NON-EQUIVALENCE BETWEEN PHONOLOGY AND PHONETICS

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ABSTRACT

In her paper, Arvaniti [1] supports a model of production and perception which distinguishes phonological representations from their phonetic surface form. She draws on intonational data as evidence that an abstract phonological representation is necessary to capture native speakers' competence to extract unique significance when faced with multiple phonetic variations. This view is in direct contrast to models which advocate that contours are holistic and all variation must be coded in detail. My commentary professes sympathy with Arvaniti's approach and adds further evidence from segmental variation in support of abstract representations.

Keywords: Phonetics, Phonology, Abstract Representation, Underspecification, Processing.

1. INTRODUCTION

Should phonological and phonetic information be unified in the grammar? This is the question that Arvaniti raises and argues in support of a model which sets apart abstract phonological representations independent of phonetic details of the output. Although she acknowledges the need to "incorporate rich phonetic detail into our models of grammar", Arvaniti contends that even in intonation, which is assumed to be more gradient than the segmental level, there is ample evidence arguing for non-holistic, and therefore, discrete representation.

2. ABSTRACT REPRESENTATION FOR INTONATION

Arvaniti's central line of argument is that since F0 is often thought to be more gradient than segments, one might consider intonational evidence to be better suited to support models unifying phonology and phonetics. If however, this assumption is questionable, then it is open to discussion whether one can entirely do away with an independent phonological representation. Her main points are:

- Even if F0 is continuous, there is evidence that speakers modulate pitch with precision.
- Further, there is also evidence that listeners do not perceive a contour as a continuous curve.

Arvaniti draws on polar questions in Greek for support. These can have rather different contours depending on the number of words in the sentence and which word is in focus. Nevertheless, although the contours may look different, the generalization is that the stressed vowel of the focused word has a low pitch followed by a phrase accent L+H and a final low boundary. If the focused word is sentence final, a pre-nuclear accent gives another rise-fall in the beginning. The discrete phonological representation (L*+H) L* L+H- L% with general principles of alignment captures the rather diverse contours and furthermore, listeners have no difficulty in extrapolating a unique significance.

Arvaniti's arguments are compelling. In what follows, I provide evidence in support of independent segmental abstract representations.

3. ABSTRACT SEGMENTAL REPRESNTATION

Where segmental alternations are concerned, despite a strong desire to keep underspecified featural representations out, an independent abstract phonological representation is advocated by most phonologists, where discrete phonological represenations are mapped onto more gradient phonetic forms [3, 6]. As Arvaniti points out, even in recent work in OT (which claims that a single representation combining phonetic facts into the phonological system is the best way of understanding variation), it is not obvious that phonetic surface forms are entirely excluded. The extreme view states that all phonetic detail as well as all exemplars of each word (encoding experience) are stored [7]. Nevertheless, Johnson too appears to have a level of prototype representation where the exemplars are mapped onto a discrete entity (although here as well, the entry includes nonlinguistic evidence).

The most controversial issue regarding abstract phonological representations, is of course, underspecification, particularly coronal underspecification. Recent phonological research on features has predominantly stated that underspecification is not only not necessary, but misguided. Those in favour of underspecification have argued that with respect to markedness, CORONAL is less marked because it is more frequent in speech and in representation, and its unmarkedness follows from underspecification. One motive for underspecification was to account for asymmetries in place assimilation [8]. For instance, CORONAL place assimilation is far more common than for instance, LABIAL assimilation. This could be accounted for by assuming that CORONAL is placeless and hence is vulnerable to acquiring the place of a neighbouring segment.

On the other hand, many persuasive phonological arguments have been made *against* underspecification [13, 14, 17]. In spite of these criticisms, phonologists acknowledge that CORONAL asymmetries do exist and they have to be accounted for. Asymmetries and markedness differences exist across features, feature distribution, and direction of phonological rules [16]. To achieve coronal asymmetry while assuming full specification, there exist a number of proposals using additional mechanisms. Calabrese [2] proposes different types of feature representations, contrastive (determined by specific algorithms), marked and full, interspersed in the rule ordering. Mohanan [14] advocates "fields of attraction" and dominance which provide a means of expressing different degrees of markedness. Clements [3] proposes a model of featural representation which distinguishes between active features (which may refer to natural classes) and prominent features (e.g., which may play a role in spreading). Note that although all of the above object to underspecification of contrastive features, they do not represent allophonic variation.

It is unfortunately not possible to address all of the criticisms against underspecification. I will briefly touch on two. One issue is that it is difficult to refer to CORONAL consonants as a group when a language has more than one such consonant (e.g. [θ s ʃ]) and distinguishing features like [±ANTERIOR] are dependent on CORONAL. The feature system [12] resolves this issue by eliminating all dependent place features. Either tongue height (HIGH, LOW) or a manner feature like STRIDENT distinguishes such consonants. Another criticism is that there are too many alternative ways of underspecifying consonants. Our model, FUL (*Featurally Underspecified Lexicon*) assumes, however, that CORONAL underspecification is universal and thus there is no second alternative. Our claim is that within FUL's framework, neither active feature specification nor extra devices are necessary to account for phonological alternations. Here we provide psycholinguistic and neurolinguistc evidence in support of this approach.

4. ASYMMETRY IN CONSONANT PERCEPTION

When Lahiri & Marslen-Wilson [9, 10] introduced the notion of underspecification in language comprehension, the claim was that vowels, predictably nasalized in a following nasal context need not be specified for the feature [nasal]. Consequently, although Bengali has nasal vowel phonemes specified for nasality as in /kãdh/ 'shoulder', the oral vowels are underspecified for orality and can be nasalized when a nasal consonant follows ([kãn] < /kan/ 'ear'). The claim was that in a gating task, perceiving nasality on a vowel e.g. [kã] (which could have come from an underlying nasal vowel in [kãdh] or from the nasalized vowel [kãn]), listeners would always find a better match in the underlying specified nasal vowel of /kãdh/. Nasalized vowel responses would be given only after the nasal consonant had been perceived. The results confirmed the hypothesis. On perceiving [kã], from either [kãdh] or from [kãn], listeners invariably responded with the word with the underlying nasal vowel, viz. [kãdh]. On hearing oral vowels, e.g. [ka] from [kadʒ], listeners responded with both [kãn] or [kadʒ] since they were both unspecified for nasality or orality, viz. /a/.

Building on this earlier work, Lahiri & Reetz [11] developed a more comprehensive model of feature representation which crucially assumes underspecification of contrastive features to account for phonological systems, as well as to account for language comprehension and production. Underspecification does not depend on syllable structure nor on possible allophonic processes alone. For example, it is often assumed that for word final place assimilation, final

coronals are underspecified because they are vulnerable to change. FUL claims that CORONAL is underspecified in all positions, initial as well as medial. The assumption is that the variation in speech is resolved by the listener in two steps:

(i) the auditory system parses the acoustic signal into features and not segments;

(ii) a mapping process, using a ternary logic of *match, mismatch* and *nomismatch*, matches the features extracted from the acoustic signal with those stored in the mental lexicon.

The *match* condtion is transparent. The *nomismatch* condition assumes that certain non perfect matches are tolerated due to underspecification. A mismatch occurs when a feature extracted from the signal is in conflict with the feature in the representation. Relevant matching predictions for consonants is given below.

(1) Mapping of features for consonants

Signal	Match	Representation
[p,b,m] LAB	*NOMISMATCH*	/t,d,n/ [ ]
[t,d,n] COR	*MISMATCH*	/p,b,m/ LAB
[k,g,ŋ] DOR	*MISMATCH*	/p,b,m/ LAB
[t,d] COR	*MISMATCH*	/k,g / DOR
[k,g,ŋ] DOR	*NOMISMATCH*	/t,d,n/ [ ]

Below, I briefly summarize experimental evidence in support of this hypothesis.

A semantic priming task (lexical decision, crossmodal) tested CORONAL underspecification in word medial and word final positions [11]. For the medial condition, where no assimilation is ever possible, words like *Ho[n]ig* 'honey' predictably facilitated recognition of *Biene* 'bee' and *Ha[m]er* 'hammer' primed *Nagel* 'nail'. Pseudoword variants of these primes, however, gave asymmetric results; **Ho[m]ig* successfully primed *Biene*, but **Ha[n]er* did not prime *Nagel*. That is, the LABIAL [m] of the pseudoword **Ho[m]ig* was tolerated as a variant of the underspecified /n/ in *Ho[n]ig* and sucessfully facilitated the recognition of *Biene*. But the CORONAL [n] of the pseudoword **Ha[n]er* was rejected by the underlying specified /m/ in *Ha[m]er*.

More recently we ran an electro-encephalographic (EEG) study using words varying in medial CORONAL vs. non-CORONAL consonants to examine whether similar asymmetry would be found with a more direct technique measuring brain activity [5]. Word medial coronals in *Hor[d]e* 'horde' are placeless and the claim is that its corresponding non-coronal variant like **Hor[b]e* cannot mismatch this empty PLACE slot and therefore would activate *Hor[d]e*. A similar mapping would not occur with coronal pseudoword variants like **Pro[d]e* of the real word *Pro[b]e* 'test'. CORONAL extracted from **Pro[d]e* mismatches the specified LABIAL of *Pro[b]e* and therefore cannot activate this word. The prediction is that lexico-semantic memory search processes would be successful when **Hor[b]e* is presented and activates the corresponding coronal word *Hor[d]e*, but not when the coronal variant **Pro[d]e* is presented, since it would lead to an immediate correct rejection as a non-existing lexical item. Thus, an asymmetry was expected at least for the initial N400 pseudoword effect, which is most likely related to lexico-semantic processing.

The task was speeded lexical decision to auditory stimuli. For the behavioral results, the error rates revealed significant differences. Non-coronal pseudowords like **Hor[b]e* (<*Hor[d]e*) had significantly more errors than coronal pseudowords like **Prode* (<*Pro[b]e*), suggesting that subjects more easily recognized **Pro[d]e* as a nonword, but had more difficulty in rejecting **Hor[b]e* as a nonword since it did activate the real word *Hor[d]e*. In the ERP-data, the early N400 results showed a clear asymmetry in the earlier activation period of 100–250ms. Mean amplitudes of the coronal pseudoword variants were significantly more negative than their non-coronal base words. By contrast, ERPs for non-coronal variants did not differ from their base words in this initial part of the N400 pseudoword effect. Furthermore, a significant difference between both types of pseudoword variants, but not between both types of words, relates this early ERP deflection to mismatch detection in the case of coronal pseudowords.

Thus, medial coronal consonants, which contrast with dorsal and labial consonants, also show an asymmetric pattern. Non-coronal pseudowords with labial or dorsal consonants are accepted as variants of the corresponding coronal word, but not vice versa as shown in the error data as well as in the early N400 effect. Medial consonants do not undergo any assimilation such that the pseudowords could have been 'experienced' or become familiar to the listeners. Further, since word frequency was controlled, full

specification or specification of phonetic detail cannot account for these results.

5. ASYMMETRY IN VOWEL PERCEPTION

FUL makes the same predictions for vowels. Given the underlying contrast between /o e ø/ in German, /o/ is specified for DORSAL and LABIAL, while the others are unspecified for CORONAL.

(2) Underspecified vowel representation

Signal	Match	Representation
[o] DOR	*NOMISMATCH*	/ø/ [ ] LAB
	NOMISMATCH	/e/ [ ] [ ]
[e], [ø] COR	*NOMISMATCH*	/ø/ [ ] LAB
		/e/ [ ] [ ]
[e], [ø] COR	*MISMATCH*	/o/ DOR, LAB

A magnetoencephalographic study reports topographic differences in the processing of mutually exclusive isolated CORONAL and DORSAL vowels in German [15]. Further, Eulitz & Lahiri [4] used a component of the event-ralted brain activity, the *Mismatch Negativity* (MMN), to investigate the issue of asymmetry in mapping. MMN is assumed to be an automatic detection measure of the brain's ability to detect change in sounds, particularly to phonemes. If a sound is presented many times in a sequence (known as the *standard*), it is considered to tap the long term sound representation, or in other words our underlying representation. If another sound is presented right after the sequence (i.e. a *deviant*), it would cause something of a jolt, and the brain would detect a change and respond accordingly. The classical MMN is high amplitude difference between standard and deviant around 180 ms from the onset. Eulitz & Lahiri [4] noted both an amplitude and a latency difference. As predicted by the matching algorithm, for the pair [o]~[ø], when /o/ was the *standard* (i.e. underlyingly specified for DORSAL) and [ø] the *deviant* such that [CORONAL] is extracted, there was a higher and earlier MMN peak than the other way around. Similar predictable asymmetric pattern of results were obtained for the other pairs. Thus, just as for the consonants, the vowels showed asymmetric perceptual responses as predicted by FUL.

6. CONCLUSION

As Arvaniti's expose points out, if intonational analyses require an abstract level of representation, it is difficult to argue against an independent phonological level. With additional evidence from perception of segments, it seems appropriate to claim that not all phonetic detail is stored in the mental lexicon.

7. ACKNOWLEDGEMENT

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