

# *Phonological output is redundancy-free and fully interpretable\**

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## **1 Introduction**

In orthodox feature theory, phonological output representations must contain redundant feature values in order to achieve phonetic interpretability. This assumption sits awkwardly with the current view that constraints on phonological well-formedness are expressed over output. One inevitable and undesirable result is that redundant feature values clutter up the statement of constraints on melodic form.

This paper explores some of the consequences of an alternative approach to segmental form — one which rids phonological output of redundancy without compromising the ability of representations to be mapped onto physical phonetics. This can be accomplished by attributing stand-alone phonetic interpretability to each melodic prime. In a model of this sort, representations which are available for scrutiny by output constraint are simultaneously redundancy-free and fully interpretable.

One specific consequence of this approach is that there is no need for major-class features. To illustrate this point, I will show how [consonantal] can be jettisoned without jeopardizing the phonetic interpretability of phonological representations.

§2 examines the relationship between redundancy and phonetic interpretability in feature theory. §3 reviews arguments for and against [consonantal] and concludes that its use as a redundant feature is largely unmotivated. §4 outlines a redundancy-free model of representation in which each melodic prime receives independent phonetic interpretation. §5 discusses a recent treatment of fortition in Cypriot Greek in which [consonantal] is alleged to be phonologically active. Under an alternative analysis, fortition is expressed in terms of independently interpretable primes which code continuancy contrasts.

## **2 Feature redundancy and phonetic interpretability**

Orthodox feature theory posits a fundamental mismatch between lexical contrastiveness and phonetic interpretability: of all the feature values deemed necessary to secure the passage of a phonological form into physical phonetics, only a subset contributes to lexical distinctness. It is only by enlisting a full assembly of both types of feature value, distinctive and redundant, that phonological output achieves phonetic interpretability: it contains all the phonological ingredients necessary for direct submission to articulation and perception.

There have been two responses to the question of how to capture the difference between lexically distinctive and redundant feature values. One is to omit such values from initial representations — a tradition that can be traced from Halle (1959) through to more recent variations on underspecification theory. This approach has the advantage of giving direct representational expression to redundancy, but only at the expense of compromising phonetic interpretability. Underspecified representations cannot be directly submitted to articulation and perception but must first be converted into fully specified output.

According to this view, phonology is an arena in which two competing forces fight for control over the melodic content of representations. One calls for representations to be stripped of all features save those that are minimally distinctive or in some other fashion predictable. The other demands that segments be fully specified in order to satisfy the requirements of phonetic implementation.

This conflict between the forces of specificational parsimony and abundance (as Itô, Mester & Padgett (1995) elegantly put it) is classically resolved by positing two independent levels of phonological representation. One, the underlying level, satisfies the demands of specificational parsimony by omitting redundant feature values. The other, the level of systematic phonetic representation, satisfies specificational abundance by containing fully specified feature values. More recently, the conflict has been recast as a play-off between two constraint families which scrutinize phonological output, with the outcome being decided by whatever ranking a particular grammar imposes on the constraints (Itô *et al.* 1995).

The other response to the problem of redundancy has been to assume that both distinctive and redundant features are present at derivation — the alternative preferred in SPE. This preserves the full interpretability of phonological form but offers no representational explanation of the difference between the two types of feature value. Instead, nondistinctive values are identified by reference to an extrinsic set of redundancy statements, cast in the form of rules or constraints (including those supplied by markedness theory). The statements make up an essentially arbitrary list of features and feature combinations and thus provide no insights into why certain values consistently function redundantly in different languages.

The relation between redundancy and phonetic interpretability has recently taken on renewed significance as phonological theory seeks to abandon derivational serialism in favour of constraint evaluation of output representations. Both of the treatments of feature redundancy just outlined continue to figure in recent constraint-oriented theory. On the face of it, it is difficult to see what place there might be for underspecification in a theory where constraints screen phonological output, given the requirement that output must be fully specified for interfacing with phonetics. And indeed much of the thinking behind featural analyses in Optimality Theory has swung back in favour of an essentially SPE model of full specification supplemented by markedness conditions (cf. Prince & Smolensky 1993 (ch 9), Cole & Kisseberth 1994).

However, some researchers, understandably reluctant to give up the representational advantages of underspecification, have proposed that, under the right constraint ranking conditions, certain redundant feature values may be suppressed in output (e.g. Itô *et al.* 1995).<sup>1</sup> The incompatibility of underspecification with full phonetic interpretability casts doubt on

whether such representations really constitute phonological output proper. Wedding underspecification to constraint-based theory inevitably requires two distinct levels of phonological output — one in which certain feature values are left blank in order to satisfy redundancy constraints, and a 'later' level in which all feature values are specified in preparation for interfacing with articulation and perception.

The putative mismatch between distinctive parsimony and realizational abundance, it can be argued, stems from a lingering attachment to an essentially phonemic-segmental conception of phonetic interpretation. According to this view, the phonetic expressibility of an individual feature value is subjugated to that of the segment in which it resides. No feature value, distinctive or redundant, can be made physically manifest unless it is harnessed to a full span of other feature values which together define the phonetic identity of a given segment.

In short, the segmentalism of conventional feature theory places output-oriented theory in an inevitable bind. Full specification guarantees the full interpretability of output but fails to provide a non-arbitrary account of redundancy. Underspecification gives direct representational expression to redundancy but compromises phonetic interpretability by moving constraint evaluation away from output proper. In order to escape this bind, it is necessary to banish redundancy from phonological representations altogether. To be able to do this while retaining full phonetic interpretability, it is necessary to abandon the segmentalism of orthodox feature theory.

There is in fact no necessary reason to consider the segment the minimal unit of phonetic interpretation. It is quite possible to conceive of a world in which that role is assumed by the feature itself. That is, we can define each feature in such a way that it has a phonetic signature which it can manifest in isolation from other features. This notion lies at the heart of the tradition in which mid vowels, for example, are viewed as combinations of primes that are individually expressible as *a*, *i* or *u* (Anderson & Jones 1974). It provides a rather direct way of detaching redundancy from phonetic interpretability — by discarding redundancy altogether. By definition, no redundant properties are needed to bolster the interpretability of a stand-alone feature. In this type of model, the only features appearing in the output representation of a phonological form are those that are lexically pertinent. Embracing this approach puts us in a position to retain the advantages of each of the two treatments of redundancy outlined above without recapitulating the drawbacks of either. Output representations in this alternative model are at once redundancy-free and fully interpretable. Moreover, output constraints on melodic form are restricted to those that regulate the combinability of features or the ability of features to appear in particular prosodic positions. There are no constraints which demand the introduction of redundant properties in order to prepare segments for phonetic interpretation.

This paper explores some of the consequences of hitching a redundancy-free but fully interpretable model of melodic representation to output-oriented theory. One far-reaching consequence is that it greatly simplifies our notion of phonological output compared to that forced on us by orthodox feature theory. For one thing, it allows us to dispense with anything resembling an independent representational level of the type traditionally referred to as systematic phonetics (SPE) or categorical phonetics (Keating 1990). In other words, PF comprises a single domain of categorical representation — whether we call it PHONOLOGICAL

or PHONETIC is a purely terminological matter — and interfaces directly with articulation and perception, domains which deal in terms of the continuously varying quantitative values encountered in speech rather than in terms of distinct categories.

Combining zero redundancy with full interpretability brings with it a number of rather more specific consequences for our conception of segmental form. A few of these require us to relinquish certain long-held preconceptions arising out of traditional feature theory. One perhaps surprising conclusion is that there are no major-class features. I will illustrate this particular point by showing how analyses formulated in terms of [consonantal] can be recast in terms of primes which code continuancy contrasts.

Compared to other features, major-class categories are rarely required to bear a heavy distinctive load or to play a major role in derivation. Accounts in which they have been called on to perform either of these functions can typically be reset in terms of other features, in some cases admittedly more readily than others. Given their very low contrastive and derivational profile, the main reason major-class features continue to figure in the literature appears to reflect an often unspoken commitment to the segmentalism referred to above: such categories are somehow felt to be necessary for guaranteeing the phonetic interpretability of segments. This assumption, as I will try to show, is neither necessary nor desirable; and abandoning it contributes to the construction of the stripped-down model of phonological output to be defended here.

The general line of reasoning running through the attack on [consonantal] is that major-class labels do not identify independent units of melodic representation. Such terms are at best no more than taxonomic descriptors. If this view is correct, MAJOR CLASS in phonology is on a par with CONSTRUCTION in syntax — both are epiphenomena of grammar. Neither is even uniquely derivable from some combination of fundamental properties which do have independent representation in grammar.

### **3 [consonantal]**

#### **3.1 [consonantal] melody**

According to SPE, 'consonantal sounds are produced with a radical obstruction in the midsagittal region of the vocal tract; nonconsonantal sounds are produced without such an obstruction' (Chomsky & Halle 1968: 302). In current terms, this specification refers exclusively to some aspect of melodic form. However, the enduring potency of traditional consonant-vowel terminology is reflected in the fact that the feature is sometimes misused as a prosodic diacritic, in essentially the same function as the now-defunct feature [syllabic]. According to this practice, a vocoid destined to surface as a glide is underlyingly specified as [+consonantal], in effect a tag which reads 'to be syllabified in non-nuclear position'. In what follows, I will only consider [consonantal] in its originally intended constriction-defining sense.

Let us briefly rehearse the main arguments that are commonly recited in support of features in general and consider to what degree they hold specifically of [consonantal].

**‘Features code lexical contrasts.’** This is not usually one of the first arguments wheeled out in support of major-class features, since the distinctive burden they are asked to carry is extremely light. Where [consonantal] is pressed into service as a bearer of lexical contrast, the distinctive load can typically be shifted, with minimal effects on a given analysis, onto other features (such as [continuant]) whose contrastive status enjoys much greater independent support.

**‘Features define natural classes of segments.’** A strong case can be made for a feature by showing that it identifies a class of segments which function as the target or trigger of phonological processes. Major-class features are rarely called on to perform this role with anything like the vigour associated with certain other features. It is in recognition of this inertness that major-class annotations are banished to the root node in many versions of feature geometry, there to be kept out of harm’s way while more peripheral nodes engage in spreading and delinking (McCarthy 1988). Even from this relatively secluded spot, major-class features still manage to get under the feet of operations which directly target other features. This is perhaps most clearly illustrated in lenition, the primary effect of which is to delink place (as in debuccalization) or [–continuant] (as in vocalization and spirantization). In the aftermath of both operations, some mopping up has to be done, including adjustments to the major-class affiliation of the affected segments. Vocalization of an oral stop (as in  $p \rightarrow w$ ), for example, calls not only for the rewriting of [–continuant] as plus but also for switches in [consonantal] and [sonorant]:

- (1)
- Vocalization:    [–continuant] → [+continuant]  
                          [+consonantal] → [–consonantal]  
                          [–sonorant] → [+sonorant]

A switch in [voice] is also implicated, if the input plosive is voiceless. A comparable battery of redundancy and repair rules is required for debuccalization (see for example Halle 1995).

Supplementary operations of this sort typically involve redundant feature values and as such are very much in the tradition of SPE linking rules. Nevertheless, the need to have them at all, it can be reasonably argued, subverts one of the primary goals of feature geometry — to restrict the set of possible phonological processes to those that target only one node each (Clements & Hume 1995). (For a more detailed critique of feature treatments of lenition, see Harris 1990.)

The need for redundancy adjustments highlights the problematic relation between conventional features and output-oriented constraint theory. Given the geometric requirement just mentioned, a constraint designed to deliver the effects of plosive vocalization should refer to just one node — in this case presumably the feature [continuant]. But satisfaction of this constraint is not sufficient to bestow on a successful candidate analysis the status of a fully interpretable output form. It still needs to transit through some post-constraint representational buffer before it can be submitted to articulation and perception. It is at this intermediate stage that redundancy modifications have to be made to those features, including [consonantal] and [sonorant], which do not directly figure in the vocalization constraint.

**‘Features determine syllabification.’** Major-class features are often accredited with the function of determining syllabification, particularly in so far as they contribute to the definition of sonority. However, the force of this argument is diluted by a number of considerations. One is the common practice of presenting the sonority hierarchy as a simple list of phoneme types with no particular concern for whether and how the ranking might be featurally defined (see for example Prince & Smolensky 1993: ch 8). Another is the degree to which syllabification is independently catered for by prosodic structure. For example, it is now widely agreed that syllable heads must be prosodically represented in the lexicon (e.g. Kaye, Lowenstamm & Vergnaud 1990, McCarthy & Prince 1993). This inevitably reduces the significance of melodic form to the determination of syllabification. In any case, it is possible and, I will argue below, desirable to derive sonority from the relative melodic complexity of a segment, something that can be calculated quite straightforwardly without reference to major class.

**‘Features guarantee phonetic interpretability.’** Even in the absence of any obvious contrastive or derivational function, the representational presence of a particular feature is sometimes deemed to be justified on the grounds that it contributes to the phonetic implementation of the segment in which it resides. This argument reprises the phonemic-segmental conceit referred to above — the assumption that the phonetic interpretability of a given feature value is dependent on its being integrated into a segment containing a full slate of specified features. Of all features, those defining major class have by far the lowest exchange value in the realm of phonetic implementation. For example, they are conspicuously absent from recent geometric models of speech production; see especially the gestural theory of Browman & Goldstein (1989) and the mini-tracts theory of Keyser & Stevens (1994). It is surely significant that the models in question dispense with anything directly equivalent to an independent category CONSONANTAL. This in itself should give us pause for thought if, in view of their low contrastive and derivational profile, we seek to justify the representational status of major-class features on phonetic grounds. This point has recently been acknowledged in feature geometry, the obvious articulatory bent of which makes it a close cousin of the gestural and mini-tracts models. Hume & Odden (1994) show how a number of processes previously treated in terms of active [consonantal] values can be reanalysed in terms of other features or class nodes. In any event, as we will see below, non-segmental models of melodic form demonstrate that major-class categories can be jettisoned without compromising the phonetic interpretability of phonological representations.

There have been several recent attempts to coax major-class features out of retirement in the root node, based on various combinations of the arguments just reviewed. In §5, we will consider one particular analysis that has been touted in support of this view and consider how it can be reformulated without reference to major class. The reanalysis draws on a particular model of melodic representation, to be outlined in the next section, which moves away from the segmentalism of conventional feature theory.

## 4 Elements

It is perfectly possible to give up an attachment to segmentalism without jeopardizing the ability of phonological representations to be mapped onto physical phonetics. This result can be achieved by attributing stand-alone phonetic interpretability to each unit of sub-segmental content. In other words, any melodic prime is independently mappable onto articulation or perception without requiring support from any other prime. The non-segmentalism of this conception departs so markedly from assumptions traditionally bound up with the usage FEATURE that it seems appropriate to adopt some other term. ELEMENT is the one I will plump for here.

The particular version of non-segmentalism to be sketched here is in most essentials that presented in Kaye *et al.* 1985, 1990, Harris 1990, Harris & Lindsey 1995. Those already familiar with this work will feel free to skip this section. The model shares many design properties with other approaches, especially as presented in Anderson & Jones 1974, Anderson & Ewen 1987, Goldsmith 1985, van der Hulst 1989, van der Hulst & Smith 1985, Rennison 1984, Schane 1984, and elsewhere. Of these various alternatives, the version adopted here is the one that is most explicitly committed to a fully non-segmental construction of melodic form.

To keep things as brief as possible, I will for the moment only introduce a minimum number of elements which will be sufficient to illustrate the basic concept of non-segmentalism and which figure in the analysis to be presented in §5.

Each of the following elements, enclosed in brackets, is presented next to a transcription of the solo phonetic interpretation after which it is named:

- (2)
- (a) [A] *a*      [I] *i*      [U] *u*
- (b) [ʔ] *ʔ*      [h] *h*

The elements in (2)a are the familiar resonance categories common to all tricorn constructions of vowel space; they also code place contrasts in consonants. Schwa-like neutral quality forms the resonance base-line on which [A], [I] and [U] are superimposed. The elements in (2)b help code manner or stricture contrasts in stops and fricatives. [ʔ] defines bare stopness, [h] bare noise (aperiodic energy).

To say that each element enjoys stand-alone phonetic interpretability is not simply to attribute to it a unique phonetic signature. That is no different from what is usually claimed for features as conceived of under segmentalism. Independence of interpretation entails more than this: crucially, an element is able to display its signature in isolation. Like an orthodox distinctive feature, an element bears its own burden of lexical contrast; but unlike a feature, it requires no support from other melodic primes (redundant or distinctive) in order to achieve phonetic substantiation. In an element-based model, there is thus nothing akin to redundancy, underspecification or blank-filling operations. This means that some segments are primitive in

the sense that they comprise no more than one element. For example, a lone [U] is manifested as the segment *u* without having to call on additional specification relating to, say, resonance, stricture or major class. Informal descriptions of [U]-as-*u* may make reference to the fact that it is, among other things, non-palatal, continuant and non-consonantal; but these properties have no phonological specification.

Melodic primes are internalized categories which code lexical contrasts and are accessed by phonological constraints. Their phonetic externalization involves their being mapped in the first instance onto sound patterns in the speech signal (see Harris & Lindsey 1995 for fuller discussion of this point). Perception and articulation are parasitic on this mapping. This fundamental Jakobsonian insight lies at the heart of the claim that generative grammar is neutral between speaker and hearer. It would hardly be necessary to remind ourselves of this truth, were it not for the fact that it has tended to become buried under the heavy articulatory bias of much feature theory. Renewing our commitment to the insight, we may view elements as internally represented pattern templates by reference to which listeners decode auditory input and speakers monitor their production. Speakers marshal whatever articulatory resources are necessary to recreate the patterns in speech output. (3) details the acoustic and articulatory interpretations of the five elements in (2) (see Harris & Lindsey 1995 for further details and references).

(3)

	<b>Acoustic pattern</b>	<b>Articulatory execution</b>
[A]	Mass: central spectral energy mass (convergence of F1 and F2)	Maximal expansion of oral tube; maximal constriction of pharyngeal tube
[I]	Dip: low F1 coupled with high spectral peak (convergence of F2 and F3)	Maximal constriction of oral tube; maximal expansion of pharyngeal tube
[U]	Rump: low spectral peak (convergence of F1 and F2)	Trade-off between expansion of oral and pharyngeal tubes
[?]	Edge: abrupt and sustained drop in overall amplitude	Occlusion in oral cavity
[h]	Noise: aperiodic energy	Narrowed stricture producing turbulent airflow

Elements can combine to form compound expressions, each of which is phonetically manifested in a manner that reflects the preponderance of one of its constituent elements over others. This asymmetry is captured by designating one of the elements the head of the compound. This arrangement may be illustrated by considering the effects of combining [U]

with other elements. Fusing [U] with [A] yields a round non-high vowel which is mid if [U]-headed and low if [A]-headed (heads underlined):

$$(4) \quad [\underline{A}, \underline{U}] \quad o \qquad [\underline{A}, \underline{U}] \quad v$$

(In what follows, headship will only be indicated where it has a direct bearing on the discussion.)

The amalgamation of [U] with [h] produces a labial fricative which is non-strident if [U]-headed and strident if [h]-headed:

$$(5) \quad [\underline{h}, \underline{U}] \quad \mu \qquad [\underline{h}, \underline{U}] \quad f$$

The glottal gesture that achieves the realization of [h] in isolation has no phonological presence. (The same goes for [ʔ].) It is the only articulatory means of orchestrating a noise pattern without superimposing independent resonance characteristics which would otherwise be contributed by some other element. The compounds in (5) illustrate the non-specification of glottality in [h]; in these particular cases, the location of the stricture in the fricative is determined by the resonance element [U].

Within this approach, all melodic operations take the form of element suppression or accretion. Suppression, the underparsing of lexical melody, derives consonantal lenition and vowel reduction (Harris 1990). (In the latter case, the stripping away of [A], [I] or [U] may lay bare latent neutral resonance, resulting in vowel reduction to schwa.) Accretion, typically achieved through the spreading of an element from one position to another, derives consonantal fortition and vowel harmony.

For example, consider the various ways in which elemental stock may be depleted in a labial plosive, composed of [U] (contributing labiality), [ʔ] (stopness) and [h] (noise release):

$$(6) \quad \begin{array}{llll} & p & [\underline{h}, \underline{U}, \underline{ʔ}] & \\ \text{Spirantization} & f & [\underline{h}, \underline{U}] & > \text{Fricative debuccalization} & h & [\underline{h}] \\ \text{Loss of release} & p^{\neg} & [\underline{U}, \underline{ʔ}] & > \text{Stop debuccalization} & ʔ & [\underline{ʔ}] \\ \text{Vocalization} & w & [\underline{U}] & & & \end{array}$$

Fortition is the reverse of one or more of these events. For example, hardening a labial fricative to a plosive results from the acquisition of [ʔ].

The set of weakening processes in (6) illustrates a general property of elements: each of the outcomes of element suppression is independently interpretable. This follows from the arrangement whereby certain segment-types are properly contained within others. For example, the representation of a labial fricative is a proper subset of that of a labial plosive. There is no

need for auxiliary operations to adjust the elemental content of a segment in the aftermath of suppression or accretion. In particular, note that there is no call for redundancy or linking machinery to alter the segment's major-class affiliation. The results of lenition and fortition can be informally described in terms of major-class labels and indeed must be formally adjusted along these lines in a feature-based analysis. For example, as noted in (1), weakening of *p* to *w* involves feature changes from obstruent to sonorant and from consonantal to vocalic. But none of these terms has any elemental equivalent.

## 5 Imagine there are no consonants

...a segment with no specification for consonantality one way or another...is hard...to imagine (Kaisse 1992: 315).

### 5.1 Cypriot Greek

The strongest pleas for the continued recognition of [consonantal] as an independent category explicitly draw on one of the main arguments cited in support of major-classism and summarized in §3. The feature, it is claimed, defines a natural class of segments that actively participates in phonological processes. Running through much of this work is an often implicit appeal to another of the arguments mentioned in §3, one based on the segmentalism of feature theory: [consonantal] is somehow felt to be an inalienable property of segments that helps secure their phonetic expressibility. The sentiment is neatly encapsulated in Kaisse's remark above.

In what follows, I will try to show that it does not require any great leap of imagination to conceive of a world without consonants. Neither the categorization of phonological oppositions and classes nor the phonetic specification of speech, I will argue, need make any reference to [consonantal].

In one of the most cogently argued defences of [consonantal] in the recent literature, Kaisse (1992) discusses a number of cases where, she alleges, the feature shows evidence of spreading. We will focus on one of the examples she treats in greatest detail, Cypriot Greek. This particular case will serve to illustrate the general point that analyses based on [consonantal] can be recast in terms of categories that independently code continuancy contrasts.

In Cypriot Greek, *i* desyllabifies before another vowel. This is most directly seen when a nasal or lateral precedes, in which context no other effects are in evidence. Compare the *i* and *y* alternants in the following nominative and genitive paradigms (all data from Newton 1972 and Kaisse 1992):

(7)

Nominative	Genitive	
<i>mantili-n</i>	<i>mantily-u</i>	'handkerchief'
<i>stamni-n</i>	<i>stamny-u</i>	'jar'
<i>tiani-n</i>	<i>tiany-u</i>	'frying pan'

When other types of consonant precede, *y* is hardened to a plosive, velar after *r* (as in (8)) and palatal after an obstruent (as in (9)):

- (8)
- |                 |   |                |   |
|-----------------|---|----------------|---|
| <i>teri-azo</i> | > | <i>terkazo</i> | 'I match' (cf. <i>teri</i> 'one of a pair') |
| <i>vari-ume</i> | > | <i>varkume</i> | 'I am bored' (cf. <i>vari</i> 'heavy')      |

- (9)
- |                           |   |                      |                   |
|---------------------------|---|----------------------|-------------------|
| (a) <i>vaθi-s</i> (masc.) |   | <i>vaθc-a</i> (fem.) | 'deep (nom sing)' |
| (b) <i>poði-on</i>        | > | <i>poθcon</i>        | 'feet'            |
| <i>trayuð-ia</i>          | > | <i>trauθca</i>       | 'singing'         |
| <i>e-pia-s-en</i>         | > | <i>efcasen</i>       | 'he took'         |

As the last form in (9)b illustrates, a plosive preceding the hardening site is subject to spirantization. This is more fully exemplified in the following forms:

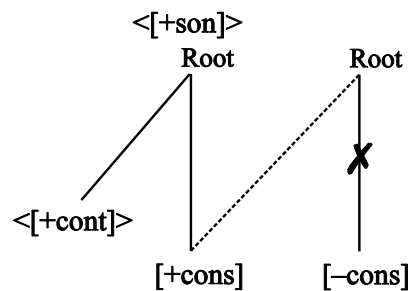
- (10)
- |                           |   |                      |  |
|---------------------------|---|----------------------|--|
| (a) <i>plati-s</i> (masc) |   | <i>plaθc-a</i> (fem) | 'wide (nom sing)'                      |
| (b) <i>ammati-a</i>       | > | <i>ammaθca</i>       | 'eyes' (cf. <i>mati</i> 'eye')         |
| <i>na pi-o</i>            | > | <i>nafco</i>         | 'that I drink' (cf. <i>pi</i> 'drink') |
| <i>not-ia</i>             | > | <i>noθca</i>         | 'dew' (cf. <i>noto</i> 'south')        |
| <i>ka-pio-s</i>           | > | <i>kafcos</i>        | 'someone, something (nom masc)'        |
| <i>ayapi-ete</i>          | > | <i>afcete</i>        | 'he is loved'                          |

Spirantization, as we will see presently, provides a clue to the cause of hardening.

## 5.2 Consonantalization

Kaisse treats Greek Cypriot hardening as the spreading of [+consonantal] from a consonant onto a following glide:

(11)  
Consonantalization



The angled-bracket condition excludes non-continuant sonorants (nasals and laterals) from the class of spreaders.

The operation in (11) illustrates one of the problems with major-class features pointed out in §3: on its own, spread of [+consonantal] is insufficient to achieve the change to a plosive. Supplementary redundancy machinery is needed to adjust the values of [voice], [sonorant] and [continuant]. Viewed in terms of orthodox features, a straightforward consonantalization of *y* would be expected to produce a voiced fricative, retaining the [+continuant] value of the original glide. That this is not the outcome, Kaisse argues, is due to an independent constraint which requires clusters of [+consonantal] segments in Cypriot Greek to conform to the following template:

- (12)  
Cypriot Greek consonant-cluster template:
- |      |                                |                                 |
|------|--------------------------------|---------------------------------|
| if   | ...[+consonantal] <sub>A</sub> | [+consonantal] <sub>B</sub> ... |
| then | ...[+continuant] <sub>A</sub>  | [-continuant] <sub>B</sub> ...  |

The [-continuant] condition in (12) ensures that a consonantalized segment is also stopped. The [+continuant] condition is responsible for the pre-consonantal spirantization exemplified in (9).

As an additional motivation for the template, Kaisse claims that it provides a reason for the failure of nasals and laterals (both [-continuant]) to spread their consonantality: 'there would be no way to ameliorate the new sequence of [-continuant] segments' (1992: 318). This is not a particularly convincing argument, since it would in principle be possible for sonorants in this context to undergo vocalization, rendering them [+continuant]. Under these circumstances, the combined effects of consonantalization and the cluster template on, say, *ly* would be expected to yield something like *yc* or *wc*.

In any case, appeal to the cluster constraint weakens the case for the [consonantal]-spread analysis, since, with a minor adjustment, the template itself can be made to trigger consonantalization. All that has to be said is that the condition applies to clusters of non-nuclear rather than [+consonantal] segments. In fact, consonantalization (11) has to be supplemented by this prosodic information anyway, suggesting that [+consonantal] here is being allowed to stray deep into territory formerly occupied by [-syllabic]. As it stands, the rule would

erroneously harden any non-consonantal segment — glide or vowel — following a consonantal segment. The target segment has to be specified as non-nuclear in order to avoid overgeneralization of the process to those vowels that are not subject to desyllabification (e.g. *kati* > \**kaθc* 'something (nominative, neuter)'). Recast in terms of a non-nuclear cluster, the template in (12) would directly harden the *y* in a *Cy* sequence to [–continuant]. In feature terms, the switch from minus to plus [consonantal] would then be no more than a redundant consequence of this change.

Kaisse, however, is at pains to demonstrate that Cypriot Greek consonantalization is not syllabically conditioned. She is certainly correct in pointing out that, although hardening consistently targets syllable onsets, this in itself is not a sufficient condition for the process to take place. In the absence of a preceding consonant, glides remain unhardened, as forms such as the following testify:<sup>2</sup>

- (13)
- |  |                |                    |  |               |              |
|--|----------------|--------------------|--|---------------|--------------|
|  | <i>yerakos</i> | 'falcon'           |  | <i>yatria</i> | 'cure'       |
|  | <i>loyazo</i>  | 'pay attention to' |  | <i>ayazin</i> | 'chill wind' |

Nevertheless, there are several considerations which confirm that the process is indeed syllabically controlled and that location in an onset is at least a necessary condition for hardening. The additional requirement that a preceding consonant must be present suggests that the relevant syllabic context is either a complex onset or a coda-onset cluster. As I will now try to show, it is the latter context that constitutes the site not only for hardening but also for spirantization.

### 5.3 Hardening is syllabically conditioned

Confirmation that onset occupation is a necessary condition of hardening is provided by the fact that desyllabification of *i* before a vowel fails in the context of two preceding consonants which form an onset cluster:

- (14)
- |  |               |   |  |               |                |
|--|---------------|---|--|---------------|----------------|
|  | <i>krias</i>  | 'meat' (* <i>kryas</i> > * <i>krkas</i> ) |  | <i>krios</i>  | 'cold'         |
|  | <i>tria</i>   | 'three'                                   |  | <i>krioti</i> | 'cold weather' |
|  | <i>kopria</i> | 'manure'                                  |  |               |                |

This effect is derivable under the assumption that onsets in Cypriot Greek contain maximally two positions.<sup>3</sup> The inability of *i* to desyllabify into an already saturated onset bleeds hardening:

(15)

(a) *kopria*

O	N	O		N	N
			\		
x	x	x	x	x	x
k	o	p	r	i	a

(b) \**koprka*

	O	N		O		N
*			/		\	
	x	x	x	x	x	x
	k	o	p	r	k	a

In other words, whatever constraint it is that frowns on nuclei in hiatus is bested by the constraint which places a binary ceiling on onsets.

Where desyllabification of *i* is able take place — that is, where only one consonant precedes — one logical outcome would be the creation of a binary onset. This alternative, it is reasonable to suppose, is the one adopted when the preceding consonant is a nasal or lateral, the cluster context where hardening fails (see the forms in (7)). The rising sonority slope of these sequences, more examples of which appear in (16), makes for well-formed branching onsets.

(16)

<i>myalos</i> 'big'	<i>nyata</i> 'youth'	<i>lyonni</i> 'it melts'
<i>psumya</i> 'loaves'	<i>enya</i> 'nine'	<i>rialya</i> 'money'

In the complementary set of clusters produced by desyllabification of *i*, hardening — in combination with spirantization of a preceding plosive — has the effect of reversing the sonority gradient associated with branching onsets. And the resulting sequence is precisely of the type that is expected of a coda-onset cluster. It is this syllabification, I will now try to show, that triggers both hardening and spirantization.

In principle, all post-consonantal occurrences of *i*-desyllabification in Cypriot Greek might have been expected to result in Cy onsets, irrespective of the nature of the consonant in question. That this would certainly have been an option is confirmed by what happens under similar circumstances in other languages, such as French (e.g. Kaye & Lowenstamm 1984). For some reason, Cypriot Greek does not tolerate complex onsets in which *y* is preceded by *r* or an obstruent. (The ban on *ry* onsets is shared with English, among other languages.) Any account of the desyllabification of CVV to CCV must thus allow for both attested outcomes — complex onset and coda-onset. The fact that Cypriot Greek opts for the former when the preceding consonant is a nasal or lateral and the latter elsewhere must be treated as a matter of stipulation.

Various pieces of independent evidence confirm that hardening occurs after a coda consonant in Cypriot Greek. Consider, for example, the following forms which illustrate how potential consonant clusters before a hardened glide are simplified:

- (17)
- |                  |   |                |  |
|------------------|---|----------------|--|
| <i>aðerfi-a</i>  | > | <i>aðefca</i>  | 'brothers' (cf. <i>aðerfi</i> 'brother') |
| <i>ðonði-a</i>   | > | <i>ðonca</i>   | 'teeth'                                  |
| <i>kumpi-a</i>   | > | <i>kumca</i>   | 'buttons'                                |
| <i>kkasti-a</i>  | > | <i>kasca</i>   | 'worries'                                |
| <i>vasti-ete</i> | > | <i>vascete</i> | 'he is held'                             |
| <i>omorfi-ia</i> | > | <i>omorka</i>  | 'beauty' (cf. <i>omorfo</i> 'beautiful') |

In traditional serial derivational terms, we have something like *aðerfi-a* > \**aðerfya* > \**aðerfca* > *aðefca*. Simplification follows directly from the assumption that the rhyme in Cypriot Greek contains no more than one coda position.<sup>4</sup> In the root *aðerfi* 'brother' (18)a, *r* occupies the coda and *f* the following onset:

- (18)
- |  |  |
|--|--|
| (a) <i>aðerfi</i> 'brother'  | (b) <i>aðefca</i> 'brothers'   |
| <pre>       R           N O N \   O N         \         x x x \   x x x                   a ð e   r f i </pre> | <pre>       R           N O N \   O N         \         x x x \   x x x                   a ð e ɾ f c a </pre> |

In the plural form (18)b, on the other hand, the onset is occupied by *c*, leaving the two root consonants to vie for the sole coda position. In this instance, it is the *r* that fails to be syllabified.<sup>5</sup>

The same cluster-reduction effect is evident in roots containing a geminate consonant:

- (19)
- |                  |   |                |          |
|------------------|---|----------------|----------|
| <i>xappi-a</i>   | > | <i>xafca</i>   | 'pills'  |
| <i>ankaθθi-a</i> | > | <i>ankaθca</i> | 'thorns' |
| <i>putti-a</i>   | > | <i>puθca</i>   | 'thighs' |

On the assumption that a geminate is a single melodic expression doubly attached to a coda-onset sequence, simplification results from the occupation of the onset by the hardened consonant. The root consonant can avail itself of no more than a single coda position (giving the effect of degemination), where it is subject to spirantization, as in *puθca*.

On the basis of the evidence just reviewed, we may conclude that hardening in Cypriot Greek is syllabically conditioned and specifically targets a glide in the onset position of a coda-onset cluster. The question now is why hardening occurs in precisely in this context.

## 5.4 The Complexity Condition

The template in (12) is representative of a class of constraints, variously referred to as coda conditions (Itô 1986) or cluster conditions (Yip 1991), which have been proposed to account for long-recognized restrictions on the distribution of consonants in particular syllabic contexts. The case in hand evidently belongs to the set of phonotactic restrictions on coda-onset clusters described in terms of syllable contact laws (Vennemann 1988). In particular, the [+continuant][–continuant] template establishes in this context the favoured sonority differential in which a coda consonant is more sonorous than a following onset segment.

The template itself, like other cluster conditions of its ilk, provides no explanation of the distributional pattern it describes. Only through consulting some formally separate sonority log are we given an inkling that this particular constraint instantiates some more general principle. It is precisely this sort of shortcoming that a proposal by Kaye *et al.* (1990) regarding the relative complexity of adjacent segments was designed to overcome. As elaborated by Harris (1990), the basic idea is that syllabic positions within particular phonotactic domains are subject to severe and unequal restrictions on the extent to which they can license segmental material. Included in this set of domains are the two sites where inter-consonantal dependencies are in evidence — complex onsets and, most relevantly for our present purposes, clusters formed by a coda and a following onset.

The asymmetric division of distributional spoils between two positions within a phonotactic domain can be derived by assuming (i) that the domain is headed and (ii) that a head position is invested with a greater degree of segmental licensing power than its complement. On the basis of the arguments set out in Kaye *et al.* (1990), let us assume that coda-onset clusters are right-headed. This accords with the well-known propensity for the melodic content of a coda to be partially or wholly dependent on that of a following onset (cf. Prince 1984, Itô 1986).

The unequal manner in which segmental licensing potential is distributed between a head position and its complement is encapsulated in the following constraint (adapted from Harris 1990):

(20)

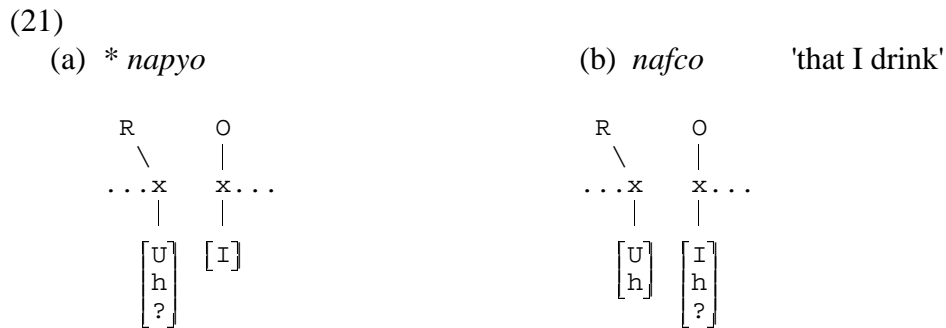
### **Complexity Condition**

Within a phonotactic domain, the melodic unit occupying the head position must be elementally more complex than the unit occupying the complement position.

In the specific context where Cypriot Greek hardening occurs, the Complexity Condition prohibits a coda position from sponsoring a segment that is representationally more complex than the segment occupying the following onset. (For a related proposal based on features, see Rice 1992.) In the framework sketched in §4, representational complexity is straightforwardly gauged by the number of elements contained in a segment. Within domains where consonant clusters are subject to phonotactic constraints, elemental complexity gives direct representational expression to sonority. There is no need for some formally independent sonority hierarchy. Specifically, the relative sonority of a consonant is in inverse proportion to

the number of elements it contains. For example, a labial approximant, with one element ([U]), is more sonorous than a homorganic fricative, with two ([U,h]); the fricative in turn is more sonorous than the homorganic plosive, with three elements ([U,h,?]).

The insight that Kaisse's continuant+plosive template is designed to capture translates into a constraint requiring the onset of a coda-onset cluster to contain the plosive-defining combination of elements [h] and [?], the second of which is barred from appearing in the coda. The result satisfies the Complexity Condition by producing an upward complexity slope between the coda and a following onset (viewed from left to right). This effect is illustrated in (21), where we can compare the relevant contexts in the illegal form \**napyo* (< *napi-o*) and the attested output *nafco*. ([I,h,?] defines a palatal plosive.)



The Complexity Condition is violated in (21)a: the coda *p* sports three elements to the onset *y*'s one. In (21)b, on the other hand, hardening and spirantization conspire to reverse the complexity slope between the two positions. Hardening consists in the accrual of the manner elements [?] and [h] to the onset, spirantization in the suppression of [?] in the coda. The resulting redistribution of melodic complexity from the complement position to the head satisfies the Complexity Condition: the onset, fortified by the acquisition of [?] and [h], beats the coda, weakened by the suppression of [?], by one element.

(22) tabulates how the output form *nafco* sees off \**napyo* and three other competing analyses of input *napi-o* (syllabification indicated by parentheses). Here we may compare how the different forms fare with respect to two constraints — the Complexity Condition and Onset, the latter specifying the familiar requirement that syllables have a filled onset. In faithfully preserving the *i-o* hiatus of the input, the final syllable of candidate (a) violates Onset. All other candidates represented in the table satisfy the constraint by syllabifying *i* (> *y*) in an onset. (This is achieved at the expense of underparsing the nuclear position which *i* occupies in input.)

(22)

<i>napi-o</i>	Onset	Complexity Condition
(a) <i>(na)(pi)(o)</i>	*	
(b) <i>(nap)(yo)</i>		* [U,?,h] > [I]
(c) <i>(naf)(yo)</i>		* [U,h] > [I]
(d) <i>(nap)(co)</i>		* [U,?,h] = [I,?,h]
(e) ✓ <i>(naf)(co)</i>		[U,h] < [I,?,h]

Candidates (b), (c) and (d) all fall foul of the Complexity Condition, each in its own way. In displaying neither spirantization nor hardening, (b) is guilty of the most flagrant violation: the coda *p* with three elements is grossly more complex than the onset *y* with one. (c) shows spirantization without hardening; this reduces the complexity gradient in the right direction but not sufficiently to satisfy the constraint. (d) shows hardening but not spirantization; this levels the complexity differential but is still an infringement of the constraint. Only through a combination of spirantization and hardening can the uphill complexity slope demanded by the Complexity Condition be achieved; the output form (e) is the only candidate in (22) that is successful in this respect.

The nearest feature equivalents to [?] and [h] are respectively [–continuant] and [+continuant]. The correspondence is only very rough in the latter case. [h] is like [+continuant] only in so far as it occurs in fricatives. The two primes are different in that [h] also appears in plosives, while [+continuant] also characterizes vocoids. In any event, both hardening and spirantization are elementally expressed without recourse to anything directly equivalent to [consonantal] or any other major-class category. There is no need for a constraint which calls on segments to be specified (either way) for consonantality in order to guarantee their phonetic interpretability.

We can imagine various ways in which the reapportionment of melodic complexity in (21) might be achieved. For example, requisite elements might be assumed to be supplied by default. Or it might be suggested that the head snatches available material from its complement; transference of [?] from one position to the other would simultaneously produce coda spirantization and onset hardening. This is not an issue that need detain us here, though. The main point is that the analysis captures the observed manner changes in Cypriot Greek coda-onset clusters without appealing to [consonantal].

## 6 Conclusion

In the analysis of Cypriot Greek presented in the last section, suppression and accretion of elemental material take place in response to a specific constraint governing the relative melodic complexity of adjacent positions. The hardening and spirantization effects that these operations produce are specified at an output level that is simultaneously redundancy-free and fully interpretable. At no point is it necessary to invoke some 'later' representational level at which missing phonological information has to be filled in prior to interfacing with phonetic implementation.

Any phonological representation constructed out of stand-alone elements is directly mappable onto physical phonetics without having to pass through some species of interpretive component in which missing phonological information is filled in. In this manner, phonetic interpretation is taken out of the hands of the generator and entrusted wholly to the perceptual and articulatory devices. The mapping between lexical input and phonological output meanwhile is strictly concerned with the grammatical well-formedness of representations and not at all with some pressure to flesh out phonetic detail. Thus there are no constraints whose sole claim on representations is that they ooze specificational detail in order to be better prepared for submission to physical phonetics. Grammar is not viewed as a battleground between opposing forces of featural leanness and segmental plenitude. Moreover, there is but one level of phonological output — a level at which representations are simultaneously redundancy-free, fully interpretable and available for constraint evaluation. **Notes**

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- [1] This is distinct from 'phonetic underspecification' — the notion that certain feature values may remain unspecified even at the stage where representations are phonetically implemented (Keating 1988).
- [2]  $y$  has two main historical sources —  $i$  via gliding (as in *terkazo* < *teryazo* < *teri-azo* 'I match') and the palatal reflex of  $y$  before a front vowel (as in *maya* < *mayia* 'spell'). On this basis, it might be tempting to suggest an analysis according to which Cypriot Greek has an underlying contrast between  $\gamma$  and  $i/\gamma$  (mirroring the historical situation), with hardening targeting only  $y$ , irrespective of phonological context (Paul Kiparsky, *voce*). It is certainly true that the bulk of hardened forms contain  $y$  from  $i$ . However, a context-free treatment of the process cannot be sustained in light of the following considerations: (a)  $y < i$  fails to harden after sonorants (see the forms in (7)), and (b) some cases of  $y < \gamma$  do indeed undergo hardening in the appropriate context (e.g. *vy-enno* > *vyenno* > *fcenno* 'I come out').

- [3] This effect is fully automatic in a theory which universally places a binary limit on all syllabic constituents (Kaye *et al.* 1990).  
Note that the failure of hardening in this context cannot be put down to some ban on over-complex word-initial consonant clusters (however that might be formulated). As the form *kopria* confirms, the same effect is observable word-medially.
- [4] Indeed this result is the only one allowed for in a restrictive theory which dispenses with the coda as an independent constituent and countenances no more than one post-nuclear position within the rhyme (Kaye *et al.* 1990). As with the branching-onset case just discussed, this effect follows automatically from the assumption that a universal binary limit is placed on all syllabic constituents. In this instance, the single-coda restriction derives from the fact that, of the maximally two positions available within a branching rhyme, one is necessarily affiliated to a nucleus.
- [5] Note that, in the two *rf* clusters represented in (18), the unsyllabified consonant is *r* in *aδefca* but *f* in *omorka*. The reason for this discrepancy is apparently related to the fact that the hardened consonant belongs to the root in the former word but to the suffix in the latter. The difference does not affect the point at issue here: both cases display coda simplification.

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