiceless" contrast can be observed in both Hungarian and English, for example, as indicated by minimal pairs like Hun. /b/*ál* 'ball' – /p/*ál* 'Paul' and Eng. /b/*all* – /p/*aul*. Although we can use the terms **"voiced"** and **"voiceless"** to identify the two types of obstruent in both languages, we must be aware that the phonetic, i.e., physical, realizations of this opposition are different—contrary to what the orthographic conventions suggest.

As an illustration, you can see in (2) the waveforms of four sound recordings in which a Hungarian and an English native speaker pronounce the above-mentioned minimal pairs. Under the waveforms, you can find the spectrograms of the four recordings, in which the darker areas indicate the dominant frequencies of the given sounds (between 0 and 5,000 Hz) and their change over time. Without going into too much detail about it, let us compare the laryngeal properties of these word-initial plosives, separated from the rest of the word by vertical lines in the figures: The /b/ in Hun. *bál* is characterized by actual **vocal fold vibration** (i.e., **voicing**), which is indicated by the periodic waveform already in the closure phase

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[1] The **set texts** for this lesson, besides the present reading and the slides, are from the textbook of the Phonology lecture course (BBN-ANG-241):

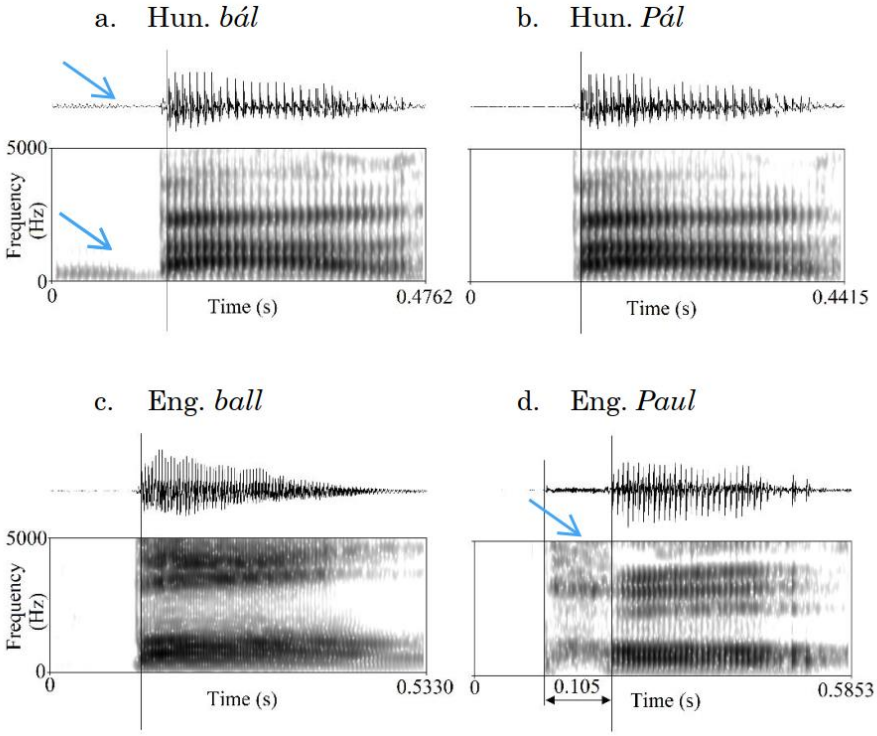
Zoltán G. Kiss. 2021–. Phonolec notes. http://www.budling.hu/~cash/courses/phonolec/phonolec-notes/index.html.

The exact links to the assigned sections of *Phonolec notes* are given in footnotes at the relevant parts of this reading.

[2] In the table, voiceless consonants are written in red, and voiced consonants in blue.

of the plosive, and in the spectrogram, by a striated darker area in the low frequency range. If we compare the initial plosive of Hun. *Pál* with that of Eng. *ball*, it is clear that they can be pronounced identically: the closure phase is silent, and vocal fold vibration begins upon release in both cases, i.e., they are **voiceless unaspirated**. Finally, Eng. *Paul* also begins with a voiceless plosive; moreover, vocal fold vibration in the next vowel is delayed (by 105 milliseconds), i.e., the plosive is **aspirated**, which is realized as a [h] sound following the plosive: [pʰ]. In words like *play*, where the plosive is followed by a sonorant consonant (more precisely, an approximant/a nonnasal sonorant consonant), aspiration is manifested as the devoicing of the sonorant consonant: [p̥l].

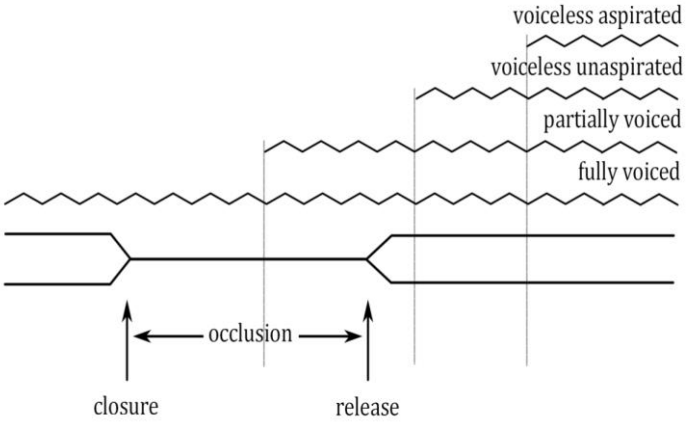
(2)



We can describe the voicing quality of a plosive using **VOT** values. "VOT" is an abbreviation for voice onset time, which gives the timing between the release of the plosive and the beginning (= onset) of voicing in the next vowel or sonorant consonant, as shown in the schematized figure in (3). Voiced plosives, in which voicing begins prior to the release of the stops, are characterized by **negative VOT**. In the case of voiceless unaspirated plosives, where vocal fold vibration begins right around its release, we can talk of **zero** or short-lag **VOT**. Finally, voiceless aspirated plosives have **positive VOT** values (a.k.a. long-lag VOT), which means that voicing is delayed, i.e., lags behind the release of the stop (e.g., in the case of the /p/ of *Paul* in the above figure, VOT = +105 milliseconds). For further details about the phonetics of laryngeal properties, please read "The

phonetics of voicing,"[3] "The phonetics of aspiration"[4] and "Voice onset time"[5] in *Phonolec notes*.

(3)



So in English, the laryngeal contrast in word-initial plosives is actually realized as the presence vs. absence of **aspiration**, not as the presence vs. absence of voicing, like in Hungarian. In English, the plosives /p, t, k/ have aspirated and unaspirated allophones: [pʰ, tʰ, kʰ] and [p, t, k]. These plosives are aspirated in the following environments (defined with reference to syllables): (i) word-initially (e.g., in [pʰ]*áralyze*, [pʰ]*olíte* and [pl̥]*áy*) and (ii) at the beginning of a stressed syllable (e.g., in *a*.[pʰ]*éar* and *a*.[pɾ̥]*óve*). In other positions, we find the unaspirated alternants (e.g., in *ca*[p] and *ca*[p].*tain*, where the bilabial plosives are syllable-final, or in *há*.[p]*en*, where it is not word-initially and is at the beginning of an unstressed syllable). For further details about this allophonic alternation, please read "The distribution of aspiration"[6] and "The effect of syllables"[7] in *Phonolec notes*.

Now, let us turn to **voicing** in English. In the case of sonorant segments (i.e., vowels and sonorant consonants), the unmarked (= phonetically most natural) way of articulating them is with vocal fold vibration (in any language); this type of phonation (or voicing) is called **spontaneous voicing**. The unmarked case for obstruents, on the other hand, is to be voiceless (in any language), and in English, they can only be **passively voiced**. That is, if a native speaker of English pronounces an obstruent voiced, vocal fold vibration is not an articulatory target

3 http://www.budling.hu/~cash/courses/phonolec/phonolec-notes/voicing.html#the-phonetics-of-voicing

4 http://www.budling.hu/~cash/courses/phonolec/phonolec-notes/aspiration.html#the-phonetics-of-aspiration

5 http://www.budling.hu/~cash/courses/phonolec/phonolec-notes/voicing.html#voice-onset-time

6 http://www.budling.hu/~cash/courses/phonolec/phonolec-notes/aspiration.html#the-distribution-of-aspiration

7 http://www.budling.hu/~cash/courses/phonolec/phonolec-notes/aspiration.html#the-effect-of-syllables

but can only be the effect of the neighboring sounds: if an obstruent is in intersonorant position, the voicing of the sonorants preceding and following it will "run through" it, turning it voiced. So in English, the obstruents /b, d, g; v, ð, z, ʒ; ʤ/ have the voiced allophones [b, d, g; v, ð, z, ʒ; ʤ] in intersonorant position (e.g., in ***a***[b]***ou****t*, *li*[z]***a****rd*, *se****n***[d]***i****ng*) and ***a***[bd]***o****men*) and only partially voiced or entirely voiceless allophones elsewhere (e.g., in *ball* [b̥oːl~poːl], *bad* [baḍ~bat], *rise* [rɑjz̥~rɑjs] and *anec*[ḍ~t]*ote*). In Hungarian, voicing in obstruents is the result of active articulatory gestures, so here, we talk of **active voicing**. For further details on voicing and its distribution in English, please read "Types of phonetic voicing"[8] in *Phonolec notes*.

What we have learned so far about **the physical realizations of the laryngeal contrast in English** can be summarized and illustrated through the following examples: In /p/*aul* vs. /b/*all*, the opposition is encoded as the presence vs. absence of aspiration: [pʰ]*aul* vs. [b̥~p]*all*. The situation is the same /p/*ride* vs. /b/*ride*, but here, aspiration is realized as the devoicing of the following sonorant consonant: [pr̥]*ide* vs. [b̥~p]*ride*. The laryngeal contrast is realized as the presence vs. absence of aspiration in *de*/k/*rée* vs. *de*/g/*rée* too, as the /k/ in the former is at the beginning of a stressed syllable; furthermore, since the /g/ in the latter is in intersonorant position, it will be passively voiced, an additional phonetic cue encoding the opposition: *de*[kr̥]*ée* vs. *de*[g]*rée*. As for *á*/t/*om* vs. *Á*/d/*am*, the /t/ in the former is not aspirated because it occurs word-medially and not at the beginning of a stressed syllable; however, the contrast is maintained via the passive voicing of the intersonorant /d/: *á*[t]*om* vs. *Á*[d]*am*.

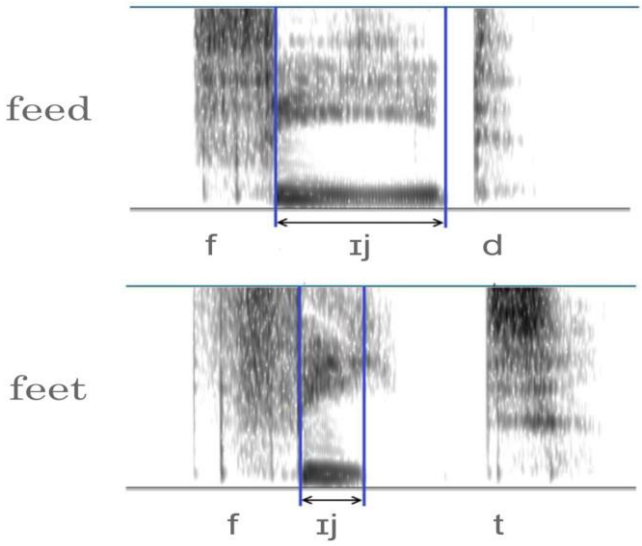
What remains to be discussed is the following: as the /t/ in *ba*/t/ is not aspirated, and the /d/ in *ba*/d/ does not undergo passive voicing if not followed by a sonorant segment, both of them tend to be pronounced as a voiceless unaspirated [t]. Nevertheless, the laryngeal contrast is not neutralized (= does not disappear) in final position either. Then what phonetic cues are used to encode the opposition? As can be seen in (4), a vowel before "voiceless" obstruents tends to be shorter than a vowel before their "voiced" counterparts (e.g., *bat* [bă̆t] vs. *bad* [bāḍ~bāt] and *rice* [ră̆j̆s] vs. *rise* [rāj̆z̥~rāj̆s]), which is referred to as **prefortis clipping** (= prevoiceless shortening). A further phonetic cue that can encode "voicelessness" in the case of plosives and the affricate /ʧ/ in this position is **preglottalization** (a.k.a. glottal reinforcement), i.e., the pronunciation of the glottal stop [ʔ] before these segments (e.g., in *bat* [bă̆ʔt]). For further details about the maintenance of the laryngeal contrast in final position, please read "Pre-fortis clipping"[9] (and, if you are interested, "Glottalization"[10]) in *Phonolec notes*.

8 http://www.budling.hu/~cash/courses/phonolec/phonolec-notes/voicing.html#types-of-phonetic-voicing

9 http://www.budling.hu/~cash/courses/phonolec/phonolec-notes/voicing.html#pre-fortis-clipping

10 (http://www.budling.hu/~cash/courses/phonolec/phonolec-notes/glottalization-and-glottalling.html#glottalization)

(4)



The terms "voiceless" and "voiced" are in quotation marks in the previous paragraph. Although we can use them to refer to the English phonemes we transcribe as /p, t, k; f, θ, s, ʃ, h; ʧ/ and /b, d, g; v, ð, z, ʒ; ʤ/, respectively, it must have become clear by now that these are phonetically inaccurate or insufficient descriptions: the members of the former set are indeed voiceless, but what may distinguish the plosives in this category is not only the stable voicelessness but also aspiration; as for the members of the latter category, it is not true that their primary characteristic is that they are voiced—they are voiced only in a given context. Therefore, we can use the terms "**fortis**" and "**lenis**" to refer to these obstruent series. For further details, please read "Fortis vs. lenis"[11] in *Phonolec notes*.

We can distinguish two types of laryngeal system (= language) based on how the laryngeal opposition between their two obstruent series is realized. Languages like Hungarian, including Romance languages (e.g., Italian, Spanish and French) and Slavic languages (e.g., Ukrainian, Czech and Serbo-Croatian), contrast negative VOT and zero (short-lag) VOT, i.e., voiced unaspirated and voiceless unaspirated plosives. They are called **(true) voicing languages**. In English and most Germanic languages (e.g., German, Icelandic and Norwegian) or Mandarin Chinese, the contrast is between zero (short-lag) and positive (long-lag) VOT, i.e., they have voiceless unaspirated and voiceless aspirated plosives. They are referred to as **aspirating languages**.

[11] http://www.budling.hu/~cash/courses/phonolec/phonolec-notes/voicing.html#fortis-vs.-lenis

2.2 The analysis of /s/+C clusters in English

For a discussion on this issue, please read "Fortis fricatives"[12] and "The effect of syllables"[13] in *Phonolec notes*.

We can observe in English, among other languages, that there is **no aspiration** after /s/—or, more precisely, **after fortis fricatives** in general. So while we can find aspirated plosives in words like [pʰ]*eak* and [kʰ]*ool*, the plosives in ***s***[p]*eak* and ***s***[k]*ool* are unaspirated, and so are the ones in *di****s***[k]*óvery* and *fí****f***[t]*éen* (cf. *níne*[tʰ]*éen*).

To account for the absence of aspiration in fortis fricative + plosive clusters, we may resort to referring to **syllables**. Note that we said earlier that a fortis plosive can be aspirated at the beginning of a word or at the beginning of a stressed syllable. This condition is not fulfilled in ***s***[p]*eak*, ***s***[k]*ool* and *di.****s***[k]*ó.ve.ry*, as their plosives are not word- or syllable-initial, so we indeed expect them not to be aspirated. However, there is no aspiration in words like *fí****f***[t]*éen* or *ká****f***[t]*an* either. The absence of aspiration could fall out of our syllable-based analysis only if we assumed the following syllabifications: *fí.****f***[t]*éen* or *ká.****f***[t]*an*, ending up with a syllable-initial /ft/ cluster, which does not occur word-initially. This leads to a peculiar situation since the occurrence of a consonant cluster in syllable-initial position is generally taken to imply the occurrence of that cluster in word-initial position too (therefore, e.g., *atlas* is to be syllabified as *at.las* and not as **a.tlas* because /tl/ is not a possible word-initial cluster).

The problem seems to be better solved if we do not let the spelling affect our phonological analysis. If we have an audio recording of the word *speak*, and we chop off the /s/ from the beginning of the word and ask a native speaker to identify the word they hear, they will say *beak* and not *peak*. It should not be too surprising if we know that a word-initial plosive pronounced without aspiration will be perceived as a lenis segment. So we could analyze the unaspirated voiceless plosives in *s*[p]*eak*, *s*[k]*ool*, *dis*[k]*óvery*, *fíf*[t]*éen* and *káf*[t]*an* phonologically as **lenis plosives**: s/b/*eak*, *s*/g/*ool*, *dis*/g/*óvery*, *fíf*/d/*éen* and *káf*/d/*an*. Actually, the identification of such clusters as fortis fricative + lenis plosive clusters is reflected in the spelling of Wesh: 'Spain' is *Sbaen* and 'school' is *ysgol*.

2.3 The phonological analysis of laryngeal contrasts

2.3.1 The phonological makeup of segments

The phonemes of a language can be analyzed as units decomposable into so-called **distinctive features**—phonetic features that distinguish one phoneme from another. For example, the features relevant for distinguishing /t/, /d/ and /n/ are the ones shown in (5).

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12 http://www.budling.hu/~cash/courses/phonolec/phonolec-notes/aspiration.html#fortis-fricatives

13 See footnote 7.

(5)

	t	d	n
consonantal	+	+	+
alveolar	+	+	+
voiced	−	+	+
nasal	−	−	+

As an illustration, the chart in (6) shows the distinctive features necessary for unambiguously defining all the consonants of English.

(6)

Features of Some American English Consonants

Features	p	b	m	t	d	n	k	g	ŋ	f	v	θ	ð	s	z	ʃ	ʒ	tʃ	dʒ	l	r	j	w	h
Consonantal	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−
Sonorant	−	−	+	−	−	+	−	−	+	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+
Syllabic	−	−	−/+	−	−	−/+	−	−	−/+	−	−	−	−	−	−	−	−	−	−	−/+	−/+	−	−	−
Nasal	−	−	+	−	−	+	−	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Voiced	−	+	+	−	+	+	−	+	+	−	+	−	+	−	+	−	+	−	+	+	+	+	+	−
Continuant	−	−	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+	−	−	+	+	+	+	+
Labial	+	+	+	−	−	−	−	−	−	+	+	−	−	−	−	−	−	−	−	−	−	−	+	−
Alveolar	−	−	−	+	+	+	−	−	−	−	−	−	−	+	+	−	−	−	−	+	+	−	−	−
Palatal	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+	−	−	+	−	−
Anterior	+	+	+	+	+	+	−	−	−	+	+	+	+	+	+	−	−	−	−	+	+	−	−	−
Velar	−	−	−	−	−	−	+	+	+	−	−	−	−	−	−	−	−	−	−	−	−	−	+	−
Coronal	−	−	−	+	+	+	−	−	−	−	−	+	+	+	+	+	+	+	+	+	+	+	−	−
Sibilant	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+	+	+	+	+	−	−	−	−	−

Note: The phonemes /r/ and /l/ are distinguished by the feature [lateral], not shown here. /l/ is the only phoneme that would be [+lateral].

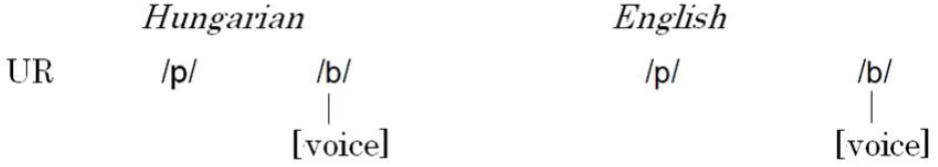
The features marked with a plus sign can be thought of as being present in the segment while the minus sign signifies the absence of a feature, e.g., /m/ is **specified for** the feature [nasal] while /b/ is **unspecified for** this feature:

(7)

2.3.2 The phonological representation of laryngeal contrasts

As for the laryngeal specification of segments, traditionally the **distinctive feature [voice]** was used to represent the contrast between obstruents in both Hungarian and English:

(8)



More recently though, in **nontraditional analyses**, the laryngeal contrast has been represented differently in the two language types:

(9)

Let us see now how the necessity of two different distinctive features, **[voice]** and **[fortis]**, for the phonological representation of the laryngeal contrast in Hungarian and in English can be supported.

*a. The **phonetic basis** for the assumption of two laryngeal features*

As discussed above, contrary to what the phonemic transcription suggests (together with the spelling), the phonetic (i.e., physical) realizations of plosives in word-initial position are different in the two languages. In Hungarian, it is actual vocal fold vibration, i.e., active voicing, that the contrast lies in: /paːl/ is pronounced [paːl], and /baːl/ is [baːl] on the surface too. In English, on the other hand, the lenis plosive of /boːl/ is not necessarily voiced on the surface (it tends to be only partially voiced or totally voiceless, so [b̥oːl~poːl]), and the fortis plosive of /poːl/ is not only voiceless but also aspirated ([pʰoːl]), which show that the distinctive laryngeal property in word-initial plosives in English is not voicing but aspiration. Therefore, more recently, in nontraditional analyses, obstruents like /b, d, g; v, ð, z, ʒ; ʤ/ continue to be **laryngeally specified** in Hungarian-type languages, so they contain the feature [voice]; the **laryngeally unspecified** series contains obstruents like /p, t, k; f, θ, s, ʃ, h; ʧ/; however, in English, laryngeal specification is the other way around: /b, d, g; v, ð, z, ʒ; ʤ/, which are only passively voiced in intersonorant position, form the unspecified series, while /p, t, k; f, θ, s, ʃ, h; ʧ/, the plosives of which bear the distinctive property aspiration, are taken to be specified for a distinctive feature, [fortis].

*b. The **phonological basis** for the assumption of two laryngeal features*

Besides the phonetic realizations of obstruents, their phonological behaviors also support the idea that the two obstruent series should be represented differently in the two language types. Let us consider the English word /dɪsgráfɪjə/ and its Hungarian equivalent, /dizgraːfiɔ/. What happens in Hungarian is that the voiceless /s/ of the prefix /dis/ undergoes voicing due to the voiced /g/ following it in the next morpheme (we know that the final obstruent of the prefix was underlyingly /dis/ by observing forms like /dislɛksiɔ/, where the following sound is a sonorant consonant or vowel (in this case, /l/), which cannot change the laryngeal identity of the final obstruent of the prefix). This process is called **voice assimilation**, and as its direction is right-to-left, it is referred to as **regressive** voice assimilation. As for English, no such assimilation takes place, which is what we expect since

voicing is not a distinctive property of lenis obstruents in the language. This follows from the different representation of obstruent series in the two language types, illustrated in (10): In Hungarian, the voiced obstruent /g/ is specified for the distinctive feature [voice], which exhibits backward spreading and turns the preceding voiceless /s/ into a voiced /z/. In English, on the other hand, the lenis /g/ is laryngeally unspecified and therefore cannot affect the fortis /s/ before it, which is the marked obstruent, specified for [fortis].

(10)

Hun. *diszgráfia* /dizgraːfiɔ/

d i **s** **g** r aː f i ɔ → d i **z** **g** r aː f i ɔ

[voice] [voice]

Eng. *dysgraphia* /dɪsgrafɪjə/

d ɪ **s** **g** r a f ɪj ə

[fortis]

What characterizes aspirating languages and can be analyzed as the spreading of [fortis] in the phonological representation is the case of sonorant devoicing after fortis obstruents. This feature spreading is illustrated in (11).

(11)

play /plɛj/ > [pl̥ɛj]

p l̥ ɛj

[fortis]

Another phenomenon supporting the specification of English obstruents for [fortis] concerns the behavior of the plural/possessive/3rd person singular present tense morpheme *-s* and the past tense/past participle morpheme *-ed*—for details, please read "Voicing assimilation"[14] in *Phonolec notes*. We can see that both of these morphemes have three allomorphs, which alternate depending on the obstruents they follow: /z/~/s/~/ɪz/ and /d/~/t/~/ɪd/ (e.g., /dɔg**z**/, /kat**s**/ and /bʌs**ɪz**/; /stab**d**/, /stɔp**t**/ and /stɑːt**ɪd**/). First, to find out what the underlying laryngeal properties of these morphemes are, we have to find an environment in which the preceding sound is not an obstruent, i.e., an environment in which there is nothing that could affect their laryngeal identity. Forms like /plɛj**z**/ and /plɛj**d**/ reveal that these morphemes are underlyingly lenis obstruents, and they may become fortis if preceded by a fortis obstruent. Then, the process /kat/ + /z/ → /kats/ can be analyzed as the forwards spreading of the feature [fortis] from the /t/ of /kat/ to the plural morpheme

[14] http://www.budling.hu/~cash/courses/phonolec/phonolec-notes/voicing.html#voicing-assimilation

/z/, turning it into a fortis /s/. This is an instance of laryngeal assimilation, and as its direction is left-to-right, it is **progressive laryngeal assimilation**. You can see the phonological representation of the morpheme alternation /d/~/t/ in (12).

(12)

a. played /plɛj#d/

p l ɛj d

b. stabbed /stab#d/

s t a b d

c. stopped /stɔp#t/

s t ɔ p d → s t ɔ p t

[fortis] [fortis]

In sum, we have seen that in Hungarian, voiced obstruents trigger regressive voice assimilation, so voicing is a phonologically active property. This can be easily represented if we assume the feature [voice] in this language type. In English, lenis obstruents do not cause laryngeal assimilation. Fortisness, on the other hand, seems to be a phonologically active property: sonorant devoicing after fortis obstruents and the allomorphic alternations of the morphemes *-s* and *-ed* can be accounted for if we assume the feature [fortis] in this type of laryngeal system and analyze these phenomena as the forward spreading of [fortis].

c. A puzzle for representing the laryngeal contrast

Hungarian and English seem to be "well-behaved" voicing and aspirating languages, respectively: which language type they belong to can be read off the phonetic realizations of their obstruents on the one hand, and the phonological behaviors of the obstruents on the other hand. This, in fact, generally applies to other languages too in these categories. However, there exist a few laryngeal systems in which these two criteria for the categorization as a voicing or an aspirating language are not both met. Swedish is such a language—let us consider the data in (13).

(13) a.

[pʰ]acka	'pack'
[b]ad	'bath'
[tʰ]ak	'roof'
[d]äck	'deck'

b.

vä/g/a	→	vä[g]a	'to weigh'
vä/g-t/	→	vä[kt]	'weighed (past participle)'
kö/p/a	→	kö[p]a	'to buy'
kö/p-d/e	→	kö[pt]e	'bought (past)'

We can see from the data presented in (13a) that Swedish contrasts voiced and aspirated plosives in word-initial position. Therefore, on a phonetic basis, we could argue that both [voice] and [fortis] should be assumed in this system, being a "mixture" of a voicing and an aspirating language. The data in (13b) show the

phonological behaviors of obstruents. We can observe that fortisness seems to be the phonologically active property as it is fortis obstruents that trigger assimilation: when a fortis and a lenis obstruent meet in these cases, it is the lenis that undergoes assimilation, turning into its fortis counterpart. As a result, regressive laryngeal assimilation takes place in *vä*/g-t/ (deriving *vä*[kt]) while in *kö*/p-d/*e*, the laryngeal assimilation is progressive (so we get *kö*[pt]*e*). As for lenisness, it is phonologically inactive. So on a phonological basis, we could argue for encoding the laryngeal contrast only with the feature [fortis]. The question then is which consideration should play a more important role in determining the phonological representation: should we decide based on phonetic forms or phonological behaviors?