The Phonetics-Phonology Interface Revisited
Where’s Phonetics?*

Abigail C. Cohn
Cornell University

1. Introduction

Optimality Theory has led to a major rethinking of the nature of phonology. Since phonetic implementation depends, of course, on the nature of the phonological structures available for implementation, it seems appropriate at this junction to consider the consequences of Optimality Theory for phonetic implementation and the phonology-phonetics interface more generally. As a caveat at the outset, this paper is a discussion of a number of questions, for many of which only sketchy answers (at best) are provided. The central point is that these are fundamental questions that those of us interested in phonetics or phonology should bear in mind and work toward understanding.

The age-old paradox that speech is both discrete and continuous is captured nicely by Hockett’s analogy:

Imagine a row of Easter eggs carried along a moving belt; the eggs are of various sizes, and variously colored, but not boiled. At a certain point, the belt carries the row of eggs between the two rollers of a wringer, which quite effectively smash them and rub them more or less into each other (Hockett, 1955, p. 210).

A common view of this dual aspect of speech is that phonology is the domain of the discrete, whereas phonetics is the domain of the continuous. This leads to the question of how we capture this dual aspect of speech in a non-derivational way. In order to consider this question, I start with some background on the relationship between phonology and phonetics. As shown in (1), there is an implicit connection between phonology, which manipulates abstract sound patterns, and phonetics, the physical realization of those patterns. Yet, what is the nature of this relationship?

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(1) An implicit connection
Phonology abstract patterns
Phonetics physical realization, what a speaker produces or hearer hears

To see what is really at issue, it is worth reviewing the recent history of the views of this relationship. As schematized in (2a), the SPE (Chomsky and Halle, 1968) view assumed that the binary features of the phonology were translated into numeric scales, resulting in a formal state in the derivation called "the phonetic transcription". Everything beyond this numeric specification of features, for example coarticulation, was thought to be universal and therefore outside the purview of the linguistic grammar (indicated here by a box). Thus the distinction between phonology and phonetics appeared to be clear cut: phonology = language specific rules, phonetics = universal mechanical realization of the phonology. As a consequence, phonetic implementation was unimportant from a linguistic point of view and, in effect, somebody else's job.

(2) a. Traditional view (SPE) b. More recent view
(e.g. Keating, 1985)

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phonological rules
↓
the phonetic transcription
↓
universal phonetic impl. rules
↓
physical output
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phonological rules
↓
lang.-specific phonetic rules
↓
universal phonetic impl. rules
↓
physical output
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More recently, much evidence of the language-specific nature of coarticulation and other aspects of phonetic implementation have been discussed in the literature. An often-cited case (which is actually more complex than it might appear) is that of vowel lengthening before a voiceless stop or sonorant (as discussed by Chen, 1970; Keating, 1985; and others.) As widely noted, vowels before voiceless stops are shorter cross-linguistically than those before voiced ones, e.g. *beet /bêt/ [bêt] vs. *bead /bɛd/ [bɛ:d]. Yet the degree to which this shortening (or lengthening, depending on how you look at it) takes place is language-specific. Based on a number of studies, typically the ratio of a vowel before a voiceless stop to that before a voiced one is about 9; while in some studies in English it has been shown to be as small as .79 and in Polish as great as .99. Keating and others conclude from this that some portion of the phonetics is under speaker/hearer control. This then leads to the model in (2b), where at least some aspects of the phonetics are part of the linguistic grammar (indicated by the box). (Though I wouldn't necessarily assume that the phonetics is divided into two parts, as this graphic representation might suggest.)

These sorts of observations showing a richer role of phonetics have led to a rethinking of both the role of phonetics and its relationship to phonology and have resulted in a couple of important strains of research. These include generative phonetics, as exemplified notably by Pierrehumbert's (1980) dissertation and the approach of laboratory phonology, growing out of the series of LabPhon meetings (starting with the first proceedings edited by Kingston and Beckman, 1990) and related work. These bodies of work have informed our understanding of the relationship between phonetics and phonology and have led to a view where the linguistic aspects of the phonetics are viewed as a system, different from, but in some senses parallel to, the phonology. Pierrehumbert and Beckman (1988, p. 5) capture this nicely:

The phonetic rules are like phonological rules in that they seek to describe complex regularities in sound structure through the interaction of a few general principles. They differ from phonological rules in the representations that they manipulate. They take as input phonological representations, but their output consists of quantitative functions, representing facts about articulations or sounds.

Once we understand this more complex view of the phonetics, many questions, both theoretical and empirical, arise about how the phonetics and phonology inform each other: What's phonetics? What's phonology? How are they related? We return below to these questions.

2. Implications of Optimality Theory for the Phonetics-Phonology Interface?

In addition to general questions about the relationship between phonetics and phonology, we might ask in what ways Optimality Theory (Prince and Smolensky, 1993; McCarthy and Prince, 1993a, etc.) leads to a rethinking of the phonetics-phonology interface. First, somewhat trivially, the results of OT suggest that phonetics should be viewed in non-procedural terms. Consistent with much recent work, I think we can conclude that a non-derivational phonetics consists of a set of quantitative constraints, resulting from articulatory, aerodynamic, and perceptual requirements, evaluated in light of phonological structure.

A non-derivational phonetics is compatible with many of the assumptions already made within generative phonetics. First is it generally assumed that there shouldn't be any extrinsic ordering of rules within the phonetics. Implementation is necessarily constrained, both by the representation it is implementing and certain independent requirements of phonetic well-formedness, as suggested by a wide body of phonetic literature (e.g. Ohala, 1983; Stevens, 1989; Kingston, 1990; Lindblom, 1990). As schematized in (3), the phonetics is thus the implementation of phonological structure mediated by phonetic constraints on well-formedness. ¹

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(3) Phonetic well-formedness

+ Implementation of quantitative values in real time and space
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While I believe such a view of phonetics is largely uncontroversial, this leads us to the more complex question of the relationship between non-derivational phonology and phonetics. I would like to break this into a few related questions:

¹ I believe that this general approach would also address some of the issues raised by Pierrehumbert (1994b).
(4) a. Are phonetics and phonology distinct?
   b. If so, how are the differences realized within a non-derivational framework?
   c. What is language-specific and what is universal?

I will argue that indeed phonetics and phonology are distinct. This leads to the question of how such differences are realized non-derivationally and here I will reach less firm conclusions, but I will suggest a couple of possibilities and finally touch briefly on the question of what is language-specific and what is universal.

Before continuing, I would like to address a terminological issue: what is meant by the term *gradience*. Gradience has been used in the sound structure literature in a number of ways recently and I want to clarify what I mean. I use the term here to refer to temporal gradience, or change over time. For example, consider the patterns of nasal airflow in French and English (as discussed in my dissertation, Cohn, 1990), with nasal airflow taken as the realization of the feature Nasal as exemplified in (5).

(5) Examples of nasal airflow in French and English

![Airflow Diagrams]

a. French daim ‘deer’ /d<e>/
   b. English den /den/

In the case of a nasal vowel in French, here exemplified in the form /d<e>/ (5a), there is almost no nasal airflow on [d] and there is significant airflow throughout the [e]. Here we observe plateaus corresponding to the phonological patterns, connected by a rapid transition. In English on the other hand, during a vowel preceding a nasal consonant, such as [e] in [den] (5b), there is a gradient pattern—or a cline—following the oral [d] and preceding the nasal [n] (both characterized by plateaus).

*Gradient* has been used in a number of other ways besides the above (though some of these may be related to the sense used here). These include first optionality and variation, as discussed by Antilla (1995) and work cited therein. Probably related to the question of optionality and variation is the notion of gradience across the lexicon, for example, gradient effects of the OCP as discussed by Pierrehumbert (1994a) and Frisch et al. (1997). These latter two senses of gradience are very important and have to be accounted for in an adequate theory, but I won't address them here. Finally *gradient* has also been used to refer to constraint satisfaction (e.g. McCarthy and Prince, 1993b), where more violations of a particular constraint are worse than a single violation. This use is quite distinct from the others and will not come into play in the present discussion.

Another important issue is the nature of phonological (under)specification from a non-derivational perspective, since most theories of underspecification are inherently derivational. See Smolensky (1993), Frisch et al. (1997), Kirchner (1997), among others, for discussion of this issue. Although this is clearly relevant for many of the questions here, it is nevertheless a separate question, and I won't focus on it in the context of this paper. I assume here that phonological representations consist of feature specifications.

3. Evidence that Phonetics and Phonology are Distinct

We turn now to the relationship of phonetics and phonology. The general position put forward by Pierrehumbert and Beckman (1988), Keating (1990), Cohn (1990), and others is that the phonetics and phonology are distinct—phonology manipulates discrete abstract units, phonetics manipulates gradient quantitative values. The output of the phonology is the input to the phonetics, with the phonetics adding the quantitative, temporal dimension to the more abstract phonological representations. From this perspective, the phonology-phonetics interface consists of the translation of a static representation into a dynamic one, realized in both time and space. I think we can take this to be the currently standard view. Yet it has been called into question in some recent work (e.g. Kirchner, 1997; forthcoming; Steriade, 1997; among others); and therefore it is important to review the evidence for these conclusions in the first place and reassess the evidence from a non-derivational perspective.

3.1. A Clustering of Properties: Phonetics vs. Phonology

First, as has been observed by a number of researchers (including Keating, 1990; Pierrehumbert, 1990; and Cohn, 1990), there are clusterings of properties characteristic of phonology on one hand and phonetics on the other. Keating’s (1996) characterization is presented in (6):

(6) Clustering of properties: phonology vs. phonetics (Keating, 1996, p. 46)

<table>
<thead>
<tr>
<th>Phonology</th>
<th>Phonetics</th>
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<tbody>
<tr>
<td>• symbolic representations</td>
<td>• physical representations</td>
</tr>
<tr>
<td>• allow idealization of temporal chunking (segmentation)</td>
<td>• continuous in time and space</td>
</tr>
<tr>
<td>• qualitative categorization (labels), timelessness</td>
<td>• internal temporal structure allows overlap</td>
</tr>
<tr>
<td>• rules manipulate features and feature values, associations</td>
<td>• quantitative values on multiple independent dimensions</td>
</tr>
<tr>
<td>• thus phonological rules can be category changing, produce static changes over the whole segment; can be lexical/cyclic</td>
<td>• rules interpret feature values in time and space, can be gradient</td>
</tr>
</tbody>
</table>

The degree to which the clustering in (6) is robust supports the conclusion that the phonology and phonetics are distinct. If the clustering of properties in (6) allows us to characterize most cases, then an adequate theory of sound structure should capture this insight. It is important to note that even if there are some exceptions to this clustering, it doesn’t mean that the distinction doesn’t exist. To identify a few ambiguous cases and therefore conclude that the distinction is not valid does not advance our understanding of sound structure; rather, we need to ask whether the distinction is useful in accounting for observed sound patterning. If so, an adequate theory should incorporate the distinction and also account for any exceptions. Keating
(1996) reaffirms these results, reviewing numerous cases of sounds patterning which are more illuminatingly treated as phonetic implementation than as phonological rules (or constraints). Let us now consider a range of additional evidence.

3.2. Phonetic and Phonological Doublets

Striking evidence for the distinction between phonetics and phonology comes from cases which display both categorical and gradient manifestations of the same phenomena, what we might call phonetic and phonological doublets.

One such case is nasalization in Sundanese. Since I have discussed this case at length elsewhere (Cohn, 1993, 1995), I will try just to give the flavor of the doublet effect here. In Sundanese, within the word, [+nasal] "spreads" rightward from a nasal consonant, till blocked by a non-nasal supra-laryngeal consonant (as originally observed by Robins, 1957). We can see the effect of this process (or constraint in non-procedural terms) in the phonetic realization, exemplified by the representative nasal airflow traces in (7).

(7) Categorical patterns of nasal airflow in Sundanese

![Airflow traces](image)

a. /ŋətut/ 'arrange' (active)  
b. /ŋəbah/ 'change' (active)

In (7a) and (b), substantial nasal airflow occurs on both the initial nasal and the following vowel, but not on any of the subsequent segments. (The marked difference in level of nasal airflow between the nasal consonant and the following vowel is due to the differences in degree of oral constriction: greater oral constriction results in higher nasal airflow, all else being equal.) In these cases, there is a rapid change in nasal airflow between the vowel and the following (blocker) consonant, precisely the kind of transition we would expect to see between adjacent nasal and oral segments.

We observe that phonologically nasal segments, either underlyingly (in the case of nasal consonants) or as a result of the phonological pattern of nasalization (in the case of nasalized vowels) have a relatively high degree of nasal airflow throughout their duration. In contrast, segments which block the phonological spread of nasalization—voiced and voiceless stops—are oral throughout most of their duration. These results suggest a direct interpretation of the phonological structure by the phonetics. But not all phonological blockers behave the same way: consider [l] and the glides. A priori, we would expect to see the same pattern as above, with a rapid change in nasal airflow between a nasalized vowel and a following blocker consonant.

Surprisingly, we see a gradient pattern of nasal airflow throughout the glide (8a) and (8b). This pattern is quite different from the more abrupt changes in nasal airflow that we saw in (7). As I have argued elsewhere, the pattern in these examples looks like smooth interpolation throughout the duration of a phonologically unspecified segment following a segment with a ‘+’ specification. In Cohn (1995), I argue that this is due to both qualitative and quantitative constraints. The categorical pattern arises due to the interactions of restrictions on NASALCOOCCURRENCE and SPREADNASAL, while the gradient results are due to the effect of a quantitative constraint PERMEATENASAL: A nasal specification is realized temporally as broadly as possible.

There are numerous other cases of phonological and phonetic doublets cited in the literature. Two such cases are discussed in this volume. Tsuvida (1997, and this volume) investigates the case of vowel devoicing in Japanese. As Tsuvida shows, vowel devoicing in Japanese exhibits both categorical and gradient manifestations. Devoicing of high vowels in the appropriate environment is categorical, while there are gradient effects of undershoot in cases with both high and non-high vowels where devoicing is not expected. Another such case is the realization of voiced singleton vs. geminate stops, discussed by Ham (1997) and Podesva (1998a). In singletons, voiced obstruents are shorter than voiceless ones, a cross-linguistically strong generalization. This is a gradient phonetic effect argued to be due to the aerodynamic difficulty of maintaining voicing in obstruents (as discussed by Ohala, 1983). On the other hand, the undesirability of voiced obstruent geminates is often dealt with categorically, either with a prohibition on voiced geminate stops (such as appears to be the case in Madurese after full vowels) or an alternate realization. This is the case in Buginese, where in voiced obstruent geminates arising across a prefix, a glottalized voiced stop surfaces, which Podesva argues is the result of a phonological constraint against voiced geminates.

Finally consider the case of palatalization in English, discussed by Zeiga (1995). Zsiga contrasts cases of lexical palatalization, e.g. impression, vs. postlexical palatalization, e.g. press you, based on both acoustic and articulatory evidence. She found that the [ʃ] in impression, which she argues to be derived from a lexical rule of palatalization (something which might be taken to be debatable) is not distinct from underlying [ʃ] in, for example, fresh. This is seen in the following figure (a composite of three of her figures).
possible ones. A nice example of this is the difference in temporal organization vowel and consonant gestures found in Japanese and Italian, as discussed by Smit (1995). Finally, phonology doesn’t seem sensitive to specific phonetic mechanism to realize a goal or outcome. For example, there are different means of achieving phonologically voiced stop (see Kingston and Diehl, 1994, and work cited therein) at different ways of achieving vowel height contrasts, as evidenced by bite block experiments (Lindblom et al., 1979).

There is also information that is relevant to phonology (in that it may play a role in conditioning phonological patterns), but which appears not to be directly relevant to phonetic implementation. These include grammatical structure and morphologic conditioning. While apparent counter-examples exist, it appears that in many of the cases, the relevant information can be represented in prosodic terms, rather than morphological or syntactic ones. Following the view presented by Pierrehumbert and Beckman (1988), the prosodic information is available to the phonetics.

3.4. Principles of Phonology

Next we might ask what the phonology proper contributes to the realization of sound patterns. What sorts of linguistic principles are specific to the phonology? Some such principles are convincingly argued for in the recent work by Hayes (1995) and Gordon (1997). Hayes, on the basis of cross-linguistic patterns of post-nasal voicing, argues that while the observed patterns are clearly driven by the phonetic realization is mediated by principles of the phonology—notably symmetry accounting for observed patterns not predicted by the phonetics alone. Gordon, on the basis of observations about the nature of weight distinctions, argues that principles of both symmetry and simplicity are required to account for observed patterns. While these principles are argued to be part of the phonology, they might of course be more general cognitive principles, but crucially they aren’t principles of the phonetics.

3.5. Non-transparent, Non-"natural" Aspects of the Phonology

There are numerous cases in the literature where the interpretation of phonological feature isn’t transparent. This conclusion is of course dependent on the degree of how features are assumed. One notorious case is that of the feature Voice (discussed by Keating, 1984; Kingston and Diehl, 1994; among others), where what argued to be a phonological contrast in Voice may show a wide range of phonetic realizations both within a given language and between languages.

In “Why phonology isn’t ‘natural’”, Anderson (1981) argues that there are numerous domains that impinge on language (or in this case phonology), but he goes on to argue that the intersection of these domains alone can’t account for everything, that the grammar itself also contributes. This is illustrated in his figure (1) (p. 494 reproduced here:}
All of these sources of evidence—observed clustering of properties, phonetic and phonological doublets, information not shared by the two domains, distinct principles and non-natural aspects of phonology—converge: phonology and phonetics are distinct.

4. How is the Distinction between Phonology and Phonetics Realized within a Non-derivational Framework?

The reaffirmation of the conclusion that phonology and phonetics are distinct returns us to the important question of how this distinction is realized within a non-derivational framework.

Minimally phonology and phonetics have different vocabularies. The differences include the following. First the units are different. In the phonology it is phonological features and abstract units of length that are the relevant building blocks; while in the phonetics, sound patterns are realized along concrete phonetic dimensions and in terms of absolute or raw duration. Also as argued by Cohn (1995) and Zsiga (1998), to account for observed patterns, both qualitative and quantitative constraints are needed, argued to be under the purview of phonology and phonetics respectively. The two domains exhibit distinct principles. For example, as discussed above, the principles of symmetry and simplicity play a role in the phonology, but not the phonetics; while principles such as ease of articulation and perceptual salience play important roles in the phonetics. (Though Myers (1997) argues that constraints of ease of articulation and perceptual salience can have phonological counterparts.) Finally it has been argued by Myers (1997) and Zsiga (1998) that phonology and phonetics exhibit different means of constraint interaction. In the phonology, constraints are evaluated through strict dominance, while in the phonetics it is argued that there is weighted evaluation. These differences are summarized in the following chart.

(12) The vocabulary of phonology vs. phonetics

<table>
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<tr>
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<th>Phonology</th>
<th>Phonetics</th>
</tr>
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<tbody>
<tr>
<td>a. building blocks</td>
<td>phonological features &amp; abstract units of length</td>
<td>phonetic dimensions &amp; raw duration</td>
</tr>
<tr>
<td>b. constraint types</td>
<td>qualitative</td>
<td>quantitative</td>
</tr>
<tr>
<td>c. principles</td>
<td>e.g. symmetry &amp; salience</td>
<td>e.g. perceptual salience &amp; ease of articulation</td>
</tr>
<tr>
<td>d. modes of constraint interaction</td>
<td>strict dominance</td>
<td>weighted evaluation</td>
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An adequate theory of sound systems must of course account for these differences in vocabulary and I believe such differences argue for there being two distinct domains. In a non-derivational way, we might think of two blocks or domains of constraints acting on a particular representation. If the evidence for distinct means of constraint interaction proves to be robust, there must minimally be distinct blocks. But beyond this, there is a sense in which the phonetics acts on the phonology, suggesting that there might actually be partial serialization. Should this disturb us? First we need to remember that parallelism is a logically independent aspect of Optimality Theory (as discussed by Prince and Smolensky, 1993). The real question is whether there is empirical motivation; not only do we want a constrained theory (which would a priori
argue against partial serialization), but we also want one which closely matches the observed phenomena. Such a solution would not be radical, as many researchers have argued for distinct levels or partial serialization within the phonology to account for what derivationally was accounted for through the "lexical" / "post-lexical" distinction. Thus the idea that two distinct domains of the grammar work this way does not necessarily seem to be troubling, and would directly account for the sort of differences detailed above. I don’t have time to present a detailed example here of how this would work, but I’d like to mention Tsuchida (this volume) as an excellent example of how OT and phonetic implementation might work together.

A consequence of these conclusions is that there will be corresponding qualitative and quantitative constraints. Is this a problem? I think not. Rather this is precisely what it means for something to become phonologized (Hyman, 1976). Once a phonetic tendency becomes enhanced or suppressed enough, the effects become categorical and the relevant phonological constraint imposes itself (presumably by becoming high ranking). The phonetic manifestation may still exist in certain environments, due to quantitative constraints; in such cases, parallel qualitative and quantitative constraints are active in the system. Under a model of partial serialization, this is accounted for directly, due to the distinct domains. Otherwise, such corresponding constraints would be an odd accident.

While I believe the evidence for such an approach is strong, let’s consider briefly the alternative. There might be no special relationship between the qualitative and quantitative aspects of the sound system. As I understand it, this is the view espoused by Kirchner (1997, forthcoming) and Steriade (1997), among others.

Kirchner (1997) argues that categorical and gradient properties, contrastive and non-contrastive ones, use the same vocabulary and formal mechanisms. Consider briefly two of his examples. First he discusses vowel height under the heading of "Categorical effects with continuous representations". He proposes that the vowel height continuum be divided in, say, 100 features of the form [+/- vowel height > n], for example, [Vht>67]. This yields, in effect, a quasi-continuous representation. The fact that no language has anything approaching 100 vowel height distinctions is due to the role of other constraints, most importantly constraints of "polarization". This solution seems to give a formal status to minute divisions in the vowel height space.

Kirchner (p. 100) says

Clearly the claim of phonological categoricity cannot mean that there is at most a binary distinction for any phonetic dimension; for at least a ternary distinction in vowel height is required. If, however, the claim of phonological categoricity is that phonology represents phonetic dimensions in terms of some number of discrete, binary features, then the distinction between categorical and gradient representations is vacuous, since this technique can be applied recursively to yield a quasi-continuum.

Yet this is not necessarily the claim of phonological categoricity, as there are theories of phonology that depend on categories, but where the features aren’t necessarily binary. Rather evidence for categories comes from a range of sources including cross-linguistic patterns and the behavior of natural classes.

Kirchner continues "Finally, I do not attempt to spell out here the relation between this gradient but still abstract scale of vowel height and actual physical measures thereof... consequently there is still room for interspeaker variation in this relation." (p. 102). Not only is interspeaker variation still to be accounted for, but there are also many other phonetic details under linguistic control which need to be included to account for the actual phonetic realization. It appears that a phonetic component, even if mechanical and automatic, is still needed.

Another case is the implementation of the F0 dimension under the heading "Gradient phonology". Here Kirchner argues that these patterns can be accounted for in terms of OT constraint interaction "without recourse to underspecification, nor to a post-phonological interpretive component". But this is by assuming that interpolation is in some sense automatic (contrary to work by Pierrehumbert, 1980; Choi, 1992; and others). Then he states "Moreover, we could easily adopt a closer approximation to a continuous temporal representation, without changing the substance of the analysis. Assume that the representation is divided into intervals of 10ms, a fine enough scale for any linguistic phonetic analysis." (p. 105). The fact that such a modification wouldn’t change the substance of the analysis suggests a problem; here formal status is granted to a whole series of minute slices in time.

There are, I believe, a number of problems with this approach. Formal status is granted to events that are in all likelihood a byproduct of the phonetics. In this respect, the approach has some of the same problems as SPE, where a formal status was given to the phonetic transcription. The large number of detailed constraints suggests a very rich factorial typology. To limit the rich set of predicted interactions to those phenomena observed cross-linguistically, other constraints are needed. This approach is highly powerful and yet still appears to require a distinct phonetics, though perhaps an automatic one.

5. What is Language-specific and What is Universal?

Turning to the final question: what is language-specific and what is universal? In SPE, the answer to this question was straightforward: anything that was language-specific was by definition part of the phonology, while the phonetics was universal. As mentioned above, one of the thrusts of phonetic research in the 80’s was documenting the language-specific nature of some phonetic information and just how much of the phonetics was under speaker control (often taken to be the definition for what is part of the linguistic grammar). The conclusion that phonetics involves both universal and language-specific facets is a strong one.

But where does language specificity lie in the phonology? Some recent proposals offer a very limited role for language specificity, seemingly suggesting a universal phonology and language-specific phonetics. This completely turns on its head the traditional view. Within the strongest version of Optimality Theory, language differences lie in the constraint rankings, not in the constraints themselves. (There are of course also differences in the inputs, though if we subscribe to the "richness of the base" hypothesis, the role of the input is greatly diminished.) Yet it is not clear that this leads to the most constrained view of the phonology. What about constraints to account for "non-natural" phonology? These must necessarily exist to account for those aspects of the synchronic grammar which aren’t natural, but are nevertheless systematic and productive. Some such patterns might be accounted for through constraint interaction, but others seem to be due to quirky constraints. If everything is universal, these too must be part of the grammar of every language, albeit at the bottom of the pile in most languages. Once we accept these sorts of constraints, as I believe we must, it seems uninformative to call such constraints "universal". This
leads to the conclusion that there are both universal and language-specific parts of both the phonetics and phonology, so the property of being language-specific or universal is orthogonal to the distinction between phonetics and phonology.

6. Conclusions

A wide range of evidence converges reaffirming the conclusion that phonology and phonetics are distinct. Strong evidence for this conclusion comes from phonetic and phonological doubles—cases which display both categorical and gradational manifestations of the same phenomena. Such cases I have suggested can be accounted for with corresponding qualitative and quantitative constraints. Minimally, the vocabulary, principles, and possibly mode of constraint interaction of phonology and phonetics are distinct. A model of phonetics and phonology with distinct domains directly accounts for these observations. How these domains might interact within a non-derivative approach is an important area for further research.

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Cornell University
Department of Linguistics
Morrill Hall
Ithaca, NY 14853-4701
acc4@cornell.edu