The representation of fricatives[1]

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1. Introduction

The phonetic properties of fricatives have recently received a great deal of attention (Shadle 1985, Ladefoged & Maddieson 1996 ch. 5, Johnson 1997 ch. 6, Stevens 1998 ch. 8, Maniwa, Jongman, & Wade 2009, Ramsay 2009, inter alia). The *phonological* properties of this class of sounds, on the other hand, have with a few notable exceptions remained largely undisputed since the publication of Chomsky & Halle (1968), which itself essentially carries on the featural analysis of fricatives in Trubetzkoy (1939) and Jakobson, Fant, & Halle (1952). In this analysis, the class of fricatives is characterised by the distinctive features [-son, +cont].

Once one scratches the surface of the subject, though, a number of challenging questions appear:

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•Do fricatives actually behave as a distinct phonological class?
•Are all fricatives [-son]?
•Are all fricatives [+cons]?
•Are all or any fricatives [+sg] (or its equivalent)?

This chapter addresses these and other challenges by synthesizing what we have learned from traditional and contemporary descriptive and theoretical studies involving fricatives, with an eye towards determining what properties (if any) consistently characterise this phonological class and why. We shall see that the exact membership and feature characterisation of the fricative class depends on how one defines the features involved, but that there are good phonological reasons for assuming the existence of a coherent fricative class defined by the features [-son, +cont] and including not only the relatively uncontroversial suspects {fvɸβθðxɣχʁ} but also what we can call the strident or sibilant fricatives {szʃʒʂʐɕʑ}. The laryngeals {hɦɬɦ̩ɧ} behave less uniformly: some of them pattern with fricatives in some languages and with sonorants in others. There is also variation within the fricative class for the features [sg], [strident], [ATR], and possibly [cons], so these should not be included in the definition of the fricative class. Since the class appears adequately defined with the independently needed features [+cont, -son], we conclude on grounds of parsimony that this definition is preferable to the introduction of additional features such as [fricative].

We do not investigate stridency in this chapter, both because it does not characterise the class of fricatives as a whole and because it has been well dealt with by Clements (2006). Nor do we deal with tongue root advancement, which Vaux (1992, 1996) has claimed to be a common attribute of voiced fricatives only by virtue of their membership in the class of voiced obstruents.

1.1. Are fricatives a bona fide phonological natural class?

Fricatives present a challenge to the ontology of distinctive feature theory in that they possess a clear and unique phonetic identity resulting from turbulent airflow through a narrow constriction that is reflected in neither of the cornerstones of distinctive feature theory, (i) properties that are phonologically active, and (ii) properties that are necessary to distinguish a phoneme (or in this case a class of

phonemes) from all others. The problem is this: if we were to postulate a phonological feature such as [fricative] to capture the distinctive phonetics of the fricative class, we would run afoul of criterion (i) by virtue of the fact that there is no evidence for such a feature being phonologically active; the attested range of phonological behaviors of fricatives can be captured by other independently-required members of their feature complement, as we will see throughout the rest of this chapter. These same features suffice to distinguish the class of fricatives from stops, vowels, and so on; the feature [fricative] therefore is not required by criterion (ii) above either.

Before examining the phonological representation of fricatives, we should therefore consider first whether there is sufficient evidence for considering them to form a natural class. Is there anything that is truly distinctive phonologically about the set of fricatives, or are they simply what is left of the class of obstruents after one subtracts the stops? Do fricatives ever behave as a class to the exclusion of all other phonemes? The answer to this question is a qualified yes: many phonological phenomena specifically target or are triggered by the fricative set of the language in question, but (unsurprisingly) for a variety of historical and accidental reasons none of the phenomena in question suffice to delineate the entire cross-linguistic class of fricatives

Tiberian Hebrew spirantisation, for instance, produces alternations between plain oral stops [pbtdkg] and fricatives [fvθðxɣ] respectively, as in (1) (Idsardi 1998:39), but does not produce alternations for the emphatic stop [ṭ] or for the guttural fricatives [ħ h]. The Tiberian Hebrew surface consonant inventory is given in table 1, based on Rendsberg (1997) and Green (2004). The interpretation of the emphatics is conjectural, and the positioning of the pharyngeals and glottals should be understood as arbitrary with respect to their [son] values, which we will not investigate here (though we discuss the sonorance of laryngeals in various other languages in §2.2).

Table 1 Tiberian Hebrew surface consonant inventory

	Labial	Dental	Alveolar	Palatal	Velar	Pharyngeal	Glottal
stops	p, b	t, d			k, g		ʔ

fricatives	f, v	θ, ð	s	š [ʃ]	x, ɣ	ħ, ʕ	h
emphatics		ṭ [tˤ]	ṣ [sˤ]		q [q]		
nasals	m	n					
liquids		l r					
glides	w			y [j]			

(1) examples of Hebrew spirantisation alternations

a. [t~θ, k~x] √ktb ka:θáv 'he wrote'; yixtó:v 'he was writing'

b. [d~ð, g~γ] √gdl ga:ðlú: 'they were great'; yiɣdá:lu: 'he was being great'

The facts in (1) are not a problem for the notion that fricatives form a phonological class, because the phenomenon can be plausibly analysed as involving spreading of [+cont] from vowels to a following singleton segment specified with [+cons] and perhaps [-cst]. This is shown in the simplified spirantisation rule in (2), which abstracts away from certain morphological and lexical exceptions (on which see Coetzee 1999, Green 2004).

(2) spirantisation rule

[-cons, -cst] [+cons, (-cst)]$_i$ X$_j$[2]

[+cont]

If this analysis is correct (see further §2.1.2), we do not expect the guttural fricatives to have [-cont] counterparts in Tiberian Hebrew; the rule only serves to produce fricatives from underlying stops, and has no effect on underlying fricatives such as the gutturals. Tiberian Hebrew spirantisation therefore provides evidence

[2] If the target is not specified [-cst], then emphatics will spirantise and need to be repaired. The analysis of emphatic stops as [+cst] (laryngeally constricted) appears reasonable because the range of articulations typically reconstructed for them (Rendsburg 1997: 73) is within the laryngeal tract (Shahin, this volume).

neither for nor against the gutturals being fricatives rather than glides (i.e. obstruents rather than sonorants).

Nor can anything clear be inferred about the lack of spirantised allophones for the emphatic stops, though it seems likely that the emphatics had some trait such that their spirantised outcomes would have been fairly unusual, complex, or difficult sounds. No emphatics, and no other comparable class of non-participants, are to be found when one considers the spirantisation processes reconstructed in Old Irish (Celtic: Thurneysen 1946) and observed synchronically in Shoshone and Southern Paiute (Numic: Charney 1993). These cases of spirantisation could also be handled by (2) or by a very similar rule.

With these examples in mind, let us briefly consider additional phonological phenomena that can be reasonably said to target or be triggered by the class of fricatives. Perhaps the best known case arguably stems from the difficulties language learners have in producing fricatives, which leads to a host of avoidance and mutation strategies by individual learners. These include replacing all fricatives with [θ] (Dinnsen 2001), deleting syllable-initial fricatives in English (Dodd 1995) and Chinese (So 1994), avoiding syllable-initial fricatives in German, Dutch, English, and Portuguese (Grijzenhout & Joppen-Hellwig 2002), avoiding all fricatives in English (Smith 1973), code switching to avoid fricatives in a French-English bilingual (Celce-Murcia 1977), and stopping word-initial fricatives (Chiat 1989, Dinnsen & Farris-Trimble 2008). Recent work on acquisition in an optimality-theoretic framework attributes these effects to the activity of a markedness constraint *Fricative (e.g. Dinnsen, O'Connor, & Gierut 2001, Goad & Rose 2004:145, Farris-Trimble 2009; see §2.1 for further details).

Moving on to adult grammars, the fricatives as a class were targeted by exceptional plural voicing in the history of English, as in (3) (Marlett 2001):

(3) English exceptional plural voicing

a. f knife → knives

b. s house → houses

c. θ bath → baths [bæðz]

It is likely that at the time this rule developed English did not possess a /ʒ/ phoneme, and hence did not extend the voicing rule to /ʃ/-final roots.

The class of fricatives was also targeted by Verner's Law (Verner 1875), which voiced Proto-Germanic fricatives when immediately following an unstressed syllable in the same word.

The Amur dialect of Nivkh voices all non-initial fricatives (but not stops) before sonorant segments and voiced fricatives at both the Word and Phrase levels (Shiraishi 2006:54, 60), as in (4):

(4) Nivkh fricative voicing

a. native word-internal	ŋɨzit 'folktale' (no alternations provided)
b. loan word-internal	Nanai ixa 'cow' → Nivkh eɣa
	Ainu sisam 'japanese' → Nivkh sezam
c. phrase-level	tɨf 'house', tɨv-ux 'at house'

Nivkh also converts fricatives into stops after nasals, as in xu- 'kill' → aŋ k^{h}u- 'kill whom?' (Shiraishi 2006:58-9).

Along similar lines, Catalan voices prevocalic prefix-final and word-final fricatives (Bermudez-Otero 2001:20). Canadian French tenses and lengthens high vowels before fricatives in closed syllables (Poliquin 2006:220), as in *missive* [mɪ.si:v] 'letter' (not *[mɪ.sɪv] as we would expect from the general rule of high vowel laxing in final closed syllables followed by leftward ATR harmony), *finir* [fɪ.ni:ʁ] 'to finish' (not *[fɪ.nɪʁ]), *diffuse* [d^{z}ɪ.fy:z] 'diffuse' (*[d^{z}ɪ.fʏz]).

Further examples of phonological processes targeting, being triggered by, or producing fricatives will be developed below, but the brief list above should suffice to demonstrate that fricatives are a legitimate natural class that can be encoded in constraints (as revealed in child language), trigger processes (as in Canadian French), or be their targets (as in Nivkh) or products (as in Hebrew). As with all natural classes, we would like to identify a parsimonious set of features characterising this class.

2. Feature specifications

Silbert & De Jong (2008) state that there is a problem with finding a parsimonious feature definition of fricatives, however: they maintain that because fricatives consist, in large part, of random turbulent noise, they present a challenge to attempts to ground our theory of phonological features in specific phonetic correlates. As far as we can tell, though, the phonological features that are generally considered to delineate the fricative class, [+cont] and [-son], do not encounter this problem. Continuants can be defined straightforwardly as sounds with oral airflow egress, and obstruents as sounds with positive oral pressure buildup. Fricatives conform to both of these definitions, so there is no difficulty in correlating the feature specification of fricatives with well-established phonetic cues.

But do fricatives show evidence of being *phonologically* [+cont] and [-son]? And do they possess any other invariant feature specifications? In this section we consider phonological evidence bearing on the specifications of fricatives for [cont] (2.1), [son] (2.2), [cons] (2.3), and [sg] (2.4).

2.1. Continuance

Continuance is perhaps the quintessential feature of the fricative class; in fact, Jakobson, Fant, & Halle (1952:43) specified the feature value [+cont] only for fricatives and not for vowels (or *h*, interestingly), making it effectively equivalent phonologically to Ladefoged's [fricative] feature. Chomsky & Halle (1968:177) add {rlh} to the continuant set, but still exclude vowels (though their definition of [+cont] in terms of not having enough constriction to stop airflow might lead us to expect otherwise). At this point, given that neither of these sources employs the feature [son], we would have to delimit the class of fricatives as consonantal continuants.

Once we assume that vowels are [+cont] and incorporate the feature [sonorant] (as Chomsky & Halle 1968 did in chapter 8), we are led to revise our classification of the fricatives to [+cont, -son]. But are either of these features phonologically active? In this subsection we provide evidence that [cont] is active in fricatives, drawing on delinking and spreading of [+cont] (stopping and spirantisation respectively), delinking and spreading of [-cont] (deaffrication and

intrusive stop formation respectively), and delinking of [αcont] (manner dissimilation). The interested reader can also consult Cser 1999 for discussion of additional phenomena bearing on the phonological status of the feature [cont]. Evidence involving [son] is presented in §2.2.

2.1.1. Stopping

Let us first consider the cross-linguistically common process of stopping, which involves changing fricatives to corresponding stops and can be reasonably analysed as delinking of [+cont] with subsequent replacement by its complement, [-cont]. This is common after nasals, as we already saw in Nivkh (and as occurs in Spanish, according to Baković 1994 and Kenstowicz 1994). It is also common as a positional and absolute neutralisation process in first language acquisition (cf. Locke 1983 and the examples in §1.1 above). One English-acquiring child, for example, stopped fricatives in all positions (though the examples provided show only word-edge environments), as shown in (5) (O'Grady & Dobrovolsky 1992):

(5) Stopping in the acquisition of English

	target	**output**	**gloss**
a.	sɪŋ	tɪŋ	sing
b.	θɪŋ	tɪŋ	thing
c.	ðɪs	dɪt	this
d.	ʃu:z	tu:d	shoes

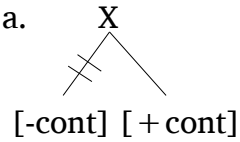
One might object that the child language facts are not a product of rules or constraints in the phonological component, but rather result from one or more performance problems involving, for example, difficulty in perceiving the auditory cues for frication reliably (Salus & Salus 1974) or producing and maintaining the necessary air pressure at the point of constriction (Paterson 1994:217). These production issues certainly seem to be involved in the phenomena in question, but the fact that Stopping (as well as avoidance of fricatives by acquirers) involves categorical rule-like behavior, such as avoidance or deletion of the entire fricative class, suggests that the production issues have been reified in the phonological component as, for example, a constraint against [-son, +cont] configurations.

In order to determine unambiguously that Stopping is phonological we would like to have evidence of it feeding or bleeding another phonological process. The famous case of Amahl's puzzle-puddle-pickle chain shift (Smith 1973) initially seems promising, because the Stopping we can see in *puzzle* → *puddle* potentially interacts with the Velarisation we can see in *puddle* → *puggle*. Unfortunately Stopping counterfeeds Velarisation (so *puzzle* → *puddle*, not **puggle*), so further searching is required. Nonetheless, it does not seem unreasonable to infer from child and adult facts of the sort presented in this subsection that fricatives contain a [+cont] specification that can be delinked.

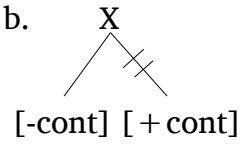
One can also view one subtype of deaffrication as akin to stopping insofar as it involves delinking of a [+cont] specification from affricates, effectively deleting their fricative component. Deaffrication processes are typically taken in the literature to involve deletion of one of the two [cont] nodes from a contour segment that is specified as both [+cont] and [-cont]. Most (perhaps all) affricates have a [-cont] closure phase and a [+cont] release; deleting the first half will therefore yield a fricative (6a) and deleting the second half a stop (6b).

(6) the two types of deaffrication

a.



b.



Type (6a) will be dealt with in §2.1.3; type (6b) occurs in the phonological system of the child studied by Dinnsen & Farris-Trimble (2008:105), who replaced affricates with alveolar stops in word-initial onsets (7).

(7) word-initial stopping deaffrication

a. [dɛli] 'jelly'

b. [dʌmp] 'jump'

c. [dus] ‘juice’
d. [dɪp] ‘chip’
e. [di:ʒ] ‘cheese’
f. [dɛ:ə] ‘chair’

2.1.2. Spirantisation

Besides delinking in the patterns just described, the feature [+cont] can spread to stop consonants, producing fricatives. In addition to the Tiberian Hebrew case mentioned in §1.1 we arguably find Spirantisation of this type in Spanish (Harris 1969), producing alternations of the sort in (8):

(8) Spanish Spirantisation (data from Baković 1994)

a.	[beso] ‘kiss’	[ese βeso] ‘that kiss’	[el βeso] ‘the kiss’	[dar βesos] ‘give kisses’
b.	[dato] ‘date’	[ese ðato] ‘that date’	[el dato] ‘the date’	[dar ðatos] ‘give dates’
c.	[gato] ‘cat’	[ese ɣato] ‘that cat’	[el ɣato] ‘the cat’	[dar ɣatos] ‘give cats’

According to Harris (1969:39), the alternants “appear as continuants except initially and after homorganic noncontinuant sonorants”. Scholars generally (e.g. Goldsmith 1981) analyse the system in terms of the feature [+cont] spreading to underlying voiced stops from preceding [+cont] segments, with the [l-d] cases being a bit of a problem. (We have encountered speakers who have [lð] in such cases, but the secondary literature appears to be unanimous on [ld] being the only option). Lozano (1979) and Baković (1994) invert the analysis, proposing underlying voiced fricatives that undergo fortition in syllable onsets under certain conditions. If they are correct, Spanish still presents evidence for [cont] being phonologically active in fricatives; the only difference is that the Spanish facts are then an example of Stopping (q.v. 2.1.1) rather than Spirantisation. (But see Mascaró 1991 for critique of these phonological solutions.)

Because the Spanish continuant allophones are often highly sonorous and even realised as glides, it could be asked whether fricatives are phonologically involved in the alternation at all or whether the fricative allophones are merely phonetically fortified variants of the glides. But the considerably different behavior of what are conventionally analysed as underlying glides indicates that this is not

the case. Although we have heard the Spanish glide /j/ realised with fortified variants [ǰ] and even [dʒ], the distribution of fricative realizations for /j/ and the strength of their frication appear to be much rarer and less salient than with the fricative realisations of /b d g/, suggesting that phonological [cont] alternation in obstruents does indeed occur in Spanish.

A simpler case of spirantisation is the phrase-level process that targets word-final prevocalic /ptk/ in Dublin and Middlesbrough English (Jones & Llamas 2008). Jones and Llamas suggest that these processes may not be related to the spirant mutation we find in Irish and other Celtic languages (for which see Thurneysen 1946, Pyatt 1997), but both are plausibly analysed in terms of [+cont] spreading or attaching to stops.

Another interesting case is the English spirantisation+palatalisation combination revealed in alternations of the sort in (9) (Chomsky & Halle 1968, Clements 1985, Zamma 2004):

(9) English spirantisation + palatalisation

a. [t]~[ʃ]	react : reaction
	invent : invention
	extinct : extinction
	delete : deletion
	part : partial
	delight : delicious
	Egypt : Egyptian
	Scot : Scotia
b. [d]~[ʒ]	invade : invasion
	divide : division

Chomsky & Halle (1968:229) and Clements (1985) argue that the data in (9) involve a feeding interaction between two separate processes, Spirantisation, which changes base-final /t/ and /d/ to /s/ and /z/ respectively, and Palatalisation, which changes these to [ʃ] and [ʒ] when followed by an i + vowel sequence. We can represent this sequence for the form *reaction* as in (10).

(10) derivation of reaction *à la* Clements (1985) (see Zamma 2004)

a. Spirantisation r e a c t - i o n

[+cont]

b. Palatalisation r e a c [s] - i o n

[-ant]

In a parallelist account, (10a-b) would occur simultaneously. Either way, the key for our purposes is the spread of [+cont] from the *i* to the preceding stop, producing a fricative.

There is a potential problem with this spreading analysis. As mentioned earlier, Jakobson, Fant, & Halle (1952) and Chomsky & Halle (1968) represent vowels as unspecified for [cont], based in all likelihood on the fact that vowels never contrast for continuancy. The non-contrastiveness of [+cont] on vowels has led to the Tiberian Hebrew postvocalic spirantisation being treated as [+cont] insertion (Idsardi 1998), though this is certainly suboptimal (Idsardi p.c.) given the extreme power of insertion and the general dearth of data requiring it (Fallon 2001, Samuels 2009). This quandary raises the question: when if ever is it acceptable to analyze systematic and categorical (as opposed to variable or gradient) spirantisation as [+cont] spreading from vowels?

The assumption that spreading of otherwise active features must have a certain status in terms of contrast structure seems reasonable, since features can only spread if they are specified, and specification is widely assumed to relate somehow to contrastiveness. But to claim that vowels cannot spread [+cont] because they never contrast for it is problematic. This assumption presupposes that there is an algorithm capable of exhaustively defining which features are contrastive in which environments in a given language by specifying them in a particular *order*, leaving the remaining features predictable from these and therefore (at least in some cases) never phonologically specified. Yet no successful algorithm has been developed for this task, *pace* Dresher (2009). The two-best known candidates, the Pairwise Algorithm and the Successive Division Algorithm, are critiqued in Samuels

(2009:77-94) and Parker (this volume) and found to have serious problems. Samuels (2009) essentially abandons the search for such algorithms, while Parker's more limited discussion (this volume) favorably highlights an application of the Successive Division Algorithm in Anywa and Dho Luo. Crucially, this application makes order of specification depend on language-particular feature activity rather than on contrast as measured by any independent criterion.

Hence, the argument that a feature cannot be active in a certain environment because it is not contrastive there must be suspended until a proper specification algorithm itself is established. This much is essentially acknowledged by Dresher (2009: 9, 209). After investigating possible algorithms for implementing the "Contrastivist Hypothesis" ("that phonological computation operates only on contrastive features"), Dresher concludes that phonological computation does apparently require non-contrastive features in some situations. Dresher recommends retaining the Contrastivist Hypothesis and a form of the Successive Division Algorithm (requiring a serial grammar theory) because they cover much or possibly most of the data, but once we allow exceptions, any data that are more elegantly treated in contravention of the hypothesis can also demand exceptionhood, including spirantisations which can be analyzed as [+cont] spreading from vowels.

It may eventually prove relevant to distinguish between two kinds of non-contrastive features, if only one of them seems needed in phonological representations. One kind is not predictable from context; an example would be archiphonemically underspecified features (on which see Inkelas 1995, Samuels 2009). The other kind is necessarily predictable from contexts: all vowels, for example, are necessarily continuant. We will not pursue the matter further here. For now it simply seems reasonable to accept cases of spirantisation like those mentioned in this section as examples of fricatives produced by [+cont] spread.

2.1.3. Deaffrication

Further evidence that [cont] is active in fricatives comes from phenomena that delink [-cont] specifications. Perhaps the most widespread process of this type is the more common variety of deaffrication, which deletes the [-cont] closure phase of the segment, producing a fricative. We find examples of this in the Aslanbeg dialect of Armenian, which deletes the stop component of affricates in coda position (11).

(11) Aslanbeg deaffrication (Vaux 2001:42)

	Std Western Armenian	**Aslanbeg**	
a.	gants^{h}nim	gasnim	'I cross'
b.	artʃ^{h}	arʃ	'bear (n)'
c.	godʒgel	goʒgel	'button (v)'
d.	dzedz	dzez	'beating'

Similar processes occur in Basque (Hualde 1987) and English fast speech (Lavoie 2001).

An interesting variant occurs in the speech of the English-speaking children Subject 14 and Subject 22 studied by Chin & Dinnsen (1991:334). Whereas spirantising deaffrication normally occurs either across the board or in syllable codas, these children deaffricate underlying affricates specifically in non-final position (12). (All of the examples provided by the authors are technically in medial position.)

(12) deaffrication in child English

a. Subject 14	[keɪdð] 'cage'	[keɪði] 'cagey'
	[bwɪdð] 'bridge'	[bwɪði] 'bridgey'
	[bædð] 'badge'	[bæði] 'badgey'
b. Subject 22	[wɪts] 'witch'	[wɪsi] 'witchie'
	[wats] 'watch'	[wasi] 'watchie'

2.1.4. Intrusive stop formation

Just as [-cont] can delink, it can also spread. The best-known case of this is intrusive stop formation, which typically applies in nasal + fricative sequences. Naidoo (2005) describes such a case in Zulu, which inserts a homorganic stop between the nominalising prefix /iN-/ and fricative-initial verb roots (14):

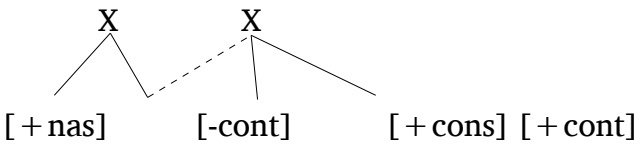
(14) intrusive stop formation in Zulu noun derivation

verb root (orthographic)	**derived noun (IPA)**

a.	fanel- ‘be suitable’	[iŋp̪fanɛlɔ] ‘suitability’[3]
b.	vakaz- ‘make spots’	[iŋb̪vakazi] ‘hair fringe (i.e. bangs)’
c.	sangan- ‘be confused’	[intsaŋganɔ] ‘confused state of mind’
d.	zal- ‘bear’	[indzala] ‘grass seed’
e.	hlab- ‘slaughter’ (hl = [ɬ])	[intɬ’aɓa] ‘good-for-nothing person’
f.	dloz- ‘seize violently’ (dl = [ɮ])	[indɮozi] ‘tiger-cat’
g.	shumayel- ‘preach’ (sh = [ʃ])	[iɲtʃumajɛlɔ] ‘sermon’

Clements (1987) analyses such cases as involving spreading of the [-cont] feature of the nasal to the following fricative, producing a [-cont]-[+cont] contour segment, which we can represent in skeletal form as in (15).

(15) intrusive stop formation as [-cont] spreading



Here again the analysis hinges in part on fricatives being [+cont]; if they were not, the reasons for a preceding nasal changing a fricative into what is essentially an affricate would be unclear.

2.1.5. Manner dissimilation

Thus far we have seen evidence for spreading and delinking of [+cont] and [-cont], each of which implicates fricatives as being [+cont]. The [+cont] specification of fricatives is also revealed in dissimilation processes such as we find in Modern Greek, where it can either trigger or undergo [cont] delinking. In this language, voiceless stop+stop and (non-s) fricative+fricative clusters optionally dissimilate to stop+fricative (Newton 1972, Kaisse 1987), as in (16) (Tserdanelis 2001):

(16) Modern Greek manner dissimilation

[3]Naidoo uses the symbol ɸ, which represents a voiceless bilabial fricative in the IPA, but we assume she is actually representing a voiceless labio-dental stop, which has no dedicated symbol in the official IPA but is represented as [p̪] in Ball, Rahilly & Tench (1996).

a.	ptero	~	ftero	‘feather’
	ktena	~	xtena	‘comb’
	epta	~	efta	‘seven’
	okto	~	oxto	‘eight’
	ekpiisi	~	expiisi	‘sale’
b.	xθes	~	xtes	‘yesterday’
	fθinos	~	ftinos	‘cheap’
	skefθika	~	skeftika	‘I thought’
	anixθika	~	anixtika	‘I was opened’
	fxaristo	~	fkaristo	‘I thank’
c.	sxini	~	skini	‘rope’
	pisθika	~	pistika	‘I was convinced’
	sfoŋgos	~	spogos	‘sponge’
d.	trex-o	:	e-trek-sa	‘I run’ (present : past)
	kafsimo	~	kapsimo	‘burning’
	kaθ-izo	:	e-kat-sa	‘I sit’ (present : past)

When the underlying cluster contains two stops the first member changes into a fricative (16a), whereas in fricative clusters the second member becomes a stop (16b). Interestingly, obstruent clusters containing an /s/ invariably delink the [cont] specification of the other segment (16c-d).

If we assume that stops and fricatives differ in being [-cont] and [+cont] respectively, we can interpret the dissimilation facts as OCP-driven delinking of [cont] values, where the relativised version of the OCP here would look something like (17).

(17) the OCP manner constraint for Modern Greek (modified from Tserdanelis 2001)

```
*    X        X
     |        |
   [-son]   [-son]
     |        |
  [αcont]  [αcont]
```

How exactly violations of this constraint are repaired is a matter of some debate, but the specifics are not relevant here. The key for our purposes is that dissimilation processes of this sort only make sense if stops and fricatives are polar opposites delimited by a single binary feature, in this case [cont]; other representational options such as [fricative] simply do not capture this sort of interaction insightfully.

In this subsection we have seen that the evidence from spreading and delinking of [±cont], which surfaces in a broad range of phenomena from Spirantisation to Deaffrication to Intrusive Stop Formation to Manner Dissimilation, and dovetails nicely with the assumption that fricatives are specified as [+cont]. Competing theories that replace [+cont] with [fricative], A_f, and the like tend to fare less well with these facts.

2.2. Sonorance

We next turn to the other feature value most commonly attributed to fricatives, [-son]. This specification is presumably invoked to distinguish fricatives from the rest of the continuants, e.g. vowels and (in some languages at least) *l* and *r*, which are [+son]. Treating all fricatives as obstruents raises a couple of questions, however:

•Are the glottal continuants /h ɦ/ obstruents? If not, are they still fricatives?
•Russian *v* patterns partly with obstruents and partly with sonorants; what is its [son] value?
•What is the relative sonority ranking of fricatives and stops?
•Why is the boundary between voiced fricatives and homorganic glides sometimes unclear?

In this subsection we consider each of these issues in turn.

2.2.1. Glottals

Trubetzkoy (1939) classed all of the fricatives as obstruents. If the glottal continuants /h ɦ/ are obstruent, then they belong straightforwardly to the class of fricatives defined as [+cont, -son] segments. If however these segments are

sonorant, as suggested by Chomsky & Halle (1968) and some of the ancient Indian phonetic treatises, such as the Taittirīya Prātiśākhya (1.13; Whitney 1871), then we must either exclude them from the fricative class or adopt one of the proposals in the literature for encoding fricativity directly, such as as Ladefoged's (1989) [fricative] feature, Articulatory Phonology's fricative gesture (Browman & Goldstein 1986), Steriade's (1993) fricative aperture node A_f, or Moren's (2003) consonantal manner feature [open]. Below we consider phonological evidence bearing on the sonorance of laryngeals, specifically the plain glottals (on the distinction see Shahin, this volume).

Glottals pattern with obstruents to the exclusion of sonorants in some languages and vice versa in others. The following examples and more like them can be found in the P-Base (Mielke 2007). Sonorant examples include Kickapoo (Algic) and Supyire Senoufo (Niger-Congo). In Kickapoo, after any sonorant including /h/ (the only glottal), the second member of a glide plus unaccented vowel sequence in either order is glottalised. In Supyire Senoufo, nasalised vowels can be preceded by only /Ṽ m n ɲ ŋ l ʔ/, and there are no other glottals or consonantal sonorants in the inventory. Obstruent examples include Jordanian Arabic, where only /ʔ h/ and other obstruents can be C_2 and only /m n ɾ l/ can be C_1 in $-C_1C_2\#$ and $-C_1C_2C_3-$; Maltese, where only /ʔ h/ and other obstruents can be C_1 of $\#C_1C_2-$; and Balangao (Austronesian), where obstruents including /ʔ h/ delete after the common prefix /maŋ/-. There is also evidence for [-son] spreading from fricatives to the palatal nasal ɲ in the Nilo-Saharan language Bilaala (Olson & Schultz 2002).

Similar ambivalence is shown by /ɦ/. In Czech (Slavic: Mielke 2007, Dankovičová 1999), this segment is the only laryngeal in the language and participates in a regressive obstruent voicing assimilation to the exclusion of sonorants. This suggests that /ɦ/ is [-son] in Czech. At the same time, in Oowekyala (Wakashan: Howe 2000), where /ɦ/ is again the only laryngeal in the inventory, the segment appears to be [+son]. This is indicated not only by the fact that /ɦ/ is voiced like all of the sonorants and unlike any of the obstruents in the language, but more importantly, by the fact that /ɦ/ takes [+constricted glottis] root-initially before a reduplicant in the plural, like sonorant consonants but unlike obstruents. Furthermore, the laryngeal continuants [h] and [ɦ] appear to systematically avoid

participating in the stopping and deletion phenomena in child phonologies discussed in §2.1.

If obstruence is cued by increased pressure in the vocal tract relative to outside air pressure, then cross-linguistic variation in the classification of glottals as obstruents or sonorants may be due to variation in whether this pressure buildup involves supraglottal impedance or not. In most sounds this is automatically the case, but with glottals it is not; hence, glottals will be sonorants if obstruents are defined by pressure buildup involving supralaryngeal impedance, and obstruents otherwise. Cross-linguistic variation in selection among phonetic cues for the definition of phonological classes is increasingly well-established (Mielke 2008:74-76, Samuels 2009:70). On the application of this perspective to ambivalent glottal sonorance in particular see also Mielke (2009:11-12).

In sum, the simplest solution of ambivalent glottal sonorance for the purpose of defining fricatives appears to be to retain the definition of fricatives as continuant obstruents, including glottal continuants in this class when they pattern with other obstruents and not otherwise. When glottal continuants are classed as fricatives on phonological grounds, an available phonetic correlate for [-son] that is consistant with all members of the class is pressure buildup in the vocal tract. When glottal continuants are classed as sonorants on phonological grounds, an available phonetic correlate for [-son] consistent with the fricative class is pressure buildup in response to supraglottal impedance. Selection among such differeing cues is not merely a descriptive afterthought, since it can play a key role in acquisition, including both correct learning and the genesis of analogical, or generalization-driven, sound change (on which see Mielke 2008:86-95).

2.2.2. Russian *v*

In the classic descriptions of Russian by Trubetzkoy and by Halle and his students, obstruents trigger and undergo regressive [±voice] assimilation (as seen in *gorodok* ‘town (nom. sg.)’ vs. *gorotka* (gen. sg.)), while sonorants do not participate (and in fact are claimed to be transparent to spreading of [voice], though we have yet to meet a speaker of Russian who shows this pattern). The exception is *v*, which patterns with the sonorants in some ways, such as not triggering regressive voicing assimilation (cf. *dver’* ‘door’ vs. *tver’* ‘(the town of) Tver’, but patterns with the

obstruents in other ways, such as its fricative realisation and the fact that it is devoiced by a following obstruent (cf. *lavok* 'bench (gen. pl.)' vs. *lafka* (nom. sg.)). This places it ambivalently between the Polish situation, where the cognate fricative participates fully in regressive voice assimilation, and Ukrainian, where the cognate segment is a glide and does not participate. As Jakobson (1978) puts it, "the Standard Russian *v*...occupies an obviously intermediate position between the obstruents and the sonorants".

Padgett (2002, to appear) formalises this notion of intermediacy by positing a category called "narrow approximants" that have just enough constriction to exhibit some behaviors associated with obstruents, but still little enough constriction to exhibit glide behaviors as well. This analysis does not require derivational levels, underspecification, or underlying /w/ for surface [v], but it does appear to require more features to distinguish approximants (or glides), narrow approximants, and fricatives.

Several other solutions to the Russian *v* problem are reviewed by Mołcanow (2007). One is a suite of ordered rules (1) [+son] → [-voice] / _[-son, -voice], (2) [w, ʍ] → [v, f], (3) [+son, -voice] → [+voice] (Hayes 1984, cf. Kiparsky 1985); another proposal is (1) /w/ → *v* / _[-son], (2) regressive voice assimilation, (3) /w/ → *v* (Coats & Harshenin 1971). The main shortcoming we can identify with these is the ad hoc character of the steps employed. Other approaches rely on a constraint that Russian *v* is [αson] / _[αson] (Halle 1959, Petrova 1997, Plapp 1999). This mechanism is open to the same objection of being ad hoc.

Mołcanow's own accusation, that having *v* be [αson] / _[αson] fails to account for why *v* is always [-son] on the surface, relies on the premise that phonetic component only allows features to be "added by default" (2007:61) according to markedness universals, so that Russian *v* cannot vary in sonorance phonologically and then become phonetically obstruent at the latest possible stage of realisation. This premise that phonetic implementation never supplies content on a language-specific basis is not a consensus view, though, and has the troubling implication that language-specific sound structure always falls on the phonological side of phonetic/phonological dichotomies such as gradient/categorical (for counter-evidence see e.g. Hale, Kissock, & Reiss 2006).

The fresh solution that Mołcanow proposes is cast within the framework of Optimality Theory (OT). It includes the constraints in (18):

(18) Some constraints on Russian /v/ (adapted from Mołcanow 2007)

a. IDENTPRESYLSON$_{[\pm voice]}$: A segment before a syllabified sonorant must be faithful to an input value for voice.

b. SHAREVOICE : Output obstruents adjacent on the laryngeal tier must share voice specifications.

c. SONDEF: Output syllabified sonorants are specified for voicing.

d. SPEC: Output segments must be fully specified.

e. Other faithfulness constraints: MAX$_{segment}$, DEP$_{\mu}$, IDENT$_{[\pm voice]}$, IDENT$_{[\pm bk]}$, IDENT$_{[\pm son]}$.

e. Ranking: *[w], MAX$_{segment}$, DEP$_{\mu}$, IDENTPRESYLSON$_{[\pm voice]}$, SONDEF » SHAREVOICE » IDENT$_{[\pm voice]}$ » IDENT$_{[\pm bk]}$ » IDENT$_{[\pm son]}$ » SPEC.

IDENTPRESYLSON$_{[\pm voice]}$ and SHAREVOICE are part of a strategy for making adjacent obstruents agree with the voice value of the second obstruent; this models regressive obstruent voice assimilation. SONDEF calls for syllabified sonorants to be voiced in the output, while another set of constraints including *[w], MAX$_{segment}$, DEP$_{\mu}$ » IDENT$_{[\pm bk]}$ » IDENT$_{[\pm son]}$ forces input /w/ to surface as an obstruent. Thus, given an input /w/ unspecified for voice because its voice is predictable, the output correspondent [v] has two important properties. First, it escapes the scope of SONDEF because it is not a sonorant, which leaves it free to devoice as part of obstruent voice assimilation. Second, it does not trigger obstruent voice assimilation, because it is unspecified for voice due to IDENTPRESYLSON$_{[\pm voice]}$.

An OT Russian grammar incorporating this analysis appears to clash, however, with the classic OT notion of Richness of the Base, which states that grammars are so designed that if all linguistically possible inputs were fed through a grammar, each input would map to a grammatical output for that particular grammar (Kager 1999:29, 31, Prince & Smolensky 2002:209, Davidson, Jusczyk, & Smolensky 2006:233, McCarthy 2008:88-95). In this case, the problem arises where a voiceless obstruent precedes an input /v/ or /w/ specified for [+voice]. Apparently, when that feature surfaces, it will (thanks to SHAREVOICE and

IDENTPRESYLSON$_{[\pm\text{voice}]}$) have associated with the preceding obstruent too, creating the wrong result: *v* triggering regressive voicing assimilation.

In other words, Mołcanow's grammar of Russian requires learners to infer that underlying /w/ is never specified for voice and that surface *v* regularly derives from underlying /w/. Both inferences are reasonable enough in their own right, but they involve well-formedness generalisations about underlying forms. The core of the output-oriented formulation of OT, which Richness of the Base is key to expressing, is the notion that grammars include well-formedness constraints on outputs only. (Numerous proposals for compromising this property are analyzed and found inadequate for their stated goals in McCarthy 2007.) The analysis of Russian fricatives in Mołczanow (2007) thus does not appear to implement the core logic of OT consistently.

An interesting aspect of Mołcanow's proposal that is independent of our concerns about output-orientedness is the idea of treating [+voice] as unmarked for labial obstruents. The basis is Petrova's (1997) argument that because labials have the largest oral cavity, they are the slowest to reach the translaryngeal pressure equilibrium that forces voicing cessation. Whether this gradient fact about labial obstruents is enough to justify the categorical conclusion that [+voice] is their unmarked phonation depends on one's definition of markedness. If labiodental fricatives are voiced by default, though, then – at least in grammars that admit input restrictions – supposing that Russian *v* is underlyingly unspecified for voice does indeed provide a coherent way to model the fact that the segment does not trigger voice assimilation, while the segment's obstruence still makes it a natural undergoer for the same process. Perhaps the simplest solution using this premise that labiodental fricatives are voiced by default would be that Russian *v* is underlyingly obstruent and unspecified for voice; it would then voice on the surface when other processes (such as regressive obstruent devoicing) have not taken priority.

Whether Russian *v* is best explained with a phonological category intermediate between glides and fricatives, a principle of default voice for labial obstruents, or some more complex analysis in a rule-based or a classic or modified OT framework awaits future consensus.

2.2.3 Fricatives vs. stops

Two other controversial aspects of fricatives are their sonority ranking with respect to stops and the boundary between voiced fricatives and some glides, which we examine in this section and the next.

Clements (1990) presents fricatives and stops as equally sonorous, Dell & Elmedlaoui (2002) treat fricatives as more sonorous than stops across the board, and Zec (2007) and Parker (this volume) recognise voiceless stops, voiceless fricatives, voiced stops, and voiced fricatives as ascending in sonority. Here we ignore voice and consider only a phonotactic problem bearing on the relative sonority of fricatives and stops when their voice values are equal.

Fricative + stop onset clusters and stop + fricative coda clusters have received attention in light of the strong cross-linguistic tendency toward sonority increase as one moves inward from the margins to the nucleus of a syllable (the Sonority Sequencing Principle or SSP; see Parker, this volume). If fricatives are more sonorous than stops, then these clusters appear to violate that tendency; hence the clusters might be taken as evidence that fricatives are not more sonorous than stops. Besides just accepting these clusters as SSP violations, however, there are two ways to handle them which are consistent with the SSP.

One is to treat the fricative in such clusters as an appendix: a segment either not incorporated into adjacent syllable structure or incorporated in an abnormal fashion by attaching to a higher prosodic node by skipping intermediate levels of prosodic structure (e.g. Vaux & Wolfe 2009). Since appendices are not assigned to syllables, they do not violate the SSP.

Another angle is to assign nuclei at sonority peaks that rise above a language-particular sonority threshold (Samuels 2009). Evidence for the threshold may come from speaker intuition (if native speakers have intuitions about syllables, as seen in metrical or grammatical traditions) or may be backed phonological evidence such as the ability to bear tone. The “appendix” is then simply a sonority peak below the nuclear threshold. In fricative + stop onset clusters and stop + fricative codas, the fricative is more sonorous than the stop, but not sonorous enough to be a nucleus. Again there is no violation of the SSP.

In keeping with the distinction between gradient sonority and categorical sonorance, the [son] specification of fricatives is not directly tied to their sonority.

Understanding that their sonority behavior is relatively normal with respect to more general principles of sonority and phonotactics, however, indirectly supports the conclusion that they do not need special provisions when it comes to their specification for [son].

2.2.4 Fricatives vs. glides

Many languages have a voiced fricative series with realisations that are highly sonorous, i.e. low in frication noise and air pressure and sometimes with lower stricture. Spanish /b d g/ (ranging from [β ð ɣ] to [β̞ ð̞ ɣ̞]) are a well-known example (e.g. Martínez-Celdrán 2008). Cser (2003:122) remarks on this "highly intimate and problematic relation between voiced nonsibilant fricatives and approximants. The frequency of changes leading from one to the other and the phonetic indeterminacy of the borderline between them has been the source of much descriptive confusion."

The confusion appears to stem from the fact that constriction, air pressure, and turbulence are inter-related gradients. At places of articulation where the constriction is fairly simple (uvular, velar, bilabial), the same degree of constriction is consistent with both a fricative and a glide, and the difference between them can be due to simply the rate of airflow. To complicate matters more, at places of articulation where the constriction creates a more complex path for escaping air, there can actually be steady contact between part of an articulator and a target surface (tongue tip or blade against teeth, lower incisors against upper lip) with greater space on the sides of the passage (due, for example, to at least partly spread lips). The full contact in these cases could make one hesitate to classify the sounds as glides, yet these sounds can still lack any significant pressure buildup or turbulent noise.

If obstruence is cued by pressure buildup, then the voiced fricatives with negligible or zero pressure that we have just discussed are not really fricatives at all. Depending on the details, they might be analyzed either as underlying fricatives and surface sonorants, or simply as sonorants from start to finish.

In spite of numerous complexities, the results of our discussion of glottal continuants, Russian *v*, and sonority are consistent with the specification of fricatives as

[-son]. In the next section we turn to their possible [cons] values.

2.3. Consonance

The [cons] value of glottal continuants may prove ambivalent in the same way that their sonorance has, raising the question of whether fricatives are always consonantal or not. Consonantality is cued by a radical constriction (see Chomsky & Halle 1968:302, Hall 2007:314), and [h ɦ] are most simply produced with glottal abduction, rather than any kind of constriction. Hence the frequent treatment of glottal continuants as vocalic is unsurprising (Pike 1943, Ladefoged 1962, Chomsky & Halle 1968, Kloster-Jensen 1991, Kenstowicz 1994:37, Hall 2007, Riggle 2008). Phonological evidence on the question seems sparse, but Hume & Odden (1996:355-56) note several languages where nasal harmony spreads only through vowels, glides, and /ʔ/ or /h/.

On the other hand, Laufer (1991) argues that [h ɦ] do involve substantial constriction at least in Hebrew and Arabic, which might suggest that they are consonantal. As recent laryngoscopic research has clarified, such constriction would have to be articulated by laryngeal constriction mechanisms higher than the reciprocally paired abductor/adductor complexes that control glottal width alone, and since the larynx has turned out to be a complex series of valves that work together, the boundaries between plain glottals, epiglottals, and pharyngeals are not always easy to locate (Esling, Fraser, & Harris 2005; Shahin, this volume).

Phonetically, then, it seems likely that plain glottal continuants are abducted, do not involve laryngeal constriction, and are thus always [-cons]. If these are dominant realisations of phonologically obstruent glottal continuants (§2.2.1), then fricatives can be [-cons]. Relating phonetics to phonological categories is not always easy, but we will not explore the matter further here. Similarly, if fricative vowels (Kelly 1974, Kaisse 1992, Connell 2007) are ever to be analyzed as [-cons, -son], then they furnish another case of vocalic fricatives, but instead of exploring this question here we only refer the reader to Kaisse (1992) who argues that fricative vowels are [+cons].

2.4. Aspiration

Our final candidate for inclusion in the invariant feature complement of fricatives is [spread glottis] ([sg]), or whatever equivalent a given theory employs to represent aspiration and related phonetic effects, such as [aspirated] in Booij (1999) or H in Government Phonology. Halle & Stevens (1971) assume that fricatives are generally [-sg], though they allow for exceptional cases to be [+sg], as in Burmese. Halle (1995), Tsuchida (1997), and Government Phonology (e.g. Kaye 2000) go in the opposite direction, proposing that all fricatives and aspirates are specified for [sg] or its equivalent. A third option that has gained ground in recent years maintains that in the unmarked case voiceless fricatives are [+sg] and voiced fricatives [-sg] (cf. Blevins 1993, Vaux 1993, 1998, Buckley 1994, Iverson & Salmons 1995 inter alia).[4] Vaux (1998) cites five classes of phenomena in support of this position: (i) voiceless fricatives cause aspiration of stops in the New Julfa dialect of Armenian and in Sanskrit; (ii) debuccalisation and deletion of voiceless fricatives can lead to aspiration of adjacent stops, as in Pali and Seville Spanish; (iii) voiceless fricatives and aspirated stops both resist post-nasal voicing, e.g. in Modern Greek, New Julfa Armenian, and Tarascan, which we can attribute to a ban on *[+nas, +sg] configurations; (iv) Thai tonogenesis groups together voiceless fricatives and aspirated stops (and voiceless sonorants), i.e. the class of [+sg, +stiff] segments; (v) voiceless fricatives pattern with aspirated stops in triggering aspiration dissimilation in New Julfa Armenian.

Subsequent research has identified many additional phenomena consistent with the theory that voiceless fricatives are [+sg] and voiced fricatives are [-sg], but the above examples should suffice to make the point. Neither the traditional Hallean nor the Government Phonology representations of fricatives are able to account for facts of this type.

Beckman & Ringen (2009) and Nicolae & Nevins (2009) suggest a modification to the generalisation proposed by Vaux (1998), namely that it holds only for languages where [sg] is active; in languages where obstruents contrast for

[4]Classic treatments of the phonological system of Nivkh make essentially the same proposal, using [strong] (Jakobson 1957) or 'fortis' (Austerlitz 1956, Hattori 1962) for aspirated plosives and the voiceless fricatives and [weak] or 'lenis' respectively for the non-aspirated plosives and the voiced fricatives.

[voice] rather than [sg], they say, voiceless fricatives are [-voice] (or unspecified for [voice] if it is privative). Both Beckman and Ringen and Nicolae and Nevins base their argument on the fact that in the [voice] languages they have examined phonetically (Finnish for Beckman and Ringen, Russian for both sets of authors), there is no devoicing of following sonorants by voiceless fricatives.

This suggestion (henceforth BRNN, after the surnames of the authors) is intriguing, but unfortunately relies on a single tenuous assumption, namely that if a language contrasts [sg] in obstruents it must spread [sg] from obstruents to following sonorants. The fact that two languages (Russian and Finnish) happen to conform to BRNN is hardly proof of its cross-linguistic validity. If BRNN is true, moreover, it makes an interesting prediction when taken in conjunction with the aforementioned finding that post-nasal voicing (PNV) avoids creating *[+nas, +sg] configurations (Vaux 1998): unlike in [sg] languages such as New Julfa Armenian, where PNV does not target fricatives, it should freely target voiceless fricatives in languages possessing a [voice] rather than an [sg] contrast in their obstruent system (i.e. systems like those of French, Japanese, or Modern Greek, which oppose unaspirated voiced and voiceless stops). This prediction is not borne out: though we know of one so-called [voice] language where PNV applies to fricatives (Nande; Hyman 2003), in all other cases known to us fricatives differ from stops in *not* undergoing PNV, exactly as we find in [sg] languages and counter to the prediction of BRNN. In Modern Greek, for example, sequences of nasal consonant + voiceless fricative either delete the nasal (optional but preferred across word boundaries, as in /ton θeó/ 'the god.ACC' → [toθeó]) or assimilate the nasal to the fricative in place of articulation, with no voicing (word-internally, as in /sin-xoró/ 'forgive' → [siŋxoró]) (Holton et al. 2004).

The BRNN typology has a phonetic dimension as well. Instead of showing that voiceless fricatives (or some of them) are [+sg] only in languages where stops are [+sg], their typology could be reinterpreted as showing that vocal fold abduction overshoots fricative release into a following sonorant consonant in languages where it also overshoots stop release into a following vowel. It is worth asking why we should use gestural overshoot from one segment into a neighboring segment as a diagnostic for that gesture's specification being phonological.

Van Oostendorp (2007) proposes a further modification for Dutch, wherein stops are opposed for [voice], but fricatives are opposed for [sg]. This system is designed to account for the peculiar properties of voicing assimilation in Dutch, which seem to implicate length contrasts as well. If van Oostendorp's proposal is on the right track, we should be able to investigate whether Dutch voiceless fricatives trigger devoicing of following sonorants as a way to explore the BRNN theory further.

What emerges from the research documented in this subsection is that there is strong evidence for a distinction in [sg] specifications between voiced and voiceless fricatives, at least in languages where [sg] is phonologically active. This being the case, we cannot include [sg] values in the set of invariant specifications for the class of fricative consonants.

3. Conclusions

We have argued that the apparently straightforward characterisation of fricatives as [+cont, -son, +cons] and perhaps some value of [sg] turns out on closer inspection to be problematic, but the simpler specification [+cont, -son] appears adequate if glottal continuants are allowed cross-linguistically variable and primarily phonologically determined membership in the fricative class. Fricatives are generally also [+cons], with some peripheral gray areas where the evidence is sparse (§2.3). Finally, it appears that voiceless but not voiced fricatives are generally [+sg], at least in languages where the feature is contrastive, but on that point too the evidence is problematic.

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