# Paradigm Uniformity and the Phonetics-Phonology Boundary
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## X.1. Paradigm Uniformity

This is a study of paradigmatic relations and of their significance for the link between phonology and phonetics[*]. A paradigm is a set of words sharing a morpheme (e.g. {*bomb, bomb-ing, bomb-ard*,...}) or a set of phrases sharing a word (e.g.{*bomb, the bomb*, ...}). The main component of the analyses presented here is the preference for uniform paradigms, that is paradigms sharing contextually invariant morphemes. A Paradigm Uniformity (PU) condition is a statement of the type shown in (1), which promotes invariance of some sound property within a given paradigm:

(1) All surface realizations of μ, where μ is the morpheme shared by the members of paradigm x, must have identical values for property P.

Examples of uniform and non-uniform paradigms appear in (2). In both cases, the shared morpheme is a root: it alternates in (2.a), but is invariant in (2.b).

(2)     a.  {bAm,  bAmb-Ard, bAmb-Ard-i,, }:  not uniform wrt  stem final C quality
        b.  {bAm, bAm-IN, bAm-,,, bAm-z}:    uniform wrt  stem final C quality

I discuss here the phenomenon of paradigm levelling, which represents the systematic generalization of one allomorph to positions where it is phonologically unjustified or unexpected, as a means of satisfying a PU condition. The degree of phonological invariance of shared morphemes stands in direct relation to the paradigm's productivity and to the transparency of the derivative's relation to its base (Bybee 1988): the paradigms like (2.b) that are generated by productive word formation processes involve less contextual variability than the unproductive paradigm (2.a). Bearing this in mind we concentrate here on highly productive and compositional paradigms.

Paradigm levelling is a staple of the phonological literature. Different aspects of it have been studied under the names of *analogy* (Kury:owicz, 1949; Kiparsky, 1970,1978), *cyclic rule application* (Chomsky and Halle, 1968) or *output-output correspondence* (Burzio, 1994 1997; Benua, 1995; Flemming, 1995,

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Kenstowicz, 1995; McCarthy, 1995; Steriade, 1995, 1998). It is the Optimality Theoretic mode of analysis pursued in the last group of references that is assumed here (cf. Prince and Smolensky, 1993). The term *paradigm uniformity* (along with the equivalent *paradigm coherence* or *regularity*) was introduced into the generative tradition by Kiparsky's work.

### X.**1.2. How much uniformity: phonetic vs. phonological?**

The critical question for this paper will be just how much invariance counts as enough for the purpose of satisfying grammatical conditions like (1). The assumption in current and earlier work is that the relevant measure of invariance is the *identity of phonological representations*. Thus we might assume that the stem final [m] of [bAm] has the same phonological feature composition throughout the paradigm (2.b): if so, the stem final consonant counts as invariant and the paradigm is maximally uniform with respect to its right edge. On this view, any differences in the actual phonetic implementation of this [m] - say differences between a phrase-final lengthened or partially voiceless [m] in [bAm] and word-internal realizations of it - will not affect the uniformity of the paradigm, if they cannot be reflected in phonological representations. Therefore what can and cannot be part of a phonological feature matrix is highly relevant for our understanding of PU conditions. Conversely, the empirical study of PU conditions can shed light on where the boundary lies between phonetic and phonological features.

This paper aims to show that paradigmatic uniformity is enforced through conditions that govern both phonological features and properties presently classified as phonetic detail, such as non-contrastive degrees in the duration of consonantal constrictions, non-contrastive details in the implementation of the voicing contrast and degrees of gestural overlap. The necessary form of the argument is as follows: one must show that some category has an identifying property of a phonetic category and then show that this category is being generalized through the effect of paradigm uniformity conditions, exactly like a phonological category. The result anticipated is that "phonological" and "phonetic" features are not being treated differently when it comes to enforcing morpheme invariance. It will then be natural to ask: does the distinction between phonetic and phonological categories serve a purpose?

There is a larger agenda behind this argument: the distinction between phonetic and phonological features is not conducive to progress and cannot be coherently enforced. It is unproductive because in order to understand phonological patterns one must be able to refer to details of their physical implementation, in perception and production (cf. Ohala, 1995 and references there; Lindblom, 1990 and references there; Flemming 1995, Jun 1995, Kirchner 1996, Steriade, 1995b): separating phonological features from their phonetic realization creates the illusion of a well-defined domain of facts that can be described and explained using an impoverished vocabulary of contrastive properties. The distinction is also unenforceable, because most lexical contrasts are simultaneously implemented on several physical dimensions, most of which never function as independently contrastive: it is arbitrary in such cases to identify some one property as the contrast's flag bearer, the actual phonological feature, with the others as its predictable side-effects (Fant, 1986; Port, 1986; Repp, 1986). Phonologists have recognized this in discussing underspecification (Broe, 1993; Stanley, 1967; Steriade, 1995a) but continue to take for granted the distinction between phonological and phonetic features.

This study examines the effects of Paradigm Uniformity on the realization of "phonetic detail" in order to highlight the fact that grammatical structures and their physical implementation cannot be separately studied.

## X.2. Phonetic vs. Phonological Features: the Contrastivity Test

I outline next what represents, in the current practice of phonologists, the criterion separating phonetic from phonological categories, since it is this distinction that I argue against. A candidate phonetic feature is the stop burst, the brief period of noise following the release of a closure. No phonological feature set includes [± burst], even though this is a perceptually important property and, as argued elsewhere, the class of segments that *can* produce a burst have distinct phonological behaviors (Steriade, 1993). What membership criteria exclude the burst from the set of phonological features? One answer - implicit in the work of Jakobson and Halle (1962)- is that a phonological feature is an articulatory or auditory property that provides the sole basis of lexical contrast in at least some language. On this view, features are a subset of the physical properties of sounds: those that can function as independently contrastive in some language. The stop burst is excluded as a phonological feature because no language has phonemically distinct released and unreleased stops in any context.

A different way of defining the phonological feature set is suggested by Keating, 1984; Ladefoged and Lindau, 1986; and assumed by Kingston and Diehl, 1994. For these writers, a phonological feature is a cover term for a class of lexical contrasts with identical phonological behavior and similar phonetic implementation. It is the abstract property distinguishing the phonological representations of contrasting sounds, rather than any of the physical correlates of the contrast. On this definition, [±burst] cannot be a feature because it does not corespond to a lexical contrast.

Both conceptions of the phonological feature set - and others not mentioned here - are motivated by the belief that, however this set is defined, it must be a very small set. This is directly said by Jakobson and Halle ("The supposed multiplicity of features proves to be largely illusory." 1962: 483) and by Keating, 1984:289, in a passage criticizing proposals by Halle and Stevens, 1973, on the grounds that they generate too many features: "Halle &Stevens (and SPE) don't simply have the wrong features in these instances; *they will always have too many features* because they want to describe exactly how individual sounds are articulated. While we want phonological features to have some phonetic basis, we also want to distinguish possible contrasts from possible differences." The implication here that the set of phonological features must be small because the set of contrasts employed in any given language is small. A mere difference between sounds is not linguistically significant if it is never contrastive.

What matters here more than the form of argument is the almost universally accepted conclusion: the phonological feature set is small and therefore some phonetic properties are not in it[1]. To figure out which phonetic properties to exclude, a test of contrastivity is being implicitly appealed to. A look at the recent phonological literature indicates that this test is invoked every time the grammatical status of a phonetic property or category is being questioned: Sagey (1986: stricture degree of secondary articulations); Mester and Ito

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[1]See also the exchange between Stevens, Keyser and Kawasaki (1986: esp. 460-463) and their commentators, esp. Repp (1986:449ff) on the idea of the small set.

(1989; voicing in sonorants); Lombardi (1990: precedence between the two phases of an affricate); Lombardi (1991: VOT-based categories; voicing in sonorants); Selkirk (1992: VOT-based categories); Steriade (1993: degrees of inter-gestural timing); Kenstowicz (1994: 40 - vertical larynx movements); Hume and Odden (1994: [±consonantal]); Rice (1994; release-related properties such as affrication); Scobbie (1995: all segment-internal precedence relations), among many others.

In what follows, I will assume that if a distinction is to be made between phonological and phonetic features then properties that are not independently contrastive in any language should exclusively in the second class. The paper attempts a reductio of this belief by demonstrating the phonological relevance of categories classified as non-phonological.

## X.3. Paradigm Uniformity constraints

The central claim of this study is that grammatical conditions of the form in (1) apply equally to three types of sound properties: (a) those that are contrastive in the language under analysis; (b) those are contrastive in some language, though not the language analyzed; and (c) those not known to be independently contrastive in any language. The argument for rejecting a principled distinction between phonetic and phonological categories rests on the existence of paradigmatic effects involving type (c) properties. For type (a) properties, the effects of paradigmatic levelling have been attributed - since Chomsky, Hale and Lukoff (1956) - to cyclic rule application. Our view of the formal encoding of paradigmatic effects is different: whether or not rule-based analyses are generally defensible, the cyclic application account is unsuccessful because it describes only a fragment of a coherent class of related phenomena and does this incompletely[2]. We justify a mode of analysis that has appropriate coverage. The gramatical conditions thus motivated will promote paradigm uniformity for contrastive, non-contrastive and never constrastive properties alike. We then consider instances of levelling for type (c).

The key observation here is that forms belonging to the same lexical paradigm - base words and their derivatives - display phonological similarities that go beyond what may be expected from the fact that they share an underlying representation. Consider a verb like *díscipline* and its *-able* form *disciplínable*. In paradigms of this sort, the accentual resemblance between base and derivative is unexpected: English words do not normally contain strings longer than two stressless sylables, yet *disciplínable* contains four, [sI.plI.n´.bl`]. An entire class of English affixes - the Level 2 or unrestrictedly productive suffixes - are similar to *-able*: they maintain intact the distribution of stressed syllables in the bases they attach to, even when this entails some measure of deviance relative to constraints reflected in the underived vocabulary. The connection between productivity and phonological invariance has a clear rationale: productive formations give rise mostly to nonce, non-lexicalized formations, whose interpretation must be computed on-line. When the derivative maintains intact the phonology of the base, listeners can easily access the lexical entry to interpret the nonce form. If the derivative's stem is modified, this makes it harder to access the lexical entry. In particular, modifying the stress of the stem will impede or slow down access (Cutler 1979, 1989).What about Level 1 derivatives? If we assume

[2]See also Burzio 1994, 1996, Flemming 1995, Kenstowicz 1996, Benua 1998 and Kager 1998 for further discussion of these issues.

that the results of unproductive affixation are lexically listed, then the meaning of such derivatives can be looked up:   and for this reason the outcome of unproductive affixation is not subject to the same requirement of phonological compositionality.

At the same time, speakers are aware of the constraints defining the phonological notion of 'possible word' and understand that upholding base invariance can lead to phonologically anomalous words. For instance speakers asked to generate novel forms in *-able* on verbs with antepenult stress (e.g. *dísciplin, bénefit, jéttison, párody*) comment that the results (*dísciplinable, bénefitable, jéttisonable, párodiable*) are "awkward", "a mouthful", "too long". Nonetheless, they recognize that there are no viable alternatives: for the vast majority, well-stressed forms like *jettisónable* are out of question. In other words, speakers understand three essential points: first, that there is a conflict between phonological well-formedness - as reflected in the shape of underived words - and the requirements of base invariance. Second, that base invariance may carry higher priority: the  stress of *dísciplinable* is due to it. And, third, speakers understand that words generated under this conflict are metrically imperfect: *dísciplinable* is not a very good word, but it is the best the system can generate[3]. All accounts must do justice to these points.

Thus for a proper understanding of paradigmatic effects in phonology one must recognize the notion of constraint conflict, the central element of Optimality Theory. There is conflict between the preference for stress invariance and the preference against strings of stressless syllables longer than two: for certain forms, both preferences cannot be satisfied. One can formulate these preferences in a number of ways but the right picture emerges only if their formulation reflects this conflict. We provide this below, employing the notion of correspondence between strings developed by McCarthy and Prince (1995).

Correspondence constraints evaluate the extent of similarity between two linguistic expressions. The typical purpose of this evaluation is to determine whether the two expresions resemble each other sufficiently to be considered realizations of the same linguistic sign. These constraints can be read as asking the question: Assuming that two surface strings $\Sigma1$ and $\Sigma2$ stem are, at the lexical level, one and the same unit, are they identical with respect to some specified phonological property P? If the answer is yes, the constraint in question is said to be satisfied; otherwise, it is violated.The strings thus compared are said to be *correspondent*  strings: this means that they are, by hypothesis, variant realizations of the same string in the mental lexicon. Whether this is the right hypothesis or not in any given case is determined by the overall constraint system, not by any single correspondence constraint, as we see below.

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[3]These points emerge also from a study by Cutler (1979) on subject preferences for nonce words using stress-neutral suffixes - *-able, -ment, -ness, -ish* - as against nonce forms built with stress-modifying suffixes: *-al (N), -ial (Adj.), --ity, -ous.* Cutler's subjects did not evince any global preference for productive as against unproductive suffixes: but their comments did display awareness of the conflict between the considerations of base invariance and metrical well-formedness mentioned in the text. Several subjects mentioned independently that "although words formed with the + suffixes (-ial, --ity, -ous.) were aesthetically more pleasing and would be preferred as permanent additions to the vocabulary, a # suffix  [i.e. a stress-neutral one] would generally be more useful to achieve understanding in everyday conversation. Thus although *villagérial* might in general be preferred to *víllagerish* as an English word, the latter would be more likely to get the message across to an audience not expecting an unfamiliar word.Words with #-affixes, which leave stress on the stem, are in [...] recognized by speakers to be morphologically more transparent." (p.84) We speculate that *villagérial*  is "aesthetically more pleasing" than *víllagerish* because the former avoids Lapse. Morphological transparency can be equated in this case with base invariance.

The property P named in specific correspondence constraints may be segmental identity, featural identity, or identity with respect to some aspect of prosodic structure. Some constraints determine whether every specified element (say every segment or syllable) in one string has a (not-necessarily-identical) counterpart in the correspondent string. Other constraints determine whether these pairs of corresponding elements are identical in detail, i.e. with respect to specified features. One should emphasize that the system of correspondence constraints for any language must be set up so that it allows the recognition that two strings are in fact correspondents, i.e. lexically related, even when they differ in some respect. Thus the English system must reject the hypothesis that [mod] and [mot] are lexically related, while accepting the hypothesis that the suffixal strings [d] (as in [log-d]) and [t] (as in [lok-t]) are one and the same lexical element, despite the voicing difference. Therefore, the hypothesis that two expressions are lexically related does not hinge on the answer to each and every correspondence constraint: Σ1 and Σ2 may differ with respect to voicing and still emerge as correspondents, if this satisfies higher ranked constraints.

There are two variable elements in every correspondence constraint. One is the property P for which the constraint mandates identity between correspondent strings. The other is the lexical relation holding between the pairs of forms considered: these may involve an underlying string and its surface counterpart; or a pair of related surface forms. The cases of interest to us here are pairs consisting of the surface realization of a morpheme in isolation (e.g *díscipline*) and its realization when affixed (e.g. *dísciplinable*). Since this aspect of the correspondence constraint is constant throughout, we will state it in the first constraint ((3) below) and omit is subsequently.

(3) Paradigm uniformity (stress)          abbreviated PU (stress)
    Let F be a form exhaustively analyzable into the constituents A(F), an affix, and S(F), a stem. If a realization of S(F) occurs as a free word W, then, for every syllable σ in S(F), if σ has a correspondent σ' in W then σ has the same stress category (stressed or stressless) as σ'.

PU (stress) states that pairs of correspondent syllables are identical with for stress: therefore PU (stress) is satisfied by the pair {díscipline-dísciplin(-able)} and violated by pairs like {dísciplin-discíplin(-able)}. The constraint that conflicts with PU(stress) in the forms discussed earlier is *Lapse:

(4) *Lapse
    Strings of stressless syllables longer than two do not occur within one word.

The tableau in (5) records the conflict between PU (stress) and *Lapse in the realization of *dísciplinable*. A tableau is a list of conceivable realizations of a given form (*candidates*), each of which is evaluated against a set of ranked constraints. In our case, the constraints are PU (stress) and *Lapse. We assume that the former outranks the latter: this is indicated by the >> symbol, thus PU (stress) >>*Lapse. We consider only two candidates, each selected to violate/satisfy different constraints; asterisks mark constraint violations. The

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candidate ['dIs´plIn´bl`] is marked as violating *Lapse twice because it contains two distinct sequences of three stressless syllables, [s´plIn´] and [plIn´bl`].

(5)

| W = dísciplin ['dIs´plIn] | PU (stress)    >> | *Lapse |
|---|---|---|
| i.+dísciplinable ['dIs´plIn´bl`] | | ** |
| ii. disciplínable [ÆdIs´ 'plIn´bl`] | * (plIn     'plIn) | |

The optimal candidate is marked by +: to identify it, candidates are compared with respect to the highest ranked constraint, here PU (stress). If some violate it and some do not, the violators are eliminated from consideration. This is the case in (5): candidate (ii) is eliminated from consideration after this first step of the evaluation, because only it violates the top ranked PU (stress). If all candidates violate the top constraint, but some more than others, then the additional violators are eliminated. If, after all candidates have been evaluated with respect to the top constraint, several viable ones remain, these are evaluated in the same fashion with respect to the second ranked constraint and so forth, until a unique winner emerges.

The conflict between PU(stress) and *Lapse revealed in (5)  is reflected in the fact that both -*able* derivatives of *díscipline*  considered in (5) violate one of these two constraints[4]. The prevalent form in actual use, *dísciplinable*, is better than the alternative, but it is imperfect nonetheless: it violates *Lapse. Our approach differentiates three classes of -*able*  forms: forms which violate *Lapse twice (*dísciplinable, jéttisonable, párodiable, bénefitable*), forms which violate *Lapse once (*éditable, estáblishable, devélopable*) and, finally, forms which do not violate *Lapse at all (*represéntable, redeplóyable, disinféctable*). We claim that ALL three classes are in potential use, in contrast with stress-shifted*jettisónable, *develópable*, etc. which satisfy *Lapse but violate PU(stress). But we also claim that some of the useable forms are better than others, in proportion to the extent they violate *Lapse. We are in the process of confirming this claim through a study of speakers' well-formedness judgments for nonce -*able*  words. Results so far, from 15 speakers, confirm that, when one controls for length and familiarity, subjects show a systematic preference for words which do not violate *Lapse at all; in addition, there is a preference for words that minimize *Lapse violations, e.g. for *estáblishable*  as against *dísciplinable*[5]. Beyond the speakers' intuitions, there is grammatical evidence for the claim that lapsed strings of three or more stressless syllables are disfavored in all Level 2 "stress-neutral" combinations (Steriade 1998).

This is, in outline, the analysis of stress uniformity effects based on the idea of conflict between PU(Stress) and metrical wellformedness constraints like *Lapse. There are no satisfactory alternatives to it. Suppose, for instance, that we describe the stress differences between non-derived and productively derived words of

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[4]The reader will note that a form like *dìsciplináble* (or *dísciplinàble)*) - with some level of stress on the suffix - satisfies both PU(stress) and *Lapse. The non-existence of such forms reflects further conditions on affix invariance, dicussed by Burzio (1994).

[5]A minority of the speakers consulted said *dìsciplínable, bènefítable*  (though none said *jettisónable*) but a majority within this small group rated such forms with shifted stress as marginal, perhaps mindful of the fact that an unacceptable change had to be introduced in order to render the form pronounceable.

English by imposing domain limitations on some metrical constraints. One can restate *Lapse so that its proper domain of application are roots and stems derived by unproductive, Level 1, affixes. We can state that sequences of stressless syllables longer than two are impermissible inside roots or in stems derived at Level 1. Under this analysis, no need arises to recognize a *Lapse violation in *dísciplinable*, etc. since the reformulated *Lapse constraint will not apply to any verb-*able* combination. If there is no *Lapse violation in*dísciplinable*, then there is no need to find a higher ranked constraint - here PU (stress) - that compels *Lapse violations. Thus the domain restriction is a descriptive substitute for the PU constraint. But it is not a good substitute, because it fails to reflect precisely the intuition that forms like *dísciplinable* are metrically imperfect and that they are being used only for lack of a better alternative.

An equally unsatisfactory analysis will consist of restricting the stress rules so that they are inapplicable to words created through Level 2 affixation. This is the approach adopted by the theory of Lexical Phonology (Kiparsky 1982, Mohanan 1986) and it is open to the same objection as above. In a rule-based approach, well-formedness is a function of the correctness of rule application in the derivational history of the form evaluated. By this standard, *dísciplinable* is as well formed as, say, *redeplóyable*: neither gives evidence of an illegitimate rule application. But these forms, as we have seen, are not equivalent in well-formedness. The right account of Level 2 phonology must distinguish better formed *redeplóyable* from awkward *dísciplinable*, while at the same time identifying the factor that induces accentual invariance in both. This factor is PU (stress).

We have seen so far that phonological constraints like *Lapse, whose effects are categorical in the core vocabulary of underived forms, may fail to shift stress in productively affixed words.This is not because constraints like *Lapse "fail to apply" to affixed words: they do, and speakers' intuitions of relative wellformedness reflect this directly. Rather, the invariance of stress must be attributed to a constraint insuring the surface similarity between base forms and their counterparts in affixed words. The constraint is PU (stress) and its functional rationale is, we speculate, facilitation of lexical access.

A large class of the phenomena thought to motivate cyclic rule application fall into the category of unexpected accentual similarity between a base and its derivatives. We have suggested here that the better account will rely on constraints requiring similarity between paradigmatically related surface forms. An equally large class of processes described earlier through cyclic rules involves segmental similarity between a stressed syllable and its stressless correspondent in related forms. For instance, in Levantine Arabic (Brame 196x, Kager 1998), a vowel in the derivative which corresponds to a stressed vowel in the base cannot delete, even though other vowels, in comparable environments, do. The pair *fíhim* 'he understood' and its inflected derivative *fihímna* 'he understood us' illustrates this. Phonologically, the latter is expected to surface as *fhímna*, since in general stressless high vowels delete in open syllables. But this particular *i*, at the initial of *fihímna*, is the correspondent of the stressed *i* of its base, *fíhim*: if it had deleted, the base stressed vowel would have no counterpart in the derivative at all. A similar situation is observed in Catalan (Mascaró 1976), where the base-derivative relation inhibits a process of glide formation. In general high vowels become glides after vowels, hence /franku-italjá/ 'Franco-Italian' realized as [frankujta'lja]. But the correspondents of base stressed vowels are not subject to glide formation: the derivative of [ru''inˊ] 'ruin' is [ru.i.'nos], not [ruj.'nos]. Here too, the

correspondent vowels differ in stress category, but an element of the base stressed vowel is maintained in the derivative and, we can suppose, signals in this way its lexical connection to that stressed syllable.

With such cases in mind, we suggest that PU (stress) should characterize not only stress identity between syllables but also the use of individual stress correlates (such as duration, pitch accents, vowel quality) to flag the stress profile of the lexical item to be accessed. To implement this, we modify PU(stress) so that it promotes identity between a stressed syllable in one form and the corresponding string in a paradigmatically related form, whether or not this string constitutes a syllable. The new class of constraints evaluates the similarity between corresponding strings with respect to specific stress correlates such as duration.

(6) PU (stress, duration) : If two strings, $\Sigma$ and $\Sigma'$, stand in correspondence and if $\Sigma$ is a stressed syllable, then $\Sigma$ and $\Sigma'$ are durationally equivalent.

"Durationally equivalent" means that corresponding strings have the same range of durational values, with the same distribution. The requirement of durational equivalence admits multiple degrees of satisfaction/violation: thus in the two pairs of Levantine Arabic forms {**fí**him-**fi**hímna} vs. {**fí**him-***f**hímna} the correspondent strings highlighted are closer to being durationally equivalent in the first pair {**fí-fi**} than in the second {**fí-f**}. Similarly for the Catalan pairs {ru.**í.**na-ru.**i.**nós} vs. {ru.**í.**na-ru**j.**nos}: neither the pair {**í-i**} nor the pair {**í-j**} may count as fully equivalent durationally, but the first pair is closer to equivalence than the second and thus better satisfies PU (stress-duration). Further evidence supporting the adoption of a constraint like PU (stress, duration) appears in Kenstowicz and Abdul-Karim (1980): the correspondent of a base-stressed vowel is exempt from a general vowel shortening process. The same notion of durational equivalence will play a further role in what follows.

We emphasize that the approach suggested here consists of decomposing the notion of accentual correspondence into multiple components, each of which represents the equivalence between two strings with respect to an individual stress correlate. (6) provides just one of these constraints, the one for which some empirical evidence is being presented. Full accentual correspondence between corresponding strings is evaluated through the entire set of constraints of the form PU (stress-stress correlate).

## X.5. Tapping and Paradigm Levelling: the Withgott Effect

We can now turn to the type of paradigmatic levelling that generalizes phonetic detail or type (c) properties, a phenomenon I refer to as *phonetic analogy*. The case discussed first is that of American English taps and stops. The difference between [] and [t], [d] is a function of closure duration (Zue and Laferriere 1979; Banner-Inouye 1995): the tap's mean duration is 26 ms, as against 75 ms for *d* and 129 ms for *t*.. The extra-short duration of [] is a good candidate for a never-contrastive property, one that cannot correspond to a phonological feature in the contrast-based Jakobsonian feature theory outlined earlier[6].

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[6]Taps and flaps are not distinguished in our discussion and the term *tap* is meant to cover both.

We reach this conclusion in two ways. First, the tap-related contrasts surveyed by Banner-Inouye's (1995) involve either alveolar rhotics - distinguishable by [+sonorant, +continuant] from the corresponding stops -  or voiced alveolar stops  - distinguished by [+voice] from *t*  and by [-son] from *r.* Banner-Inouye's instances of tap: trill contrasts  involve, in a restricted phonological feature set, differences of either syllable weight or point-of-articulation. The tap [ɾ] is never in clear contrast, in the same system, with  a homorganic voiced stop *and*  a homorganic rhotic of identical   moraic count. This is one reason, for a feature theory that adheres to the contrastivity test, to reject any expansion of the feature set meant to accomodate [ɾ]. The second reason is that any closure-duration feature that distinguishes [ɾ] from [d]  will  have to be restricted to  coronal obstruents: no comparable contrasts exist between   short and extra-short   labials or short and extra-short   velar stops. The conclusion then is that a feature such as [extra-short closure] will not pass the contrastivity test.

This is reflected in the fact that most phonological discussions of English flapping avoid  mentioning by name the feature that distinguishes [ɾ] from [t], [d][7]. It is not satisfactory to use [+sonorant] for this purpose. The context that induces tapping is one where *all*  oral constrictions are shortened (Browman and Goldstein, 1992; cf.also data in Sharf, 1962), to a greater or lesser degree: but the difference between sonorants and obstruents is not a function of gesture duration[8]. Therefore identifying taps on the basis of their durational category - the feature [extra-short closure] -  allows the tapping effect to emerge from a   general statement of  closure shortening, whereas labelling them as [+sonorant] results in a description that ignores any connection between the tap and the shortening context that produces it. I assume then that at least one of the features of the tap is [extra short closure] a reference to a duration  category distinct from that of both voiced and voiceless stops (cf. also Williamson (1977) and Banner-Inouye (1995)) .

Despite being generally non-contrastive, the  feature  [extra-short closure] plays a role in English phonology: this is shown by the paradigmatic extension of the unflapped stop [t] in contexts where taps are normally expected. The extension is systematic, language specific and serves the purpose of generating uniform paradigms, in exactly the same way as the extension of the phonological properties discussed in section 3. If the facts of stress discussed earlier belong in the phonology, then so does the paradigmatic extension of the [extra short closure] feature. We consider now the data leading to this conclusion.

Withgott (1983) notes the near-contrast between [t] and [ɾ] in the accentually parallel forms *militaristic* [mɪ~lˈɪˊrɪ!stɪk] and *capitalistic*  [kÓœˈp ́|ɪ!stɪk]. In both words, orthographic *ta*  is realized with a stressless [ˊ] nucleus, but  the onset of [ˊ] is - or can be - unflapped in  *militaristic*, whereas it must be flapped in *capitalistic*,  [tˊ] vs. [ɾˊ]. The essential fact here is that unflapped [t] in [mɪ~litˊrɪ!stɪk] corresponds to unflapped and stressed [tÓ] in  the corresponding base *military*  [mɪ!lˊtÓœ-ri], while the flap in *capitalistic*  corresponds to the flap in *capital* [kÓœɾp ́|]. The principle at work is Paradigm Uniformity: the paradigm of *military* -

[7]Cf. Kahn 1976, Selkirk 1982, Gussenhoven 1986 among others. Chomsky and Halle (1968), Williamson (1977) and Banner-Inouye (1995) discuss carefully the features needed to  characterize the  stop-tap-flap distinction, but leave the issue of contrast potential untouched.

[8]Contributing to the tapping effect may be the articulatory influence of the tongue body gesture of the preceding vowel, as argued by  De Jong 1996. An account like De Jong's, which is based on the notions of  gestural blending and deactivation, is also incompatible with  the idea that taps differ from stops in being [+sonorant], since the tap maintains a shortened or partially blended  version of the original *stop*  gesture. It does not become a sonorant in any identifiable sense of this term.

*militar(-istic)* becomes less variable phonologically if the stop *t* is generalized to the stressless syllable. Further, non-flapping maintains to a greater extent the durational equivalence between [t´] in [mi~lit´rI!stIk] and [tÓɑ] in [mi!l´tÓœri]: Withgott's observation thus fits into a larger class of phenomena whereby correspondence between stressed and stressless syllables is signalled through partial durational equivalence, as in Catalan and Levantine Arabic.

To verify this, one must first establish that the Withgott effect is systematic. This has been done on the basis of the list in (7), checked with 12 speakers of American English.

(7)    (a)    Bases:    *voluntary, positive, primitive, relative, negative*

                    Derivatives:    *voluntaristic*, *positivistic, primitivistic, relativistic, negativistic,*

    (b)    Bases:    *rotary, fatal, fetish, totem, notary*

                    Derivatives:    *rotaristic, fatalistic, fetishistic, totemistic, notaristic*

We used *-istic* adjectives because this formation is productive and compositional, and thus most likely to display stem invariance effects. Most *-istic* words in (7) are nonce formations. The base forms were selected according to the following criterion: we anticipated that speakers will differ individually in stress in stressing *-tive* forms and the penult in *voluntary*. Under stress, the *t* in *-tive* would not flap; without stress, we expect [|Èv]. This expectation was borne out and subjects did differ on this point. I infer from this that there is no established norm on whether to tap or not in the *-tive* forms of (8.a). In the absence of a clear norm in the pronunciation of the bases, the prediction is that tapping in the derivative will occur subject to the effects of Paradigm Uniformity: if the base contains [|Èv], the derivative will too, whereas if the base contains [tÈv], its derivative will be more likely to contain a stop. When PU is moot, in monomorphemic V'CVtV strings, stressless *t* is generally tapped: *mèri[|]ocrátic, hèma[|´]génesis, pèri[|´]nítis, hèma[|´]cy!stic*[9]. Therefore the interaction of phonological principles alone, without the contribution of the PU factor, favors a tap in this context: any stops observed in the *-tivistic* forms should therefore be counted as effects of paradigmatic levelling.

The 12 speakers were asked to read at a normal rate the randomized list of base forms in (7), pausing briefly after each item. After a pause, they were asked to read a randomized list of corresponding derivatives. All were naive as to the purpose of the experiment. Most of the forms presented are nonce formations (e.g. *voluntaristic, rotaristic, totemistic, primitivistic*) yet the speakers produced the forms without hesitation or false starts.

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[9]Withgott rejects a cyclic analysis of the *capitalistic-militaristic* contrast on the grounds that an unexpected stop is also encountered in the word *Mèditerránean*, where no cyclic principle can predict it. I attribute the unflapped [t] in this unique form to the orthographic geminate rr, which is interpreted by speakers as an indication of secondary stress on the preceding vowel (Nessly 1977). In forms lacking a geminate - e.g. *mèri[|]ocrátic* - the t is regularly flapped.

The effect of tap suppression observed here does not obtain in syllables that directly follow the tonic: *statístic - stà[|]istícian*. The interpretation of this data is not entirely clear but what seems certain is that very few instances of non-tapped t's in the V'_V context have been encountered so far. This may be due to the fact that constraints that induce tapping are more stringent (= more highly ranked) in the immediate post-stress position than elsewhere. PU effects surface only when the tapping constraint is weaker.

The list of *-tive* forms (7.a) was interspersed with the base forms in (7.b) to detect the possibility that the pronunciation of one *-tive* word might influence that of the following items on the list. This did not happen: the base forms contained almost invariably taps, regardless of what words preceded. Similarly, the *-tivistic* forms (7.a) were interspersed with the *-istic* forms listed in (7.b). An added reason to include these items on the list was to verify that speakers would not produce artificially untapped pronunciations: the *-istic* forms in (7.b) should contain taps, both because of the segmental context where the *t* occurs (V'_V) and because their bases contain taps. Indeed, we observed no artificial stops: all base forms in (7.b) - where a tap was predicted - did in fact contain a tap. Thus the tap/stop variation we observed for the items in (7.a) can interpreted as reflecting the speakers' internalized linguistic knowledge rather than an artificial response to the experiment.

The results of the survey show tapping variation for most of the bases in which *t* is separated by one syllable from stress. The observed ratios of tappers to non-tappers were 1/5 for *positive*, 7/5 for *primitive* and *relative*, 2/1 for *negative*. One speaker failed to tap in *fetish* but, aside from this, all t's occurring in directly posttonic position were tapped. On the other hand, we observed virtually no variation on the issue of base-derivative correspondence: of the 12 speakers, 11 had [t]'s correspond to [t]'s and tap to tap in every single one of the relevant base-derivative pairs. There were 6 word pairs in which a stop was phonologically possible in the unaffixed base while a tap or a reduced stop would be expected in the derivative, absent the PU factor, hence 72 pairs of forms that could in principle have shown a disparity between the stop quality of the base and the tapped quality of *t* in the derivative. In fact, however, only one speaker produced a tap in *primitive* and then a stop in the corresponding form *primitivitistic*. With this exception, the forms produced showed complete correspondence between the tap or stop quality of the base and its counterpart in the derivative.

The tapping variability we encountered contrasts with the strict correspondence observed in the quality of base-derivative consonant pairs. This suggests that a productive correspondence principle - rather than rote learning of lexical properties - insures the complete identity in tap/stop quality between the *-tive* and *-tivistic* forms. This point was confirmed by the observation that one speaker had an atypical stop pronunciation for the *t* in both *fetish* and the corresponding item *fetishistic*[10].

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[10]Bruce Hayes points out that for him both the [t] and the [|] pronunciations are acceptable in every single *-tive* form in (17.a) and each corresponding *-tivistic* derivative. The judgment of "acceptable" is ambiguous: it may mean either that Hayes is aware that his own production may vary between, say, *primi[t]ive* and *primi[|]ive*, or else that Hayes is aware of the inter-speaker variation observed in the text, while he himself is a constant non-flapper. On either interpretation, this report does not contradict the main point discussed in the text, since Hayes also indicates that the normally untapped *-tary* forms (e.g. *voluntar y* ) correspond to untapped *-taristic* forms (*voluntaristic*), while invariably tapped *-tary* (*notary*) corresponds to obligatorily tapped *-taristic*.

However, the variation reported by Hayes in the pronunciation of *-tive, -tivistic* raises some interesting issues, which have not been settled. One interpretation of the results presented is that any one speaker may produce either the stop or the tap in any one of the **-tive, -tivistic** forms. If so, the *-tive* forms produced during the interview were chosen at random from among the two variants [-tIv] and [-|Iv]. The correspondence in tap/stop quality between each *-tive* form and its *-tivistic* counterpart should then be attributed to the fact that the use of the [-tIv] allomorph activates that sub-entry in the speaker's lexicon and makes it more likely that the same sub-entry will be used again in producing the *-tivistic* derivative. Similarly, the use of the [-|Iv] allomorph activates the [-|Iv] sub-entry and thus accounts for its use in the *-tivistic* form. This observation suggests that two distinct PU effects may exist: short term priming effects and long-term identity effects, which determine general properties of the speakers' permanent lexicon. This critical issue is left open here.

These observations confirm that the medial stop in the *military/militaristic* pair must be attributed to a paradigm levelling effect. An abbreviated analysis of the phonological pattern is shown in (9). I focus first on the constraints that predict the occurrence of the tap in the canonical lenition context V_V[11].

(8) Constraints relevant to the realization of alveolar stops in medial syllables (American English)

   a. **Fortition**: Consonants are realized with increased closure duration at the onset of stressed syllables.

   b. **Tapping**: Alveolar stops are tapped in intervocalic contexts, where tap refers to: extra-short duration of closure, lack of a concomitant jaw raising gesture and lack of a glottal opening gesture[12].

   c. **Reduction**: A stressless vowel must be schwa.

Note that two of the constraints in (8) conflict: **Fortition** and **Tapping** cannot both be satisfied in the production of the same *V'tV* sequence. It is also clear that **Fortition** outranks **Tapping** in American English, since the *V'tV* sequences (including forms like *atómic, Satánic, Platónic*) are always realized with an unflapped, aspirated stop. Therefore we assume that **Fortition** is the more highly ranked of the two. A candidate satisfying **Fortition** but violating **Tapping** will count as preferable, under this constraint ranking, to one that satisfies **Tapping** but violates **Fortition**.

(9) a. **Fortition** >> **Tapping**

| *atómic* | Fortition | Tapping |
|---|---|---|
| + [´tÓa!mIk] | | * |
| [´|a!mIk] | *! | |

   b. Effect of **Tapping** when **Fortition** is moot:

| *átom* | Tapping |
|---|---|
| + [œɫ|´m] | |
| [œɫt´m] | *! |

Turning now to the Withgott effect, we note that the stop [t] in *militaristic* cannot be due to Fortition since its syllable is stressless. Rather, the stop is due to the constraint identified earlier, PU (Stress, duration): the non-flapped [t] in *militaristic* is a partial preservation of the stress carried by its syllable in *military*. Reduction outranks PU (Stress, duration), since the latter fails to block reduction to schwa in forms such as *militaristic*. However, PU (Stress, duration) outranks Tapping, as seen below:

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[11]See Kirchner 1998 on the reasons why this particulat context induces closure shortening and lenition.

[12]The articulatory properties of taps are reviewed by Banner-Inouye 1995. The absence of a jaw raising gesture in flaps is noted by Fujimura (1986). Voiceless taps do occur which indicates that the effect of shortening on glottal opening may have to be controlled by a distinct condition. The characteristic absence of jaw raising and glottal opening movements may be seen as consequences of the extra-short duration allotted to closure.

(10) Constraint interaction producing stressless [t´] corresponding to stressed [to] in base

Ranking: Reduction >> PU(Stress, duration) >> Tapping

| | Reduction | PU (Stress, duration) | Tapping |
|---|---|---|---|
| + i.mI~l´t´rI!stIk | | * | * |
| ii. mI~l´ʆ´rI!stIk | | **! | |
| | *! | | * |

The violation marks in the PU(Stress, duration) column mark *degrees of durational equivalence* between the stressed syllables in the stem *militari-* of *militaristic*, as realized in individual candidates, and their correspondents in the isolation form *mílitary*. We focus here on the syllable *ta*. The candidate that comes closest to achieving durational equivalence is (iii), the form in which the vowel is unreduced and the stop is untapped.This candidate, however, violates Reduction, the highest ranked constraint. The remaining two candidates are differentiated by tapping in the stressless *t[´]*. The reduced but untapped [t´] is durationally closer to the stressed [tÓo] of *military* than the [ʆ´] of candidate (ii) and thus emerges as optimal. Although this analysis does not attempt to explain the relative ranking of Tapping and Reduction, we note that the ranking may derive from conditions on the segmental properties signalling stress. Reduction is the correlate of the [± stress] distinction in English, therefore non-reduction (i.e. the ranking PU stress >> Reduction) will yield forms with the perceived stress contour *mìlitàrístic*. This suggests that a final analysis of this data may be able to minimize the role of stipulated ranking among constraints.

We have seen that in deciding whether a PU constraint is satisfied by a given candidate, the grammar of English must consider the specific properties with respect to which the base stressed syllable differs from its correspondent in the derivative. At least one of these properties is non-phonemic in English, and also non-phonemic in all languages we know: this is the durational difference between [t] and [ʆ]. This is not a phonological feature, judging from the only clear test of what should count as one. However, this difference between [t] and [ʆ] must be identified by a grammatical condition. Therefore [t] and [ʆ] cannot count as phonologically equivalent, despite the fact that the difference between them is necessarily classified as a matter of phonetic detail in a contrast-based feature theory.

### X.7. French C(´)C

The second case we discuss involves the realization of French consonants in the alternating contexts C´C/CC. Morpheme-final schwa can delete in French. Rialland, 1986 notes that when schwa is lost, the consonants left of its original syllable maintain allophonic qualities that would only be appropriate if schwa was still present. Rialland came to this conclusion by comparing pairs like*bas r'trouvé* [baÂtÂuve] 'stocking found again' - a realization of *bas retrouvé* [baÂ´tÂuve] - with *bar trouvé* [baÂtÂuve] 'bar found'. The postvocalic [Â] in *bas r'trouvé* is similar to an onset allophone ("fort et vibré") and has no lengthening effect on the preceding vowel. The post-vocalic [Â] in *bar trouvé*, an underlying coda, is lenited and doubles the duration of the preceding vowel (O'Shaughnessy 1981). Rialland formulates the comparison in syllabic terms stating that [Â] in *bas r'trouvé* is not resyllabified as a coda after the loss of schwa. If it had been, it would have been

realized identically to the [Â] of *bar*. We will see however that the syllabic organization of the string resulting from schwa loss does not contribute to an explanation of the data. Rialland's observations are summarized in (11):

| (11) | Syllable initial **r** | Coda **r** | **R** next to lost schwa |
|---|---|---|---|
| EXAMPLES: | *bas retrouvé* [ba Â´tÂuve] | *bar trouvé* [baÂ tÂuve] | *bas r'trouvé* [ba ÂtÂuve] |
| PROPERTIES | • greater acoustic energy; | • decreased energy | • greater acoustic energy |
| | • longer duration | • shorter duration | • longer duration |
| | • no lengthening effect | • preceding V lengthened | • no lengthening effect |
| | on preceding V | by about 130% | on the preceding V |

The same study compared *pas d'rôle* 'no role' with *pas drôle* 'not funny' noting that onset [Â] has a syllable-initial allophone, as in *rôle* , and a syllable-internal one, as in *drôle*. After schwa loss, in *d'rôle,* [Â] maintains the syllable initial quality.

| (12) | Syllable initial **r** | Onset **r**, syllable internal | R next to lost schwa |
|---|---|---|---|
| EXAMPLES: | **pas de role** [pad´Âol] **pas drole** [padÂol] | | **pas d'role** [padÂol] |
| PROPERTIES | • greater acoustic energy | • decreased energy in the higher formants | • greater acoustic energy |
| | • longer duration | • shorter duration | • longer duration |

Rialland concluded that the string resulting from schwa loss is syllabified differently from strings lacking an underlying schwa. She suggests that syllables originally headed by schwa survive the loss of their nuclear vowel: thus *pas d'rôle* consists of the syllables [pa.dÂ`.Âol], with ambisyllabic and partly nuclear [Â]. This parse explains the observations made earlier: [Â] in *pas d'rôle* is different from [Â] in *pas drôle* because the former continues to stand in syllable-initial position in [Âol], unlike the latter.

There is a basic obstacle to this interpretation: the syllable count depends in French on the presence of audible vowels, including [´]. A verse such as *Il en est de pires il en est d'meilleurs* [il A)n e d´ piÂ, il A)n e d mEj"Â] ('There are worse and there are better ones.')[13] scans correctly only when it contains exactly 10 syllables.If *d'meilleurs* 'of better ones' is pronounced with schwa, as [d´ mEj"Â], the verse becomes unacceptably long. (Cf. Dell, 1989). Therefore we cannot adopt Rialland's suggestion that the invariant property in C(´)C sequences is the number of syllables: when schwa deletes, the syllable count is correspondingly decreased. What will account then for her observations on allophone distribution?

Here too the answer we suggest invokes the effect of PU conditions on phonetic detail. Consider the phrase *de rôle* in *Il n'a pas d(e) rôle***.** At least one component of this phrase - the noun *rôle* - can be produced in isolation. Its isolation form will necessarily contain a syllable initial [Â] allophone, characterized by longer

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[13]From a poem by Georges Brassens.

duration and increased acoustic energy. It appears that such properties of the citation form are preserved in the reduced string *d'rôle,* after loss of schwa, whether or not the syllable structure is recomputed. Similarly, the citation forms of the components of *bas r(e)trouvé* are *bas* [ba] and *retrouvé* [Â´tÂuve], with schwa and syllable initial [Â]. It is the relative duration of *a* in [ba] and the syllable-initial properties of [Â] in [Â´tÂuve] that are preserved in the corresponding schwa-less phrase [baÂtÂuve]. The preservation of these properties of the citation form (or of the careful pronunciation for function words like *de*, which cannot be uttered in isolation) can be attributed to constraints requiring the invariance of morpheme edges: all cases discussed by Rialland, involve morpheme-initial or morpheme-final consonants whose quality remains relatively invariant in utterances with and without schwa. With this in mind, Cécile Fougeron and I have attempted to replicate Rialland's results through electropalatography (Fougeron and Steriade 1997; Steriade and Fougeron 1997). One group of utterances we studied is (13):

(13)    a.  Il n'a **pas de rôle** en ce moment        [ilnapad´Âola)s´moma)] ('He has no role right now')

        b.  Il n'a **pas d'rôle** en ce moment        [ilnapadÂola)s´moma)] ('He has  no role right now')

        c.  Il n'est **pas drôle** en ce moment        [ilnepadÂola)s´moma)] ('He's not funny right now'.)

        d.  Il voit le **jade rose** en ce moment. [ilvwal´ZadÂoza)s´moma)] ('He sees the pink jade now.')

Item (a) involves an unambiguous prevocalic onset [d] followed in the next syllable by a syllable initial  Â. Item (b) involves *d′* from [d´] followed by [Â]. It is the properties of this [d] that we focussed on. Item (c) involves an underlying onset [dÂ] sequence. Item (d) involves a coda [d] followed by an onset [Â]. Our conjecture was that the *a#d#Âo* sequence (item b) will be systematically different from both *a#dÂo* (item (c)) and *ad#Âo* (item (d)). Moreover, on the dimensions that distinguish (b) from (c) and (d), the (b) tokens will be closer to (a), the morphologically related form. We did not expect  complete identity between the allophone of [d] in (a) - *a#d´#Âo* - and that of [d] in (b) - *a#d#Âo*, given that one is followed  directly by a consonant while the other is followed by a vowel. However, any similarity between (a) and (b) that is unexpected based on the surface composition of the string should be attributable to the effects of Paradigm Uniformity.

Two speakers fitted with Kay pseudopalates produced 20 repetitions of each of the sentences in (13). The results indicate that the amount of linguopalatal contact (measured at the point of maximum closure) is greatest for the prevocalic [d] of (13.a) and not significantly different for the paradigmatically related preconsonantal [d] of (13.b). The [d]'s of (13c-d) - which are lexically unrelated and not underlyingly prevocalic - have significantly reduced contact in comparison to those in (a-b). The duration of dental closure shows the same pattern as the amount of linguopalatal contact: the [d]'s of (13.a) and (13.b) are significantly longer than those of (13.c) and (13.d). Finally the incidence of [d]-lenition (tokens lacking a linguopalatal seal) displays a comparable pattern: under 10% of the [d] tokens in (a-b) were lenited in contrast to 30% of the (c) tokens (onset [d] in *drôle*) and 40% of the (d) tokens (coda [d] in *jade*).

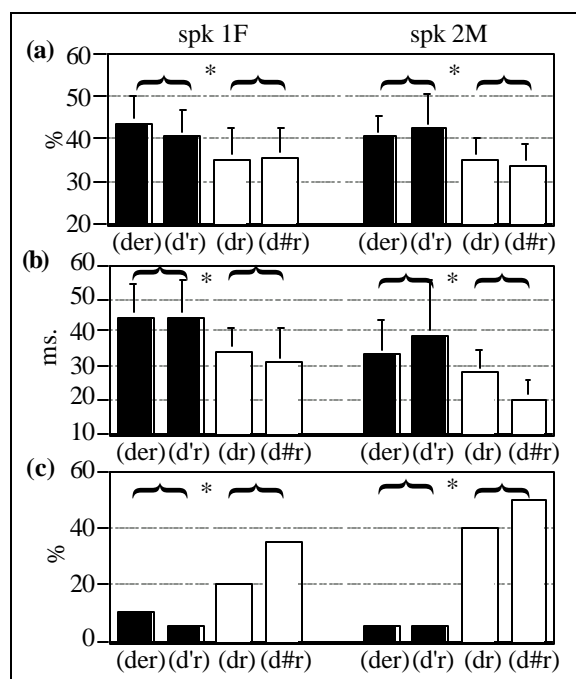Figure 1 (from Fougeron and Steriade 1997)

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*Figure 1: (a) Amount of linguoplalatal contact in [d]; (b) Duration of the lingual occlusion gesture of [d]; (c) Frequency of lenition of [d] in the 4 types of sequences: "de rôle" (der) ([e] = schwa), "d'rôle"(d'r), "drôle" (dr), and "jade rose" (d#r).*

These results confirm Rialland's original observations. But they also establish that the syllable-based explanation she offered is insufficient to account for the similarity between lexically-related strings such as *de* and *d'*: According to Rialland's analysis, the *d'* of *d'rôle* occurs in the syllable [dÂ`], whose nucleus is the syllabic first half of [Â]. Therefore this [d] occurs in a segmental context that differs from that of the original string [d´]. Nothing in the analysis predicts that such a [d] will be identical to the prevocalic [d] of [d´] in duration, amount of contact and lenition possibilities. Thus, even if the hypothesis of syllable invariance could have been maintained, one would still be left without an explanation for the similarities between *de* and *d'*

The analysis we propose for this data involves the interaction of constraints inducing durational reduction and eventually lenition with PU constraints. A possible interpretation is that [d] tends to be temporally reduced in preconsonantal position (or perhaps just before certain consonants such as [Â]). The diminution in extent of contact and [d]'s lenition are, perhaps, consequences of this durational reduction. It is also possible to speculate that the PU constraint which insures the close similarity between the articulation of [d] in *d'* and *de* refers only to the durational category of the consonant. Under this interpretation, a single correspondence constraint will be needed here, which imposes durational equivalence between the left edges of morphemes in careful and casual pronunciation.

(14)    PU (Left: duration): If two consonants, C and C', stand in correspondence and C is morpheme initial in the careful pronunciation of the relevant morpheme, C' is durationally equivalent to C.

This condition can shield the non-prevocalic [d] of *d'rôle* from lenition, if indeed lenition is a direct consequence of temporal reduction. On the alternative interpretation that the temporal and spatial reductions observed here are independent of each other, we will need to adopt a distinct PU condition - or an augmented version of (14) - that mentions equivalence for extent of contact.

This analysis agrees with Rialland's on the point that some characteristic property of the citation or careful form is inherited by the phrase-medial schwa-less variant. However this property cannot be the number of syllables. We must identify it as the durational category of the consonants and possibly their extent of contact: neither of these is an independently contrastive property and both display the sort of token-to-token variability that is said to characterize phonetic detail properties. Yet both of them are subject to paradigmatic levelling. This is then another phonetic analogy effect.

Other studies (Jun & Beckman, 1993, and Manuel & al. 1995) observe effects comparable to those reported here: a process of gestural reduction or an increase in overlap between two gestures is inhibited to maintain lexical distinctions that are more prominently present in the careful pronunciation of the relevant forms. Thus the reduced pronunciation of *in the* may appear to sound just like *in a* but in fact maintains a systematically longer between-vowel interval and is identifiable as *in the* by listeners (Manuel & al.1995). The loss of French schwa could be analyzed similarly, by claiming that a trace of the original schwa gesture is maintained, albeit reduced and completely masked by the neighboring consonants. However, what makes the case of French uniquely relevant to our discussion is the fact that schwa loss has phonological consequences: the syllable count depends on it. This is why all previous work on French schwa assumes that phonological rules and principles govern the occurrence of this vowel. Thus, while the processes discussed by Manuel & al., Jun & Beckman may be interpreted as phonetic implementation rules, the case of French schwa indicates that phonetics and phonology are not easily separated.

## X.8. Conclusions

The phenomena discussed here suggest that the realization of phonetic detail properties is governed by some of the same principles that must be invoked in studying phonological or potentially contrastive features. The family of principles discussed here involves paradigm uniformity. One may anticipate that the conclusions reached here can be extended to other grammatical conditions. Earlier work (Docherty 1992; Keating 1984; Kingston and Diehl 1994; Pierrehumbert and Beckman 1987) has established that some aspects of phonetic implementation are speaker-controlled, rule-governed and possess language-specific characteristics, just like the rest of grammar. The present study has suggested a means of strengthening this result, by showing that some processes applying in the "phonetic implementation component" are qualitatively the same as the ones classified as phonological. Phonetic analogy is qualitatively the same process as cyclicity, the paradigmatic extension of contrastive properties. If this result can be maintained, then it should lead us to question the distinction between phonology and linguistic phonetics, i.e. speaker-controlled phonetic processes. The claim made here is that at least the *feature sets* of phonetics and phonology need not be distinct. A more conservative assessment of what has been shown is that if the phonological and phonetic feature sets are in fact distinct, they are not distinguished by potential contrastivity but in some other still unidentified way.

Let me conclude by raising at least two of the questions that will have to be addressed in exploring the possibility of unifying phonological and phonetic features. The first of these questions involves the functioning of paradigmatic uniformity. One aspect of the data that I have so far glossed over is that phonetic analogy - the paradigmatic extension of non-contrastive properties - is far less categorical than instances of paradigm levelling affecting the global distribution of contrasts. Thus, a given token of French *d'rôle* can be produced with a *d* that is identical in duration and extent of contact to the *d* of *drôle*. The PU effect in the French case accounts for the trend rather than for the quality of individual tokens. Similar variability is not reported in the study of "phonological" cyclic effects. This may be due to the fact that phonological studies typically rely on introspective reports but it is very likely that a difference will emerge even if the investigative methods used are held constant. Such a difference in the categorical status of paradigmatic extensions will have to be explained. At present I would speculate that any sound property or any cluster of properties may give rise to paradigmatic levelling but that the categorical or variable nature of of the effect will depend on the perceptibility of the property being generalized through levelling. The less perceptible the contrast generated in this way, the harder it will be to detect and enforce uniformity in each and every relevant token.

The second question takes us back to the beginning of the paper. The idea that some phonetic categories lack phonological relevance was inspired by the correct observation that lexical contrasts are very limited in number, in any given language. How should this observation be handled if we fail to distinguish phonetic from the much smaller set of phonological categories?

Let me sketch an answer to this second question. We must start by drawing a distinction between *feature* and *contrast*. Thus the grammatical object that phonologists refer to with the term *the feature [±voice]* is a contrast, not a feature (cf. Keating 1984). It is a contrast implemented through a large number of features: closure duration, prevoicing, VOT, pitch etc. The contrast is robust across contexts and speech circumstances only when many features are jointly employed to distinguish its terms. This means that in order to have some optimally differentiated contrasts, a language must drastically limit their numbers, so as to minimize the featural overlap between contrastive categories (Lindblom 1990, Flemming 1995). A primitive example of the role played by this distinction between features and contrasts is the statement in (15), which requires every stop to possess a certain number of attributes that jointly identify it as belonging to either the "voiced" category (a) or the "voiceless" category (b).

(15)    A stop must have either one of the following sets of properties:
    (a)  {short closure duration, voicing during closure, VOT value < xms, long $V_1$}
    (b)  {long closure duration, no voicing during closure, VOT value > yms, short $V_1$}

The condition in (15) requires voice-differentiated stops to differ with respect to four distinct features. In principle, this condition prohibits the contrastive use of any of the properties listed in (15) in stops: for instance, any stop that possesses a long closure will necessarily possess all the other attributes of voiceless stops, the absence of closure voicing, the longer VOT, the shorter $V_1$. To do otherwise would violate condition (15). (In practice, the surface effects of (15) will be a function of the interactions between it and competing constraints of

the language.) The statement in (15) therefore amounts to a constraint on the expression of the voicing contrast. Now let us compare a contrast based on all of the features in (15) with one based exclusively on closure duration, i.e. the sort of smallish durational difference that separates *t* from *d* in English. The contrast implemented through only one feature is obviously a worse contrast than the one based on four: it is worse not because it uses the *wrong* feature but because it does not use enough features to sufficiently differentiate its terms.

The suggestion then is that by exploiting constraints on contrast like (15) we eliminate a major reason to impose limitations on what should count as a phonological feature. The feature set need not be restricted in order to distinguish good contrasts from bad ones: a theory of contrast goodness and specific constraints on contrast are sufficient for this task (Flemming 1995). We are therefore free to assume, if necessary, that all properties listed in (15) are grammatically relevant despite the fact that none of them is independently contrastive. This paper has shown that this is indeed necessary: non-contrastive features such as [extra-short closure] *are* grammatically relevant, in the sense that the evaluation of paradigmatic uniformity constraints requires the grammar to note distinctions based on these attributes.

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