

# A brief remark on the role of phonetics in phonology\*

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It is generally agreed that classes of sounds that pattern together are typically definable in phonetic terms and common phonological processes often have a plausible phonetic origin. However, there is a great deal of disagreement in terms of the extent to which phonetics should be built into the phonological machinery or directly referenced by the phonological grammar. In this paper, I examine a few types of phenomena that bear on this issue and suggest how these cases could be handled by theories that adopt different views on the role of phonetics in phonology.

## 1. Introduction

Phonology is generally phonetically natural; classes of sounds that pattern together in phonological processes are typically definable in phonetic terms and common phonological processes generally have a plausible phonetic origin. For example, Kochetov and Alderete (2007) show that Japanese affective palatalization is more likely to target sibilants than other types of consonants and suggest that there is a functional explanation for the special behaviour of sibilants. Sibilants are distinct from other classes of sounds and also distinct from each other psycho-acoustically, and are thus an ideal site for housing “cognitively loaded ... phonological processes” such as affective formation. Most would agree that a proper account of the Japanese affective palatalization should refer to the class of “sibilants”, although it is controversial whether such a functional motivation should be stated as part of the grammar or not. Similarly, Roeder (2009) shows that the distribution of the null variant of the definite article ‘the’ in Yorkshire English is conditioned by the sonorancy of the preceding segment; the null variant is more likely to occur when the preceding word ends in an obstruent rather than a sonorant. The avoidance of having the obstruent dental fricative occur next to another obstruent may be attributed to the difficulty in distinctively perceiving adjacent sounds that are too phonetically similar. Again, whether the functional basis underlying the pattern should be part of the phonological grammar proper or not is controversial, but the proper description of the facts crucially needs to refer to the distinction between obstruents and sonorants.

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One of the contentious issues in the interface between phonetics and phonology is how much of the phonetic details of speech sounds should be visible to the phonological component. What we may refer to as the traditional view of the phonology-phonetics interface assumes that “only a subset of the abundant available phonetic dimensions are chosen for use in formal phonological computation” (Keating 1988, p.283). I will refer to such a view as the Limited Access Hypothesis. More specifically, many of the contributions to this volume share the view that only a minimal amount of phonetic detail — that which is necessary in distinguishing contrastive elements — is visible to the phonological component and is encoded in the form of distinctive features (Rice and Avery 1993, Hall 2007, MacKenzie 2009, Drescher, forthcoming). Under this view, the phonological component may not refer to even very pronounced phonetic characteristics of speech sounds if they do not serve to define a contrast. Moreover, even those phonetic characteristics that define phonological contrasts of the language may still be phonologically inert if they designate the unmarked member of the contrast. I will refer to this particular version of the Limited Access Hypothesis as the Contrastivist Hypothesis, following Hall (2007).

Two recent developments in phonological theory hold a rather different view about the relationship between phonology and phonetics. The “phonetically-grounded OT” claims that phonological processes can be sensitive to fine-grained phonetic details which traditional distinctive features are too coarse to properly describe (Steriade 2001, Hayes, Kirchner, and Steriade 2004). The proponents of this approach claim that phonological patterns may directly refer to the phonetic niceties of speech sounds, and are not necessarily mediated by distinctive features (Flemming 2001). Similarly, the Exemplar model of phonology claims that phonological categories and generalizations on their patterning emerge from “detailed memories of specific linguistic experiences — rather than ... impoverished descriptions of such experiences” (Johnson 2006) and *a priori* there is no limit as to the amount of phonetic information that phonology may refer to; if phonetic characteristics are present, they are visible to phonology and a phonological generalization can develop based on any of them. I will refer to these views as the Direct Access Hypothesis.

In this article, I will briefly discuss a few phonological phenomena that bear on this issue. In section 2, I will discuss cases of phonology-phonetics mismatch where only a subset of the available phonetic details seem to play a role in the phonology. In section 3, I will discuss cases where having more phonetic details, rather than contrastive features, seems relevant. Section 4 concludes the paper.

## 2. "Underrepresentation" of phonetics in phonology

In this section, I will discuss cases of phonology-phonetics mismatch where only a subset of phonetic details seems to play a role in the phonology, which is potentially problematic for the Direct Access Hypothesis. I will consider three different ways such situations arise and discuss how the Direct Access Hypothesis and the Limited Access Hypothesis would deal with each.

## 2.1 Systematic underrepresentation of phonetics in phonology

First, certain phonetic dimensions never define a phonological contrast in language and hence do not play a role in phonology. For example, Keating (1988) discusses how “vocal tract wall tension” alone never seems to define a phonological contrast in any language. Keating also points out that, with ever more sophisticated instrumental phonetic techniques, we may very well discover phonetic regularities we never noticed before, but those phonetic generalizations may have nothing to say about phonological patterns (cf. Coleman 2003).

It is not clear, however, whether this type of evidence counts as an argument against the Direct Access Hypothesis — the fact that certain phonetic dimensions are never exploited by phonology in and of itself does not dispute the rich representational model because it is not the claim of the phonetically-grounded OT or the Exemplar theory that all phonetic details *should* form a phonological contrast or condition phonological patterning. The question remains as to why certain aspects of phonetic details never form the basis of a phonological natural class if all sorts of phonetic dimensions are accessible to phonology. However, a similar question arises for the Limited Access Hypothesis as well — why are only certain phonetic dimensions ever chosen as distinctive features? One way of imposing these restrictions is to assume that features are innate and learners are primed to learn phonological contrasts that are distinguished by their innate set of distinctive features. This solves the learnability puzzle by brute force, but the question still remains as to why certain features are innate, but others are not. In other words, the burden falls equally on the Limited Access Hypothesis and the Direct Access Hypothesis to provide an explanation for such systematic gaps in phonological contrasts.<sup>1</sup>

## 2.2 Temporary underrepresentation I: based on phonetic distinction

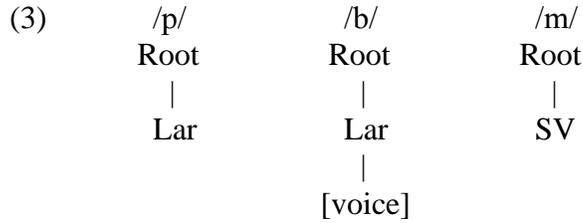
Potentially more problematic for the Direct Access Hypothesis are cases of “temporary underspecification” (cf. Steriade 1995), where a phonetic property that is clearly present in the phonetic form is phonologically inert for only a subset of sounds in the language. For example, in languages with contrastive voicing in obstruents, sonorants often do not pattern with the voiced obstruents, despite the fact that sonorants and voiced obstruents are both voiced. The oft discussed *Lyman’s law* in Japanese illustrates the inertness of the voicing feature in sonorants (Ito and Mester 1986). According to *Lyman’s law*, a voiced obstruent in the second member of a compound blocks the association of a [voice] feature to the initial obstruent of the same morpheme, as shown in (1a), but a (voiced) sonorant does not block the association of [voice], as shown in (1b).

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<sup>1</sup> Quantal theory (Stevens 1972) and Dispersion theory (Lindblom 1990) provide some explanation of the limited use of phonetic dimensions in phonological contrasts. For example, the absence of the feature [vocal tract wall tension] may be due to the fact that this phonetic dimension is not salient and phonetically stably distinctive enough to be consistently employed for contrast. See Flemming (1995/2002) for an attempt to incorporate Dispersion Theory in synchronic grammar.



Laryngeal node). Thus, in languages where nasals do not pattern with voiced obstruents in voicing-related processes, the feature specification would be as shown in (3).<sup>3</sup>



In other words, the feature [voice] is reserved for the type of voicing that is found only in obstruents and not sonorants. Therefore, the inertness of voicing in sonorants is no longer a case of temporary underspecification. Rather, the observed natural class is definable in purely phonetic terms once we revise the relevant phonetic distinction slightly and the apparent mismatch between phonetics and phonology disappears.

### 2.3 Temporary underrepresentation II: based on contrast

However, it does not seem likely that all cases of temporary underspecification could be reanalyzed by modification to the phonetic definition of distinctive features. Radisic (2009) shows that in Serbian first palatalization, /k/ becomes the affricate [tʃ] retaining its [stop] (= [-continuant]) feature, as shown in (4a). /g/, on the other hand, turns into the fricative [ʒ] by the same palatalization process, essentially patterning with the fricative /x/ as shown in (4b), despite the fact that the affricate [dʒ] is available in the same place of articulation.

- (4)
- |     |                      |   |                    |
|-----|----------------------|---|--------------------|
| a.  | ru <u>k</u> a + itsa | → | rutʃitsa, *ruʃitsa |
| b.  | drug + ε             | → | druʒε, *drudʒε     |
| cf. | pra <u>x</u> + iti   | → | praʃiti            |

The key insight of Radisic (2009) is that since Serbian does not have a voiced velar fricative /ɣ/, /g/ can be distinguished from other sounds in the language without being specified as [stop]. /k/, on the other hand, contrasts with /x/ and needs to be specified as [stop]. The featural specification in (5) results when [voice] first specifies the velar obstruents before [stop]; /g/ is uniquely distinguished from the rest of the inventory by being specified as [voice] without the need for any other features. At the next step, /k/ is specified for [stop], but /g/ does not get specified for [stop]. As a result, for phonological processes, /g/ being unspecified for [stop], patterns with /x/ and other fricatives. /g/ is supplied with the feature [stop] by a later rule and is realized as a stop phonetically, resulting in a mismatch between its phonological patterning and its phonetic properties.

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<sup>3</sup> Rice (1993) and Avery (1996) allow variability in the precise phonetic definition of the feature SV (Sonorant Voicing). They allow for voiced obstruents to be specified as SV (“sonorant obstruents”) if they pattern with sonorants in the relevant respects.

(5)		/k/	/x/	/g/
	[voice]			√
	[stop]	√		

From the perspective of the Direct Access Hypothesis, it is puzzling why /g/ patterns with the fricatives (/x/ and /ʒ/), rather than with the stop /k/ or the affricate /dʒ/. Can the Direct Access Hypothesis be salvaged by revising the relevant phonetic dimension that defines this natural class, as in the case of voicing in sonorants? For example, is the closure characteristic of /g/ somehow different from that of /k/ or /dʒ/ such that a more fine-grained phonetic definition of the manner distinction can group /g/ with fricatives and not with stops or affricates? This does not seem very likely. At the postlexical level, where non-contrastive features can be filled in and play a role in regressive voicing assimilation, /g/ devoices to [k], not to [x], patterning as a stop.

Other cases of temporary underspecification that pose a challenge to the Direct Access Hypothesis are found in Dyck (1995), Frigeni (2003), and MacKenzie (2009), among others. These cases provide a strong argument for the special status of the phonetic features that define a contrast of the language. In the next section, we turn to the opposite type of cases, where phonological patterning requires reference to aspects of phonetic representation which do not define a contrast.

### 3. “Overrepresentation” of phonetics in phonology

That the explanation for at least some phonological phenomena should be sought in the physical properties of sound production and perception is not a new idea. However, the phonetic explanation for phonological processes has taken a more prominent status in the phonetically-grounded Optimality Theory (Steriade 2001, Hayes, Kirchner, and Steriade 2004). In this section, I discuss two types of phenomena where phonological processes are sensitive to aspects of speech sounds that are not necessarily contrastive. I will discuss how these phenomena pose a potential challenge to the Limited Access Hypothesis and then introduce some alternative analyses that may still allow us to maintain the Limited Access Hypothesis.

#### 3.1 Same feature in different contexts

The first type of situation where phonetics seems “overrepresented” than necessary for the purpose of contrast is when the same feature behaves differently depending on the context it occurs in. The place feature restriction in consonants of different manners of articulation in Finnish is one such case (Kang 2000, based on Posti 1953, Hakulinen 1961, Harms 1964, Itkonen 1964, Campbell 1976, Karttunen 1970, Keyser and Kiparsky 1984, Branch 1990, Musselman 1997).

In Finnish, the distribution of stop consonants is restricted such that in word-final position and in certain preconsonantal positions, the only stops allowed, other than stops homorganic to a following consonant, are the coronal stops *t* and *n*. Yip (1991) proposes that Coronal underspecification along with the Modified Coda Condition (“Codas may not have Place features”) can account for the place feature restriction in Finnish. However, the generalization regarding the place restriction in stops cannot be stated as a straightforward prosodic restriction on codas. A closer look at the data shows that the

degree of place contrast allowed in Finnish stops varies, as conditioned by the neighbouring segmental contexts and also by the manner features (i.e., nasality) of the stop itself. Table 1 summarizes the patterns of place restrictions for nasal and oral stops in various non-prevocalic contexts.

Table 1: *Place licensing by internal and external segmental contexts*  
(V: vowel, C: consonant, T: nasal or oral stop, F: fricative, L: sonorant)

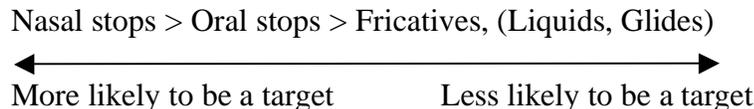
Neighbouring segments	Place restrictions	
	Nasal stops	Oral stops
V_F	HOMORGANIC, COR	HOMORGANIC, COR, LAB, DOR
V_#	HOMORGANIC, COR	HOMORGANIC, COR
V_T	HOMORGANIC	HOMORGANIC, COR <sup>4</sup>
L_C	N/A	HOMORGANIC

It is notable that the external context effect, or the positional effect, is more detailed than a traditional syllable-based account could handle in a straightforward way and likely require reference to the quality of phonetic cues for explanation (cf. Steriade 1997, Côté 2000). Here I will focus on the effect of the internal context, i.e., the manner of articulation of the consonant that houses the potential place feature itself. The striking generalization is that in contexts where there is any asymmetry in the range of allowed contrast between nasal and oral stops (i.e., V\_F and L\_C), it is the nasal stops that allow less possibilities than the oral stops. For example, the environment V\_F (following a vowel and preceding a fricative) shows the least restricted pattern of place licensing. Here, all three oral stops occur before a fricative, as shown in (6). In the same context, however, only a coronal nasal is found in this position as shown in (6).<sup>5</sup>

- (6) a. *lapsi* ‘child’    *katso* ‘look’    *laakso* ‘valley’  
 b. *kansa* ‘folk’    *vanha* ‘old’

Such an asymmetry between nasal and oral stops, with respect to their place feature specification, has been attested in other languages as well. Jun (1995, 2004) observes that, crosslinguistically, nasal stops are more likely to be subject to place assimilation than oral stops, which are in turn more likely to be targeted by place assimilation than fricatives.

- (7) Hierarchy of place assimilation targets (Based on Jun 1995, 2004)



<sup>4</sup> While early loanwords with original /kt/ or /pt/ clusters were adapted in Finnish as /ht/, recent loanwords retain these clusters, as in *adjektiivi* ‘adjective’ and *kapteeni* ‘captain’.

<sup>5</sup> According to Karttunen (1970), *Jämsä* (place name) is the only word with the sequence /ms/.

The data from Malayalam (Mohanani and Mohanani 1984, Mohanani 1993) in (8) illustrate the contrast between nasal and oral stops in this respect. The nasal consonants /m/ and /n/ assimilate to the place of articulation of the following stop consonants, as shown in (8a), but the oral stops /p/ and /t/ do not, as shown in (8b). Jun (1995) reports a similar asymmetry in Brussels Flemish, Hindi, and Keley-I.

- (8) a. *kamala[m k] araŋŋu* → *kamala[ŋ k] araŋŋu* ‘Kamalam cried’  
*kamala[m t] aŋiccu* → *kamala[ŋ t] aŋiccu* ‘Kamalam became fat’  
*kamala[m c] aaŋi* → *kamala[ŋ c] aaŋi* ‘Kamalam jumped’  
*kamala[m p] araŋŋu* → *kamala[m p] araŋŋu* ‘Kamalam said...’  
*awa[n k] araŋŋu* → *awa[ŋ k] araŋŋu* ‘he cried’  
*awa[n t] aŋiccu* → *awa[ŋ t] aŋiccu* ‘he became fat’  
*awa[n c] aaŋi* → *awa[ŋc] aaŋi* ‘he jumped’  
*awa[n p] araŋŋu* → *awa[m p] araŋŋu* ‘he said...’  
 b. *sa[pt]am* ‘eight’  
*u[tk] arŋsam* ‘progress’

The asymmetry between stops and fricatives is illustrated by the German examples in (9) (Kohler 1990, cited in Jun 1995). In German, coronal stops (both nasal and oral) assimilate to the place of articulation of the following stop, as shown in (9a), but coronal fricatives are not affected, as shown in (9b). Jun (1995) also reports a comparable asymmetry in Catalan, Malay and Yakut.

- (9) a. *a[n b] ringen* → *a[mb] ringen* ‘to attach’  
*mi[t b] ringen* → *mi[pb] ringen* ‘to bring along’  
 b. *au[s g] eben* → *\*au[xg] eben* ‘to distribute’

Jun (1995, 2004) explains the implicational hierarchy in (7) based on the relative salience of perceptual cues for the place of articulation in consonants with different manners of articulation. The less salient the perceptual cues for the place of articulation, the more likely the consonant are to be the target of assimilation. Consonantal place cues may be internal (i.e., present during the constriction of the consonants, as in the frication of a fricative) or transitional (i.e., found during the period of coarticulation between the consonant and its neighbouring segment, as in CV or VC formant transitions). While the place cues for pre-consonantal nasal and oral stops are mostly found in the vowel formants (VC transitions), the place cues for pre-consonantal fricatives are encoded not only in the vowel formants (VC transitions), but also in the frication noise itself. A perception test by Hura et al. (1992) indicated that English speakers found fricatives to be less confusable with respect to place than stops and nasals.

In comparing the place cues for nasal and oral stops, nasal stops contained both an internal cue (i.e., nasal murmur), as well as VC transition cues. However, Kurowski and Blumstein (1984) found that neither nasal murmur nor VC transitions alone were enough to reliably signal the place of articulation of preconsonantal nasals. Various studies have converged to show that the place cues for nasals are more similar and confusable than those for oral stops (Miller and Nicely 1955, Malecot 1956, Wang and Bilger 1973,

Ohala and Ohala 1993, Walter and Hacquard 2004). A comparable difference in the confusability of place contrast in nasals vs. oral stops is also found in imperfect rhymes in English and Japanese (Zwicky 1976, cited in Steriade 2001, Kawahara 2007). In other words, the place features of nasals are different from those of oral stops in their acoustic and perceptual manifestations and that difference affects their phonological patterning; [m] and [p] in Malayalam do not pattern together as a target of place assimilation because the quality of their perceptual cues for the place feature differ. Such differential patterning of the place feature in nasals and oral consonants has been put forth as an argument against the Limited Access Hypothesis, and the Contrastivist Hypothesis in particular, since distinctive features appear to be too coarse to capture some of the phonological patterning which shows sensitivity to fine phonetic details (Steriade 2001, Walter and Hacquard 2004, Kawahara 2007). We can consider three possible ways to accommodate this type of data within the Limited Access Hypothesis.

The first possibility is to declare that the type of phonetic motivation that Jun proposes is outside the purview of the grammar proper (cf. Hale and Reiss, to appear). Rather, in these cases, phonological representation is only required to identify the natural classes of sounds attested in phonological patterns, such as nasal stops and oral stops, with contrastive features. For example, in Malayalam, the target of place assimilation can be restricted to the class of sounds specified as [nasal] (or [SV]) and the different behaviour of place features in nasal vs. oral stops need not be built into the place feature per se and thus the phonetic details of the place feature need not be referred to by the phonology. In this approach the phonology is not obligated to account for why it is that [nasal] sounds are preferentially targeted by assimilation rather than, say, [strident].

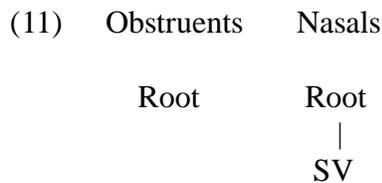
However, such a move to declare certain phonological generalizations as “outside phonology” raises the question as to which type of facts require phonological explanation and which do not. In fact, the asymmetrical patterning of sound classes in assimilation processes forms the basic evidence for structural asymmetry (Rice 2003, Arsenault 2009, Kim 2009, Jamirez 2009, Rohany Rahbar 2009). For example, Rohany Rahbar (2009) proposes that the Persian mid front vowel /e/ is unmarked for both place and height features, since it is preferentially targeted by place and height assimilation processes. However, then, it is unclear why the asymmetrical patterning of nasal and oral place features should not inform our hypotheses about phonological structure. Without principled criteria to determine why certain phonological generalizations require phonological treatment and others do not, this first approach remains unsatisfactory.

The second possibility is that the place feature specification may differ for nasals and obstruents within the same language, due to asymmetry in the inventory. This difference in the representation could then account for the asymmetry in assimilation and distributional restrictions. Indeed, in Malayalam, nasals allow less place contrasts than oral stops underlyingly, as shown in (10), based on Mohanan (1986, p.68).

(10)	Bilabial	p	p <sup>h</sup>	b	b <sup>h</sup>	m
	Dental	t	t <sup>h</sup>	ɖ	ɖ <sup>h</sup>	
	Alveolar					n
	Retroflex	ʈ	ʈ <sup>h</sup>	ɖ	ɖ <sup>h</sup>	ɳ
	Palato-alveolar	c	c <sup>h</sup>	ɟ	ɟ <sup>h</sup>	
	Velar	k	k <sup>h</sup>	g	g <sup>h</sup>	

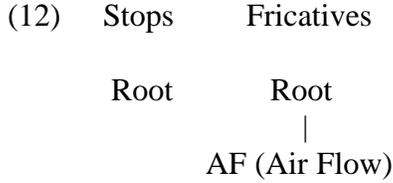
In Malayalam nasals, unlike in oral stops, /m/ is the only Peripheral place and oral stops contrast more in coronal places than nasals. The asymmetry in the areas of contrast affects the way features are specified and as a result, they are not necessarily expected to pattern the same way in assimilation, contrary to the implicit assumption made in some studies on this topic (Steride 2001, Walter and Hacquard 2004, Kawahara 2007). However, it remains to be seen whether the Malayalam place assimilation asymmetry in nasal and oral stops could be derived from a difference in place feature specification based on the asymmetry in the inventory. Also, it remains to be seen whether all cases of nasal and oral stop asymmetry reported in the literature could be reanalyzed and attributed to asymmetry in the inventory.

The final possibility we will consider is to allow the place assimilation restriction to follow from the general principle of structural complexity, along the lines of Rice and Avery (1993). Rice and Avery (1993) observe that crosslinguistically, the range of place of articulation contrast decreases with increasing sonority. In particular, if the number of places of articulation available to oral stops and nasals is not equal in a language, stops tend to show a greater range of place contrasts than nasals (Ferguson 1963, Crothers 1975, Maddieson 1984, Rice and Avery 1993, Hamilton 1996). Rice and Avery (1993) account for this crosslinguistic tendency by assuming that inventories are built up, gradually adding more structure, such that the existence of more complex segments presupposes the existence of less complex ones. Their auxiliary assumption is that different manners of articulation are distinguished by other levels of structure under the Sonorant Voicing node, with more sonorous sounds having additional specifications. The relevant part of the structure for obstruents and nasals is shown in (11).

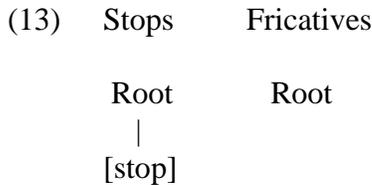


As a result, the degree of place contrast allowable for a given manner of articulation is inversely correlated with the complexity of its SV structure, since an inventory allows a more complex structure only after a less complex structure is already in use. In particular, the theory correctly predicts more place contrasts for obstruents than for nasals. We can extend this idea to the place assimilation facts. An independent place specification in a prosodically weak position, e.g., pre-consonantal position, is more likely to be avoided when the segment has a more complex structure. Therefore, pre-consonantal nasals are more likely than obstruents to lose their place feature and be assimilated to the following consonant. While the contrast between obstruents and nasals is straightforward, we must now see whether the contrast between fricatives and stops could also be accounted for based on the structural complexity principle.

Rice and Avery (1993) assume that fricatives are more marked than stops and are therefore structurally more complex, as in (12).



However, the structure in (12) and the principle of structural complexity predict fricatives to be more susceptible to assimilation than stops, contrary to Jun’s generalization in (7). One possibility is to assume that the markedness relationship between stops and fricatives is language-specific (as in the case of place of articulation: cf. Rice 2007). In languages where stops are preferentially targeted in place assimilation over fricatives, the markedness relationship between fricatives and stops could be as in (13), i.e., the opposite of (12).



Indeed, in German, since fricatives outnumber stops in place contrasts (/ f v s z ʃ ʒ ç x (h)/ vs. /p b t d k g/), we can assume that stops are marked with more structure than fricatives with respect to manner. This would account for why fricatives can afford more place structures in general and why they can also maintain their place feature in the prosodically weak pre-consonantal position. Further research is required to examine whether the structure-based account could be extended to other languages with fricative-stop asymmetries in place assimilation.

### 3.2 “Redundant” features and the boundaries of phonology

Another situation where phonetics seems “overrepresented” than necessary for the purpose of contrast is when a given contrast is distinguished by multiple phonetic attributes. The laryngeal contrast in English is a very thoroughly studied case, where a single contrast is signalled by multiple cues, i.e., voicing, VOT, F<sub>0</sub>, F1, neighbouring vowel length, constriction duration, etc. (Kingston and Diehl 1994, Kingston et al. 2008) A common approach is to designate one of the attributes as “contrastive” and derive the other “redundant” phonetic characteristics from phonetic enhancement rules (cf. Keyser and Stevens 2006). The Contrastivist Hypothesis makes a very tight empirical prediction in these cases — namely, that only one of these phonetic attributes can be phonologically active. This prediction is applicable not only to synchronic grammar, but also to the potential development of new phonological patterns via reanalysis by the language learner. For instance, we can consider a situation where two segments /b/ and /p/ are differentiated by both voicing ([slack vocal folds]) and the F<sub>0</sub> of the following vowel ([stiff vocal folds]) (cf. Halle and Stevens 1971).

(14)

	/b/	/p/
Voicing ([slack])	+	-
F <sub>0</sub> raising on the adjacent vowel ([stiff])	-	+

In the absence of phonological processes that crucially refer to either of the two features, the learning data are ambiguous as to which of the two features should be designated as contrastive and which should be redundant. This creates the potential for a new phonological process to develop that refers to either of the two features, making it unambiguously the contrastive feature. For example, in this hypothetical case, the language could develop a voicing assimilation rule in obstruent sequences, making [slack] a phonologically active feature, and therefore contrastive, as shown in (15).

(15)

	/b/	/p/
Voicing ([slack])	√	

However, once such a pattern is established, the Contrastivist Hypothesis predicts that no phonological process actively referring to the redundant feature [stiff] could develop, because our hypothetical language cannot have both [slack] and [stiff] be contrastive features.

In this respect, recent developments in the Korean lenis-aspirated stop contrast provide an interesting case study. Korean has a much discussed three-way contrast in stops and affricates: lenis, fortis, and aspirated. Here, for ease of exposition, I will limit the discussion to the contrast between the lenis and the aspirated series of stops. In the traditional description of sounds, the aspirated series is differentiated from the lenis series by a longer VOT and higher F<sub>0</sub> on the following vowel (See Cho et al. 2002 for a recent review of the literature), among other cues, as summarized in (16).

(16)

	/p/	/p <sup>h</sup> /
Aspiration ([spread])	-	+
F <sub>0</sub> raising on the adjacent vowel ([stiff])	-	+

Here again, the question arises as to which of these multiple phonetic attributes should represent the underlying contrast and which are the redundant properties (Kim 1965, Kim 1998, Avery and Idsardi 2001, Kim and Duanmu 2004, Ahn and Iverson 2004, among others) Ahn and Iverson (2004), for example, assume that the contrast is one of aspiration (or Glottal Width, following the Dimension theory of Avery and Idsardi 2001) and the [stiff] (or Glottal Tension) feature is added as an enhancement feature.

Phonologically, there is evidence for the role of [spread]. When a lenis stop occurs next to /h/, which is [spread], the lenis stop and /h/ merge and are realized as an aspirated stop, as shown in (17). Based on this phonological evidence, [spread] should be designated as the contrastive feature for /p/ and /p<sup>h</sup>/, as shown in (18).

- |      |            |                       |                           |
|------|------------|-----------------------|---------------------------|
| (17) | /ip-hi-ni/ | [ip <sup>h</sup> ini] | ‘wear-CAUSATIVE-QUESTION’ |
|      | /noh-ta/   | [not <sup>h</sup> a]  | ‘let go-ENDING’           |
|      | /tok-hak/  | [tok <sup>h</sup> ak] | ‘self-study’              |
- 
- |      |                       |     |                   |
|------|-----------------------|-----|-------------------|
| (18) |                       | /p/ | /p <sup>h</sup> / |
|      | Aspiration ([spread]) |     | √                 |

Given that [spread] is contrastive, the other feature, i.e., [stiff], is not expected to play a role in phonological patterning. However, studies on Korean intonation show that the consonant-induced F<sub>0</sub> perturbation is conditioned by prosodic structure and is far-reaching in its effects (Jun 1996, Silva 2006).

The Korean AP (Accentual Phrase) is marked by boundary tones. The AP-initial boundary tones are LH when the initial segment is a sonorant or a lenis obstruent, but they are HH when the initial segment of the phrase is an aspirated obstruent, a fortis obstruent, /s/, or /h/. Jun (1996) compares the consonant-induced F<sub>0</sub> perturbation in Korean with that of English and French in similar phonological contexts. The results show that the consonant-induced F<sub>0</sub> difference in Korean in AP-initial position is far greater than that found in English and French. Also, unlike in English and French, the F<sub>0</sub> difference in Korean is sustained through the entire syllable and beyond (also see Silva 2006). In addition, the significant consonant-induced F<sub>0</sub> difference was found only in AP-initial position, indicating that the F<sub>0</sub> effect interacts with the prosodic structure. Based on these findings, Jun (1996) concludes that “unlike in English and French, the phrase initial H tone in Korean is ... *phonologized* [emphasis YJK].”<sup>6</sup> Perception studies also show that, in contemporary Korean, it is the acoustic characteristics of the vowel following the stops, rather than the VOT of the stops, that provide the primary perceptual cue in distinguishing lenis and aspirated stops (Cho 1996, Kim et al 2002). This clearly presents a challenge to the Contrastivist Hypothesis, since both [spread] and [stiff] appear to be phonologically active in Korean. We can consider a few ways to reconcile these facts with the Contrastivist Hypothesis.

The first possibility is that situations where redundant features participate in phonological activity can exist only as a transitional stage and cannot persist over time. We could assume the contrast between /p/ and /p<sup>h</sup>/ is transitioning from one of aspiration to one of tone in Korean; as the tonal contrast further establishes itself, the aspiration contrast is expected to fade out. Interestingly, an apparent time study of laryngeal contrast change in Korean (Silva 2006) shows that, while in older speakers both VOT and F<sub>0</sub> are reasonably differentiated for aspirated and lenis categories, in younger speakers, F<sub>0</sub> remains systematically distinctive, but VOT lost its distinctiveness and is almost indistinguishable between the two categories. In other words, a grammar where both [spread] and [stiff] features are active (i.e., the grammar of older Koreans in Silva 2006) is an undesirable grammar which can exist only in transition, soon to be replaced by a more stable grammar where only one of the two features play a role (i.e., the grammar of younger Koreans in Silva 2006). However, whereas the surface phonetic distinction appears to be shifting from one of aspiration to one of vocal fold tension, there is no

<sup>6</sup> See Ko (2003) for an alternative view that the consonant-induced F<sub>0</sub> effect is phonetics, not phonological.

evidence that the aspiration process in (17) is disappearing in the speech of the younger generation of Korean.

The second possibility is to assume that the features that phonological processes are dealing with are more abstract than [stiff] or [spread]. Rather, the phonological feature could be realized as either [stiff], [spread], or both, depending on the context. In other words, a phonological feature need not necessarily be defined by a single phonetic attribute (i.e., a single gesture or acoustic parameter) but multiple phonetic attributes contribute to signaling the contrast.<sup>7</sup> But, this move needs a concrete theory of how abstract phonological features could be established and learned and what types of phonetic attributes can be yoked together under a single feature.<sup>8</sup>

The third possibility is to limit the domain of “phonology” where the Contrastivist hypothesis holds true to what amounts to a lexical level in Lexical Phonology (Kiparsky 1982; cf. Clements 2001). The H tone insertion at the AP boundary in Korean is clearly a post-lexical process and would then not be bound by the Contrastivist Hypothesis under this assumption. This then creates an interesting empirical prediction that can be tested — namely, a “redundant” feature ([stiff] in this case) can develop a phonological activity only arise at the post-lexical level; the phonological activity cannot develop into a lexical process or a lexical contrast as long as the original consonantal contrast ([spread] in this case) is phonologically still active.

#### 4. Conclusion

In this paper, I addressed the question of how much phonetic detail should be available to the phonological grammar by examining both those cases where phonetics seems “under-represented” — compared to the surface phonetics — and those where phonetics seems “overrepresented” — compared to what is minimally necessary for contrast — in phonology. While it is clear that allowing the phonology full access to phonetic information, whether the phonetic attributes are contrastive or not, is inadequate, the Contrastivist Hypothesis requires a clearer demarcation of the domain of phonology where it is purported to hold.

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<sup>7</sup> Keyser and Steven (2006) similarly allow enhancement relationship can be established between unrelated gestures and acoustic attributes as long as they all contribute to a contrast more distinct.

<sup>8</sup> Kingston (2007) pursues a possibility that there may still be an invariant phonetic attribute that ties together all acoustic characteristics that participate in English voicing contrast, namely, low frequency energy.

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