# Distinctive features and phonological change: vowel fronting and gravity interactions in Altamurano*

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Altamurano (a southern Italo-Romance variety) displays a set of phonological processes and/or diachronic changes which are best explained with reference to the gravity of the vowels, glides and consonants involved. These processes (insertion and deletion of a labio-velar glide, back vowel fronting; cf. §1), for which I propose the overall label of *gravity interactions*, represent a counterpart to the often discussed *coronal interactions*. While the latter are neatly accounted for within Feature Geometry models (cf. e.g. Hume 1992, Clements & Hume 1995), Altamurano gravity interactions provide a challenge to some basic assumptions underlying mainstream research on phonological processes and change in Generative Phonology. In §2, it is demonstrated that a sensible account of the phonological processes at issue requires direct reference to the acoustic substance linguistic sounds are made of.

After developing my account, I move on to discuss alternative analyses of the Altamurano data which have been recently put forward (§§3-4). In the Appendix, I discuss a further process of Altamurano, viz. open syllable diphthongization, and, based on this discussion, briefly tackle the collateral issue of the relationship between dialectological fieldwork and theoretical speculation in phonology.

## *0. Introduction*

The relationship between synchrony and diachrony in the study of language can be conceived in either of the following ways: there is a system, viewed synchronically, and then change modifies that system; or, alternatively, there are phonological processes which bring about changes, and the system itself is viewed as the product of these changes. This sort of hen-and-egg story tells us that the basic assumptions and the technical machinery by means of which we describe phonological systems, on the one hand, and phonological change, on the other hand, cannot radically diverge, a fact on which most linguists of different theoretical beliefs nowadays agree. Take for instance Labovian sociolinguistics: it describes synchronic variation by quantifying the behaviour of (classes of) speakers by means of indexes for any given variable, and then it applies the same descriptive tools to account for change in the speech community, in real or apparent time (cf. Labov 1994). Or take Optimality Theory (Prince &

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Smolensky 1993). It describes synchronic patterns by means of hierarchically ordered constraints, and then goes on to describe change as mutual re-ranking of (some of) these constraints (cf. e.g. Löhken 1997).

A further, quite banal fact is that language is used by human beings, who have with it a two-fold relationship: as speakers (speech-producers) and as hearers (speech-perceivers). Once this elementary observation is brought into the picture, however, a paradox quickly arises. In this respect, in fact, there is a striking difference between what is common practice in the two fields of synchronic analysis of phonological patterns, on the one hand, and of the study of sound change, on the other.

In the latter field, there is a fair amount of work which shows that the factors conditioning language change have to be sought in either production or perception: some changes are better explained as due to articulatory constraints, others as due to perceptual ones.[1] This holds true for several lines of research, which can be defined – in epistemological terms – as either substantialist (like e.g. Ohala's 1989 Experimental Phonology) or functionalist (such as e.g. Dressler's 1985 version of Stampe's Natural Phonology).[2] But the paradox becomes evident as soon as we consider the descriptive machinery currently used in the synchronic analysis of phonological systems. Here, the most fully developed models all share a conventionalist-formalist orientation: what matters is the production of the most economical formalized description of patterns and processes. In this connection, the theory of distinctive features (henceforth **DFs**) plays a major role. And since descriptive economy must be achieved first and foremost, emphasis is placed on the elaboration of a maximally constrained set of DFs. One major economy, to spare descriptive redundancy, has been to choose to have DFs grounded in only one of the two dimensions, either acoustic (like Jakobson *et al.* 1952) or articulatory, like all other current systems since then, starting with Chomsky & Halle (1968) up to more recent Feature Geometry models such as e.g. Halle *et al.* (2000).

However, if at the same time we take seriously the idea that generalizations about phonological systems must be expressed in terms of DFs, as well as the idea that phonological change and its output (phonological systems) are determined by both production and perception, then a straightforward conclusion ensues: models that choose only one of the two dimensions, singling out either production or perception as the only relevant foundation for generalizations about language structure and change, cannot be correct.[3]





A further, more general problem of these models is the fact that they tacitly assume that sound change can be satisfactorily and exhaustively described in terms of DFs which, although grounded in the phonetic dimension, build a self-contained formal system. This follows from a well-established view according to which phonology is linguistic *form*, by definition, and is best described in purely internal terms (cf. e.g. Hyman 2001). However, there are alternative views of phonological systems, according to which these are best understood as the formal reflex of *substantial* constraints (cf. e.g. Stampe 1979, Ohala 1989).

In this paper I intend to argue in favour of the latter position, and show that the exclusive focus on form (vs. substance), on the one hand, and on the articulatory (vs. perceptual) dimension both prove disadvantageous for the analysis of phonological change. Rather, successful elucidation of change requires that the form/substance and the articulation/perception dichotomies be taken into account seriously. The empirical material I will discuss is provided by a set of phonological processes at work in a dialect of south-eastern Italy, Altamurano, spoken by some 60,000 people in the town of Altamura (in the province of Bari, Apulia). In §1 I describe these processes: *w*-insertion (§1.1), *w*-deletion (§1.2), and back vowel fronting (§§1.3-1.4). In §2 I develop my account of the facts, which relies crucially on the assumption that the changes at issue – or, more precisely, the conditions constraining them – must be understood in the light of acoustically motivated perceptual constraints, much in the spirit of Ohalian experimental phonology. To demonstrate this, it is necessary to refute alternative explanations of the same data that have been proposed by several scholars after the Altamurano facts were first described, in Loporcaro (1988).

These alternative analyses are discussed in §§3-4, with special focus on Cox (1997) and Calabrese (2000), who propose separate accounts of *w*-deletion and back vowel fronting, respectively. I will show that these accounts have several shortcomings: first of all, they single out only some of the processes at issue, while I argue that a conjoint consideration of all these processes is essential to a correct characterization of them. Secondly, Cox and Calabrese both assume that the processes follow from articulatory constraints and can be expressed formally, as a consequence, in terms of articulatorily based DFs. I will show that this basic assumption inevitably leads to bad descriptive results and makes a sensible explanation impossible. Finally, with specific reference to Calabrese (2000), I show in §4 that this reanalysis is also flawed by both empirical and theoretical shortcomings, as it is based on a conception of the relation between phonological form and phonetic substance in phonological research which turns out to be misguided.

## *1. The facts: four phonological processes in the dialect of Altamura*

### *1.1. [w]-propagation*

In this dialect, an assimilation process propagates a labio-velar glide, under the appropriate conditions, as shown in (1):[4]

| | | | | | |
|---|---|---|---|---|---|
| (1) | a. | /ʊ # 'pɛnə/ | → | [ʊ 'pwɛi̯n] | 'the bread' |
| | | /ʊ # 'bbenə/ | → | [ʊ 'bːwei̯n] | 'the good' |
| | | /'kʊssʊ # 'melə/ | → | ['kʷʊsːʊ 'mwei̯l] | 'this honey' |
| | | /ʊ # 'felə/ | → | [ʊ 'fwei̯l] | 'the gall' |
| | | /ʊ # 'vaɲɲə/ | → | [ʊ 'waɲː] | 'the tub (to wash sheep)' |
| | | /'kʊddʊ # 'kɛnə/ | → | ['kʷʊdːʊ 'kwɛi̯n] | 'that dog' |
| | | /nʊ # gga'raddʒə/ | → | [nʊ gːwa'radːʒ] | 'a garage' |
| | b. | /ʊ # 'tau̯lə/ | → | [ʊ 'tau̯l] | 'the table' |
| | | /nʊ # 'dɪʃtə/ | → | [nʊ 'dɪʃt] | 'a finger' |
| | | /ʊ # 'nɛsə/ | → | [ʊ 'nɛi̯s] | 'the nose' |
| | | /'kʊssʊ # 'rɛnə/ | → | ['kʷʊsːʊ 'rɛi̯n] | 'this wheat' |
| | | /ʊ # 'lattə/ | → | [ʊ 'latː] | 'the milk' |
| | | /ʊ # 'sɛlə/ | → | [ʊ 'sɛi̯l] | 'the salt' |
| | | /nʊ # 'tsɛmbrə/ | → | [nʊ 'tsɛmbr] | 'a he-goat' |
| | | /ʊ # 'ddzɪrrə/ | → | [ʊ 'dːzɪrː] | 'the oil-jar' |
| | | /ʊ # 'ʃekə/ | → | [ʊ 'ʃei̯k] | 'the game'/'you.SG play it.M' |
| | | /ʊ # 'tʃɛrnə/ | → | [ʊ 'tʃɛrn] | 's/he sifts it.M' |
| | | /ʊ # 'cevə/ | → | [ʊ 'cei̯f] | 'the nail' |
| | | /'kʊddʊ # 'jattə/ | → | ['kʷʊdːʊ 'jatː] | 'that cat' |

As is apparent from a comparison of the underlying and the surface forms in (1a-b), some more processes apply which we will neglect for the moment. (In particular, final schwa deletion and non-low vowel diphthongization, to which we will return in the Appendix.) As is also apparent from the two columns in (1), the propagation of the labio-velar glide [w] takes place whenever a particular morpheme containing a /ʊ/ vowel (either the definite article /ʊ/, or the indefinite article /nʊ/, or the direct object clitic /ʊ/, or the determiners /'kʊssʊ/, /'stʊ/ 'this', /'kʊddʊ/ + noun/adjective) is added before one of the words in (1a), not before those in (1b). Evidence for the underlying





representation, and hence for the process, is provided by the fact that in all other contexts, the words in (1a) surface without [w]: e.g. [ʊ 'pwaʃː] '(s/he) pastures it.M' vs. ['kwanːə 'paʃː] 'when (s/he) pastures'.

Propagation is subject to some conditions. The initial consonant must be labial or velar ((1a)), while dentals, palato-alveolars and palatals block the process ((1b)).[5] A further condition requires that the initial consonant be followed by a non-back vowel. As shown in (2), back vowels block propagation:[6]

(2)

| | _ɔ | _o | _ʊ |
|---|---|---|---|
| p_ | [ʊ 'pʷɔrdʒ]<br>'the flea' | [ʊ 'mou̯f]<br>'I move it.M' | [ʊ 'mʊu̯t]<br>'the funnel' |
| k_ | [ʊ 'kɔnd]<br>'I count it.M' | [ʊ 'kou̯r]<br>'the heart' | [ʊ 'kʊu̯l]<br>'the arse' |
| t_ | [ʊ 'tsɔmb]<br>'I jump it.M' | [ʊ 'nou̯f]<br>'the nine' | [ʊ 'tʊu̯f]<br>'the (block of) volcanic tufa' |

For clarity, table (3) shows the relevance of the two conditioning factors: place of articulation of the initial consonant, on the vertical dimension, and of the following vowel, on the horizontal dimension. (The borderline underscores the role of place of articulation).[7]

(3)

| | _a | _ɛ | _e | _ɪ |
|---|---|---|---|---|
| p_ | [ʊ 'pwaʃː]<br>'s/he pastures it' | [ʊ 'pwɛi̯n]<br>'the bread' | [ʊ 'mwei̯l]<br>'the honey' | [ʊ 'fwɪi̯l]<br>'the thread' |
| k_ | [ʊ 'kwallə]<br>'the heat' | [ʊ 'kwɛi̯n]<br>'dog' | | ([nʊ 'kɪi̯l])<br>'one kilogram' |
| t_ | [ʊ 'tau̯l]<br>'the table' | [ʊ 'rɛi̯n]<br>'the wheat' | [ʊ 'sei̯n]<br>'the sound' | [ʊ 'tsɪi̯t]<br>'the bridegroom' |

Note that propagation is not triggered by just any preceding /ʊ/, but only by the /ʊ/ contained in the morphemes listed above. Thus, for instance, the subject pronoun /'tʊ/ has no effect (cf. (4b) vs. (4a)):

| | | | | | |
|---|---|---|---|---|---|
| (4) | a. | /ʊ # 'paʃʃə/ | → | [ʊ 'pwaʃː] | 's/he pastures it.M' |
| | b. | /'tʊ # 'paʃʃə/ | → | ['tʊ 'paʃː/*'pwaʃː] | 'you pasture' |

This clearly shows that the rule has been morphologized.[8] Summing up, the generalization is that a [w]-glide is inserted after a word-initial labial or velar consonant before a non-back vowel, whenever a /ʊ/ morpheme carrying the morphological specification [msg] precedes. We will discuss a possible explanation of these facts in §2 (elaborating on the account in Loporcaro 1988: 185-196).[9]

Before closing this section, however, let us briefly discuss the non-application of propagation in (2). Note, firstly, that inserting a *w*-glide would pose no articulatory problems at all: on the contrary, it would smooth out the transition from the initial consonant to the following back vowel. Thus, an explanation in terms of a perceptually motivated phonotactic constraint seems to be more promising *a priori*. If propagation were to apply in (2), the output would be a string of /w/ + back vowel, a combination which appears to be cross-linguistically disfavoured (diphthongs aside, of course). Ohala & Kawasaki (1984: 122ff) consider in particular the rarity of /wu/ (as well as /ji/) strings in the languages of the world. This rarity, they argue, cannot be explained in terms of the sonority hierarchy, since the symmetrical strings /wi/ and /ju/ are not subject to any such restrictions, and account for it by the acoustic circumstance that "[wu] and [ji] […] create minimal modulations in amplitude, periodicity, and spectrum" and are therefore perceptually bad.

This would be the case in (2): if /w/-propagation were to apply, the output would be perceptually bad, because of the minimal syntagmatic contrast between /w/ and the following back vowel. Hence, the process is blocked in this context, whereas it applies before non-back vowels (cf. (3)).

*1.2. [w]-deletion*

Altamurano has undergone a diachronic change which is in a way complementary to the synchronic *w*-propagation rule just considered. As shown in (5a-b), lower-mid PRom /ɔ/ and /ɛ/, from Latin short ŏ and ĕ respectively, diphthongized through metaphony to /we/ and /ɪə̯/ under stress, when originally followed by the final high vowels /i u/ (which ultimately merged into schwa as a consequence of a later change).[10]

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (5) | a. | PRom | /ɔ/ | FŎCUS | > | /'fwei̯kə/ | → | ['fwei̯k] | 'fire' |
| | b. | PRom | /ɛ/ | LĔGIS | > | /'lɪə̯ʃə/ | → | ['lɪːʃ] | 'read.2SG' |

The output of /ɔ/-metaphony, viz. the diphthong /we/, was not preserved in all environments. Rather, when preceded by a coronal consonant, the /w/ glide was deleted, whereas it was preserved when preceded by a labial or a velar consonant:





| (6) | [–voice] | [+voice] | [+nasal] |
|---|---|---|---|
| a. /p/_ | PŎTES (PŎTIS) /'pwetə/ 'you can' | BŎNU /'bbwenə/ 'good.MSG' | MŎDU /'mwetə/ 'manner(s)' |
| b. /k/_ | CŎLLU /'kweddə/ 'neck' | IN+CŎLLU /'ngweddə/ 'on (one's shoulders)' | |
| c. /t/_ | TŎXICU /'teskə/ 'poison' | SŎNU /'senə/ 'sound' | NŎSTRU /'nestə/ 'our.MSG' |

Actually, the data provided in (6) could also authorize the opposite interpretation, viz. that a coronal consonant triggered the process. But it is easy to show that this would be incorrect and that (6c) is indeed the elsewhere case. The proof is elementary. As shown in (7), the glide was deleted word-initially as well:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| (7) | HOMINES | > | */'wemmə/ | > | /'emmə/ | → | ['emː] | 'men' |
| | HORTUM | > | */'wertə/ | > | /'ertə/ | → | ['ert] | 'vegetable garden' |
| | HORDEUM | > | */'werʃə/ | > | /'erʃə/ | → | ['erʃ] | 'barley' |
| | OSSUM | > | */'wessə/ | > | /'essə/ | → | ['esː] | 'bone' |
| | OCULUM | > | */'weccə/ | > | /'eccə/ | → | ['ecː] | 'eye' |

In functional terms, what happened is that a deletion process applied, one that was blocked by a preceding labial or velar consonant.

*1.3. /ʊ/-fronting*

Let us now consider an allophonic process that affects the back high vowel /ʊ/. When occurring in stressed syllable, this vowel phoneme shows the three different phonetic realizations in (8):

| (8) | a. | [ʊu̯] | b. | [ʏ] | c. | [ʷʊ] |
|---|---|---|---|---|---|---|
| | ['pʊu̯r] | 'also' | ['tʏnː] | 'round' | ['pʷʊtːs] | 'well' |
| | ['tʊu̯f] | 'tuff' | ['nʏtːs] | 'stone' (of a cherry, olive, etc.) | ['abːʷʊtː] | 'inflate.2SG' |
| | ['kʊu̯s] | 'sew.2SG' | | | ['fʷʊnː] | 'deep.M' |
| | ['ʃʊu̯t] | 'gone' | ['ʃʏɲː] | 'rush' (bot.) | ['mʷʊnː] | 'world' |
| | ['sʊu̯t] | 'sweat.SG' | ['sʏtːs] | 'dirty.M' | ['kʷʊsː] | 'this.M' |
| | [a'cʊu̯t] | 'close.SG' | ['cʏmː] | 'lead' | ['ŋgʷʊːtənə] | 'anvil' |
| | ['mʊu̯l] | 'mule' | ['jʏʃk] | 'smart.3SG' | ['wʊɟː] | 'boiling' |
| | ['nʊu̯t] | 'knot' | [a'cʏːtənə] | 'close.3PL' | ['wʊːnətʃə] | 'eleven' |
| | ['cːʊᵘ] | 'more' | [a'bːrʏːʃənə] | 'burn.3PL' | | |
| | ['tʊᵘ] | 'you' | ['dʏːdətʃə] | 'twelve' | | |
| | ['jʊu̯n] | 'one' | ['ʏrs] | 'bear' | | |
| | ['ʊu̯s] | 'use' | ['ʏltəmə] | 'last' | | |

In (8a) diphthongization takes place. Consider that, as already shown in (1) above, all words in this dialect end in a schwa that is deleted prepausally (as in the quotation forms in (8)) but is phonetically realized when it occurs sentence-internally (cf. Loporcaro 1988: 159ff). Therefore, stressed vowels in (8a) are underlyingly in an open syllable and the process affecting them can consequently be characterized as an instance of open-syllable diphthongization. More precisely, since the process does not apply in proparoxytonic words (cf. (8b-c)), the environment contrast in (8a) vs. (8b-c) is best captured in terms of morae, as shown in (9) (from Loporcaro 1996: 172):

(9) V → VV̯/_$\mu_0^1$ ##

This characterization of the relevant environment is a revision of the one proposed in Savoia (1987: 240) for a similar diphthongization in a dialect of Lucania, viz. _$\mu_1^1$ (see also Savoia 1990 on Abruzzese). Savoia's formulation is at odds with the fact that, in all varieties of south-eastern Italy including Altamurano and the dialect he analyses, such diphthongizations also apply to word final stressed vowels, as first recognized as early as Merlo (1926: 87).[11]

In the data in (8b-c), the structural description of diphthongization in (9) is not satisfied, since the stressed vowel is in a closed syllable and/or in an antepenult. Therefore, instead of diphthongization, two other processes apply: in (8b), /ʊ/ is fronted to [ʏ], whereas in (8c) no fronting takes place, and labialization of the preceding consonant is found instead.[11]

Speakers exhibit some variation in realization of the fronted allophone: while [ʏ] largely prevails, some elderly speakers (especially, though not exclusively, women) have a somewhat tenser [ʏ̝], even approaching [y] in some occurrences. Note that this purely phonetic variable tensing only affects the fronted allophone ((8b)), whereas the allophones in (8a) and (8c) are invariably lax throughout the speech community (a fact we will return to in §4.2).

Also here, just as for /w/ deletion in (6), there is clearly an elsewhere case, viz. (8b). Fronting applies, in fact, either after a coronal consonant or word initially (see the last two examples in (8b)). On the other hand, the condition on labialization in (8c) can be stated positively: whenever (9) is not met, after [+grave] consonants the [+grave] vowel /ʊ/ did not front, and labialization of the preceding consonant was triggered instead. Elsewhere, fronting did apply. In other words, the vowel lost its acoustic gravity via fronting, if the process was not blocked by the presence of an adjacent consonant that could enhance that property (as labials and velars did, in (8c)).





*1.4. /o/-fronting*

We turn finally to the last set of empirical data to be considered, which concerns the allophonic realizations of the phoneme /o/ under stress. This is the Altamurano outcome of the same etymological vowel considered in (6)-(7), viz. PRom /ɔ/ < Lat. ŏ, in the environments in which it was not affected by metaphony:

| | | | | | | |
|---|---|---|---|---|---|---|
| (10) | a. | [ou̯] | b. | [ø]/[œ] | c. | [ʷo] |
| | ['pou̯t] | 'can.3S' | ['tøst] | 'hard.F' | ['pʷort] | 'door' |
| | ['bːou̯n] | 'good.F' | [an'døn:] | 'Antony' | ['pʷorʃ] | 'hand.3SG' |
| | ['wou̯f] | 'ox' | ['køsː] | 'thigh' | ['fʷort] | 'strong.F' |
| | ['kou̯s] | 'sew.3S' | [a'kːøɟːənə] | 'gather.3PL' | ['mʷoːnəkə] | 'monk' |
| | ['lou̯r] | 'they' | ['ʃøːkənə] | 'play.3PL' | ['wokːələ] | 'brood hen' |
| | ['ʃou̯k] | 'play.3SG' | ['sørd] | 'your sister' | | |
| | ['sou̯r] | 'sister' | ['cøːvənə] | 'rain.3PL' | | |
| | ['cou̯f] | 'rain.3SG' | ['jørd] | 'warp.3SG' | | |
| | ['mou̯r] | 'die.3SG' | ['tørt] | 'crooked.F' | | |
| | ['nou̯f] | 'nine' | ['ɲːøtː] | 'swallow.3SG' | | |
| | ['ou̯f] | 'egg' | ['øbːr] | 'hubbub' | | |
| | ['moᵘ] | 'now' | ['ømː] | 'man' | | |

Also here, we find three allophones which closely parallel what we saw in (8), generated by basically the same processes. In (10a) we find diphthongization in open stressed non-antepenultimate syllable (i.e. in the environment stated in (9)), which is a general process, applying to all non-low vowels in this dialect (cf. (40) below). In closed syllables, a fronting process applies ((10b)), which is again the elsewhere case, as it is found also word-initially.[13] Here as well, the fronting process was blocked by the presence of an adjacent consonant which could enhance the [+grave] specification of the vowel concerned ((10c)).

But, crucially, in this case only labials blocked the fronting, not velars.

*2. Altamurano gravity-interactions: description and explanation*

In this section I will propose a unified account of the facts discussed in §1. Let us begin by providing in (11) a summary of the environments in which the above mentioned processes apply:

(11)

| | p__ | k__ | t__ | #__ |
|---|---|---|---|---|
| a. /w/-propagation | + | + | – | – |
| b. /w/-deletion | – | – | + | + |
| c. /ʊ/-fronting | – | – | + | + |
| d. /o/-fronting | – | + | + | + |

A first observation is that the two processes in (11a-b) show a mirror-image distribution. This is not at all surprising, since the processes themselves are symmetrical, one involving *w*-insertion, the other *w*-deletion. The generalization is that the presence of [w] (either its insertion or its preservation) is conditioned by a preceding labial or velar consonant. If we now look for an explanation of these facts, and in particular of the relation between the changes and their contexts, we can try to account for this relation from one of the perspectives outlined in the introductory section with reference to the two basic dichotomies: form vs. substance and articulation vs. perception.

If we first focus on phonetic substance, we can say that both labial and velar consonants display an articulatory affinity with [w], because the latter involves both a labial and a velar (tongue-body) gesture. Acoustically, we can say that both labial and velar consonants, in the environments considered in (11a-d), display a concentration of energy in the lower part of the spectrum. In this, they resemble back rounded vowels, an elementary fact for which the reader can be referred to introductory handbooks in acoustic phonetics (cf. e.g. Pickett 1980: 50-53, Giannini & Pettorino 1992: 162-163).

Let us now leave the ground of phonetic substance and try to translate both of these characterizations (viz. the articulatory and the acoustic-perceptual one) into a formalized phonological description making use of DFs. The history of binary DF models begins with Jakobson *et al.* (1952). Among their acoustically based features, one seems to suit our case best:

> "When the lower side of the spectrum predominates, the phoneme is labeled grave; when the upper side predominates, we term the phoneme acute" (Jakobson *et al.* 1952: 29).

The feature [±grave], like other features in that system, applies to both consonant and vowel phonemes. Among consonants, labials and velars are [+grave], as opposed to dental/alveolars, palatals, and palato-alveolars, and they share this feature specification with back vowels and glides, due to the fact that all of these segments display a concentration of energy in the lower frequency range. (As is well





known, a major innovation of Jakobson *et al.* 1952 was the assumption of a unified feature set for both consonants and vowels.) Consequently, at least for the processes (11a-c), reference to the feature [±grave] seems to provide an elegant account. In (11a), insertion of a [+grave] glide is triggered by a [+grave] vowel (plus extra morphological specification) and applies only in the environment of a [+grave] consonant. In (11b), conversely, a [+grave] glide is deleted unless a [+grave] consonant precedes, and in (11c) a [+grave] vowel (in a stressed closed or antepenultimate syllable) becomes [–grave] unless a [+grave] consonant precedes.

For the process (11d), however, such a revealing formalization does not seem directly within reach. Here, a [+grave] vowel (in a stressed closed or antepenultimate syllable) becomes [–grave] unless preceded by only a subset of [+grave] consonants, i.e. by labials (which are specified [+grave, –compact]). Velars, in spite of their being formally specified as [+grave] as well, are unable to prevent the fronting process. This clearly requires a more complicated statement of the environment, with the introduction of a disjunction, and makes it impossible to achieve such a neat formalization of the relationship between structural change and context as is available for (11a-c). Crucially, the two processes (11c-d) will have to be formalized in substantially different ways, which blatantly contradicts the intuition that they are tightly related.

The prospects for a successful account of our Altamurano changes do not improve if we now consider DF systems which followed that of Jakobson *et al.* (1952). As is well known, since Chomsky & Halle (1968) (henceforth **SPE**) formal DF systems returned to an articulatory foundation, projecting Jakobson's binarism onto Trubetzkoy's (1939) articulatory-based taxonomy. Consequently, after SPE the feature [±grave] is no longer a part of the descriptive machinery of current phonological theory. In the SPE system, the generalizations in (11a-c) would have to be expressed not in terms of [±grave] but rather of the mirror-image feature [±coronal], as shown by the correspondences in (12):[14]

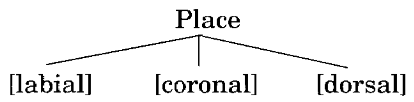
(12)

| | /p/ | /t/ | /k/ |
|---|---|---|---|
| [grave] | + | – | + |
| [coronal] | – | + | – |

This however entails a complete loss of the insight that all of the processes at issue are clearly guided by the affinity between the vowels, consonants and glides involved, either in the change or in the environment. In (11a), a [+back] glide is inserted and in (11b) it is not deleted after a [–coronal] consonant; in (11c) /ʊ/ becomes [–back] unless preceded by a [–coronal] consonant. Change and context are totally unrelated formally.

Things become even worse if we move on to consider more recent developments of DF systems within the 'Feature Geometry' line of research inaugurated by Clements (1985). Most current submodels, in spite of differences in other respects, agree on representing place of articulation by means of unary features, included in a feature tree whose nodes correspond to articulators (cf. e.g. Halle 1992, Clements & Hume 1995, Halle *et al.* 2000). The nodes (and thus the monovalued DFs) standardly available to describe place for consonants are shown in (13):[15]

(13)




From (13) it stands out clearly that no node captures labials and velars at the same time while opposing them to coronals. This implies that such systems are incapable of characterizing the set of segments {p b m k g ŋ} as a natural class. And this in turn has led many authors to question the empirical evidence in favour of this natural class, i.e. the substantial bulk of phonological rules in the languages of the world in which labials and velars pattern jointly. An example for this line of argument is provided by Yip (1989):

> "in fact the classes [+anterior], [–anterior] and [–coronal] do not occur. These are exactly the groups of sounds that are not natural classes in the Articulator model, and so their non-occurrence is predicted in that model." (Yip 1989: 350).

Yip (1989) goes on to reconsider some of the data previously adduced in the literature as supporting evidence for the existence of the natural class of [+grave] segments. But (as I will show in more detail in §3.1) the Altamurano data in (11a-c) clearly fly in the face of such a claim, as far as [–coronal] is concerned, as do the host of sound changes in which labials and velars pattern together. To quote just one example, consider Klingenheben's law in Haussa, discussed in Vennemann (1988: 26). This is a coda-weakening process by which all coda labials and velars turn to [w], whereas all dentals undergo rhotacism:





(14) Haussa, Klingenheben's law (Vennemann 1988: 26)

| | | | |
|---|---|---|---|
| /p/ > /u̯/ | in codas: | *ma.kā.fo*/*ma.kaw.ni.ya* | 'a blind one.M/F' |
| /k/ > /u̯/ | | *ta.la.ka* 'a poor one'/*ta.law.či* | 'poverty' |
| /t/ > /r/ | | *fa.tā.ke* 'merchants'/*far.ke* | 'merchant' |

For many of these phenomena, of course, it will be possible to claim that the change actually involves coronals, and that what happens to labials and velars (or in the context of labials and velars) is just the elsewhere case. However, for Klingenheben's law such an alternative account would lead us to say that the concrete implementation of *p* / *k*-weakening (i.e. vocalization to *u̯*) is merely coincidental, which is of course hard to believe. Both $t \rightarrow r$ and $p/k \rightarrow$ *u̯* represent perfectly natural changes, by which a stop weakens to a more sonorous sound which shares basic properties with the input segment. In the latter case this shared property is clearly acoustic gravity.

If this is so, then we must conclude that a descriptive system which limits available categories for the description of change to articulation only, categorically excluding that natural classes can be defined also in acoustic/perceptual terms, represents an impoverishment in our understanding of the sound structure of human language.

There was actually a debate about this problem until the early Eighties, concentrated on the need for preservation of the acoustically based DF [±grave] within different models, and eventually settled in Generative Phonology after the advent of Feature Geometry (cf. e.g. the statement by Yip 1989 quoted above). To mention just two classics of our discipline, Martinet (1955: §3.16), commenting very critically on Jakobson's approach, nevertheless admits:

> "Ecartant la théorie dans son ensemble, nous pourrions peut-être en retenir certaines suggestions, celle par example selon laquelle labiales et dorsales sont acoustiquement plus étroitement apparentées que ne le laisserait attendre la distance qui sépare les points d'articulation respectifs."

Ladefoged (1975: 265), in his eclectic list of DFs, mostly articulatory in nature, salvages precisely the acoustic feature [±grave], as it proves useful in the analysis of both synchronic rules and diachronic processes in many languages of the world. It is not my intention to revive this dispute here (cf. e.g. Hyman 1973, Vennemann & Ladefoged 1973, Odden 1978, Vago 1976, all adducing evidence in favour of [±grave] from several languages). For our present concern, on the formal side the conclusion is that among the three types of DF systems considered, the one proposed by Jakobson *et al.* (1952) is best suited to describe the Altamurano facts. SPE and Feature Geometry totally fail, even descriptively. However, also within the system of Jakobson *et al.* (1952) (or in any revised form of the SPE set with the addition of [±grave]), an insightful formalization of (11d) and of its relationship to the other processes seems to be precluded. Moreover, from such a formal expression of the changes at issue we gain no hints as to the differences between (11d) and (11a-c). This seems to point to a more radical conclusion, the same one reached by Pagliuca & Mowrey (1980: 513), with specific reference to the debate on the feature [±grave] in Generative Phonology:

> "Of two possible sources of input into the feature system, contrast-oriented classification and process-oriented description, the former has dominated the latter to such a degree that processes have been judged unnatural or 'crazy' if their expression in contrast-oriented features looks clumsy. The solution to clumsy expression lies, of course, in improved expression, not in a condemnation of the process. The persistence of essentially structuralist biases has resulted in a gulf between our ability to understand and describe phenomena and our ability to formalize such descriptions".[16]

Now, to pursue our search for an explanation, let us reconsider the Altamurano changes from the point of view of phonetic substance, rather than phonological form. We can take the articulatory or the acoustic route here as well, but the former clearly does not lead us to an insightful account in this case. We have said above, commenting on (11a-c), that both labial and velar consonants display an affinity with /w/ and with /ʊ/. However, the crucial issue is to explain why fronting is more pervasive with /o/ (affecting it after both /t/ and /k/; (11d)) than with /ʊ/ (which is affected only after /t/; (11c)). And here, consideration of the articulatory dimension is of no use. In fact, no gradient can be established between the consonants /p k t/ (in this sequence). The only gradient dimension unifying these articulations is antero-posteriority, which does not yield the order we need (but rather /p t k/) and is clearly irrelevant here.

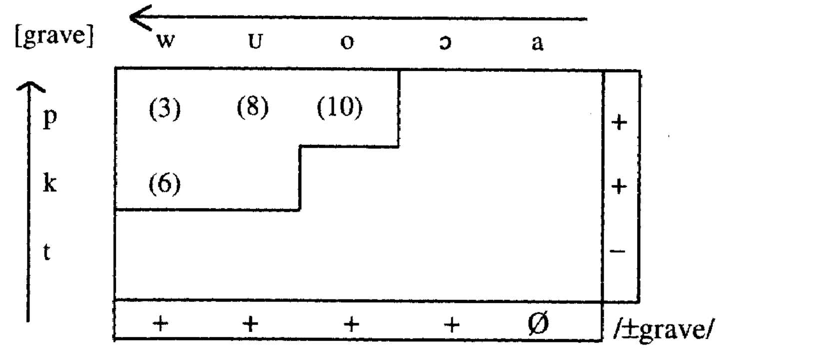
The gradient we are looking for, however, becomes readily apparent as soon as we focus on the acoustic/perceptual dimension. This proves crucial for an explanation of our empirical evidence, provided that we do not stick to a formalized representation of acoustics in terms of (binary) DFs but rather consider, more broadly, the interplay between form and substance. This interplay is schematically repres-





ented in (15), with reference to the four Altamurano processes at issue, indicated by the numbers in brackets in the gray zone.

(15) [phonetic substance]




The horizontal and vertical dimensions in (15) display vowels/glides ordered according to place of articulation and consonants, respectively.[17] In the lower corner on the right-hand side we find the phonological feature [±grave]: the two boxes show the binary specifications with respect to this feature for consonants and vowels/glides. The upper corner on the left-hand side shows gravity in substantial terms, to be understood as the acoustic (gradient) reality the phonological binary feature is based on. As symbolized by the two converging arrows, the farther we go from the left upper corner, the lesser the gravity of the segments involved. The gray zone delimits the area of the gravity interaction phenomena described in §1.

This picture has an elementary acoustic motivation, which resides in F2-height for vowels and in the height of the locus for consonants (cf. the classical theory of loci, inaugurated by Cooper *et al.* 1952). Among vowels, /u/ has the lowest F2 value, followed by /o/, /ɔ/ and /a/ etc., with F2 values gradually increasing. As for consonants, labials are the most strongly grave, as they have the lowest locus in F2 transition (at 600-800 Hz); dentals have a locus at about 1800 Hz, whereas the locus of velars depends on the adjacent vowels: it reaches up to 3000 Hz in the environment of non-back vowels, whereas it coincides with the labial locus when the velar stop is adjacent to a back rounded vowel. This is easily explained (cf. e.g. Giannini & Pettorino 1992: 195-203, elaborating on Delattre 1969): velars are the only consonants among those listed in (15) whose articulation crucially involves the tongue-body:

consequently, their locus, as opposed to the loci for labials and velars, crucially interacts with (the F2 of) adjacent vowels.

The scale along the vertical dimension in (15) is directly reflected in perception, e.g. with regard to the release burst of stops. As shown by Cooper *et al.* (1952: 597), a noise burst at 2800 Hz or higher correlates with the categorization of the stop as dental; a noise burst at the same frequency as the vowel's F2 (or slightly higher) causes the stop to be perceived as velar; finally, a noise burst at a frequency lower than the vowel's F2 (or at the same frequency level, for /o/ /u/) induces perception of the stop as labial.

Now, we have to ask how this substantial gradient is reflected in phonological structure. The latter builds on phonetic substance, and converts acoustic/articulatory continua into discrete choices, i.e. into discrete processes/rules/alternations: either there is fronting, or there is not; either propagation takes place, or it does not, and the like. For the description of these processes/rules/alternations, a formal apparatus of DFs is needed, which has to do justice to both articulation and perception.

With all this, we have not yet said anything about explanation. In fact, we can further ask why processes are the way they are, and not the other way around. More specifically, in our case, we can ask questions such as those in (16):

(16) a. why don't we find a process of /w/ deletion which applies after labial consonants and not after velars?
b. why isn't back vowel fronting more pervasive with /ʊ/ than with /o/? (Formally, they are both [+grave] – or [–coronal] – consonants, after all.)

In keeping with a general epistemological criterion, the answers to such questions – or, in other words, the explanation for phonological patterns – must come from outside the domain we are describing. This is the chief maxim for a sound explanation as formulated in Vennemann (1983: 9):

> "We can gain interesting explanations" [for a given domain] "only by turning to theories that are not theories for that particular domain".

An obvious candidate is the experimental inspection of phonetic reality (that is, the left upper corner in (15)). Again, in Vennemann's words (concerning one specific aspect of phonological form, viz. syllable structure):





> "The preference laws for syllable structure have their basis in the human productive and perceptive phonetic endowment. They, as well as their natural gaps, would be derivable – and thus explained – in a sufficiently rich phonetic theory" (Vennemann 1988: 4).

This is precisely what we have done in this section, developing a comprehensive account of Altamurano gravity interaction phenomena involving [+grave] vowels, glides and consonants. The answers to the questions in (16a-b) come from inspection of the acoustic signal. The fact that velar consonants pattern alternatively with either labials ((11a-c)) or dentals ((11d)) follows from the in-between nature of velars in acoustic terms. More specifically, the probability that velars will behave like labials is higher when the environment crucially involves a sound which displays acoustic gravity to a higher degree (i.e. either /w/, in (11a-b), or /ʊ/, in (11c)). Therefore back vowel fronting, a process implying a rise in the vowel's F2, applied in Altamurano after dentals and palatals, which always have a high locus, and never applied after labials, whose locus is invariably low. After velars, it applied to /o/ but not to /ʊ/, because the latter has a lower F2 and was consequently more suited to resist the change, which in *ko* → *kø* strings implied a rise in both the F2 of the vowel and the locus of the consonant. (Remember that the velar locus is crucially sensitive to the backness of the vowel, not to lip rounding.)

### 3. *Alternative analyses of the Altamurano data*

We will consider now some alternative analyses of the facts for Altamurano discussed in §§1-2. These data, first described in Loporcaro (1988), have attracted some attention since then. For instance, diphthongization and schwa deletion (cf. (8)-(10) above) were discussed in Kenstowicz (1994: 448) (cf. Loporcaro 1998: 168 fn. 10). More recently, Cox (1997) and Calabrese (2000) have reanalysed some of the phonological processes I have just described as gravity-effects in §§1-2, arguing for radically different accounts. The rest of this paper is devoted to a discussion of these alternative accounts.

#### *3.1. Cox (1997) on Altamurano /w/-deletion*

Cox (1997) discusses /w/-deletion, and maintains that the acoustic gravity of the segments involved is irrelevant to the analysis.[18] In his view, /w/-deletion is a dissimilative process which was triggered by a preceding coronal consonant. This is apparently at odds with the fact that deletion also applied word-initially, as shown in (7). Cox's solution for this difficulty is summarized in (17):

| | | | | | |
|---|---|---|---|---|---|
| (17) a. | /l # 'weccə/ → | *[l 'wec:] | /n # 'weccə/ → | *[n 'wec:] | 'the/an eye' |
| b. | /l # 'weccə/ → | [l 'ec:] | /n # 'weccə/ → | [n 'ec:] | |
| c. | /l # 'eccə/ → | [l 'ec:] | /n # 'eccə/ → | [n 'ec:] | |

It consists in assuming that deletion in such cases as (7) first arose in sentence phonetics ((17b)) in the context where the word was preceded by a determiner. In fact, the prevocalic form of the definite and indefinite articles (for both genders) consists of a coronal consonant: /l/ and /n/ respectively. In a later step, the /w/-less form was generalized and became eventually the new lexical form of the words involved ((17c)).

This account is appealing. I can even add some further data which seem to support it. In fact, the few lexical exceptions to /w/-deletion concern precisely forms that are normally used without a determiner. One such case is the numeral ['wet:] 'eight'.[19] Furthermore, the word for 'eye', reported in (17), still retains the glide only in some lexicalized derogatory expressions such as ['wec:ə də 'la:tr] literally '(you,) thief's eye!', in which the word occurs without an article. This clearly represents a remnant of a former stage.

However, the difficulty for Cox's account is represented by the fact that the numeral ['wet:] 'eight' can actually occur with an article. In this case, however, the preconsonantal form of the determiner is selected, not the prevocalic one: e.g. [ʊ 'wet:] 'the eight', [nʊ 'wet:] 'an eight' (in card games). In fact, in this dialect word-initial glides of any origin always pattern with consonants and never with vowels for the selection of the allomorph of determiners, as shown in (18):

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (18) a. | [ʊ 'wʊst] | 'the taste' | b. [ʊ 'kwɛi̯n] | 'the dog' | c. | [l 'arɣ] | 'the tree' |
| | [nʊ 'wʊst] | 'a taste' | [nʊ 'kwɛi̯n] | 'a dog' | | [n 'arɣ] | 'a tree' |
| | [ʊ 'jat:] | 'the cat' | [ʊ 'cei̯ʃ] | 'the nail' | | | |
| | [nʊ 'jat:] | 'a cat' | [nʊ 'cei̯ʃ] | 'a nail' | | | |

This means that the intermediate step postulated by Cox in (17a) is entirely *ad hoc*, lacking any independent evidence from the phonological system of the language.

Furthermore, the shortcomings of Cox's account become even more apparent if we try to extend it to the other processes considered in §§1-2 above. Extending Cox's approach to /w/ propagation, we





could simply say that a coronal consonant blocks the process. For /o/ and /ʊ/ allophony, on the other hand, following Cox's line of argument we should assume that the presence of a preceding coronal consonant induced fronting. For the application of fronting word initially (cf. the data in (8b), (10b)), Cox's argument in (17) could be replicated, this time without problems, since the forms in (19) – with the determiners' coronal consonant immediately preceding the word-initial vowel – actually occur in Altamurano, unlike the assumed intermediate steps in (17a):

| | | | | |
|---|---|---|---|---|
| (19) | [n 'ʏrs] | 'a bear' | [l 'ʏrs] | 'the bear' |
| | [n 'øm:] | 'a man' | [l 'øm:] | 'the man' |

This explanation, however, is totally incapable of accounting for the different distribution of fronting with /o/ and /ʊ/ which, as we have shown, fit into a neat picture, under the assumption that the acoustic gravity of the segments involved is crucial. Under Cox's assumptions, fronting would have to be treated as an instance of coronal consonant/vowel interaction, of a kind not uncommon in the languages of the world (cf. Hume 1992).

We can compare the similar processes found in the now extinct Agn dialect of Armenian, where precisely the two back vowels /o/ and /u/ are fronted to [ø] and [y] respectively after all coronal consonants, whereas they remain unaffected after non-coronals (cf. Halle *et al.* 2000: 400 with further references):

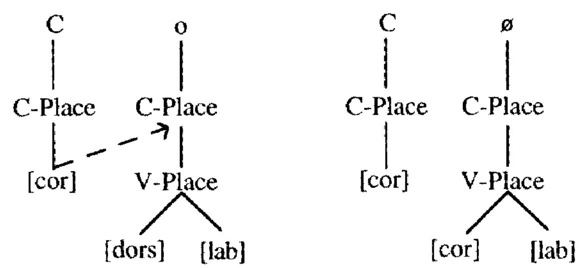
| (20) | Classical Armenian | Agn | |
|---|---|---|---|
| a. | nor | nør | 'man' |
| | dʒur | dʒʰyr | 'water' |
| | χoʃor | χoʃør | 'large' |
| | soχ | søχ | 'onion' |
| | heru | hery | 'last year' |
| b. | port | bord | 'navel' |
| | pʰoɫk | pʰoχg | 'throat' |
| | kotsʰ | gʰotsʰ | 'closed' |
| | gud | gud | 'grain' |
| | χutsʰ | χurtsʰ | 'room' |

Stating the change in a classical binary SPE model entails the loss of the generalization concerning the interaction, as the assimilative nature of the process becomes obscured:

(21) [+son, –cns] → [–back]/ [+cor] __

Within Feature Geometry, articulator models offer various ways of capturing this assimilatory nature. In particular, Unified Feature Theory (UFT; cf. Clements' 1989, Clements and Hume 1995), which employs a single set of place features for both consonants and vowels (extending to the latter the nodes seen in (13) above), would allow expressing the change in a straightforward way, as shown in (22) (irrelevant nodes are omitted):

(22) a. b.



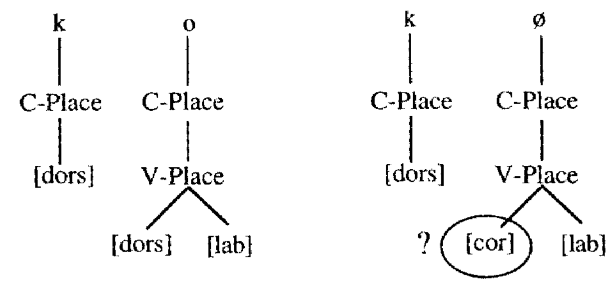

After spreading of [coronal] in (22a), and some other intermediate steps involving re-association of [coronal] to the V-place node, and delinking of the incompatible feature [dorsal], the output representation is that in (22b).[20] By virtue of this representation, the functional (assimilatory) nature of the process is formally expressed under the form of [coronal] spreading.

It might be tempting to extend the same account to Altamurano vowel fronting. However, while /ʊ/-fronting would fit the statement in (22) perfectly since it applies after coronals only, an account of /o/-fronting along the same lines would lead to major complications. Here, fronting occurs not only after coronals but also after velars. Since the two classes are described formally with alternative unary features ([coronal] vs. [dorsal]), /o/-fronting would have to be expressed disjunctively, in the first place. Moreover, after coronals the same representations in (22) could be proposed. But /o/ fronting also applies after dorsals: cf. Altamurano words such as ['køs:] 'thigh', ['køc:] 'couple' etc. ((10b)). After dorsals, a rule formulated in (any version of) the articulator model would have no chance of formally conveying the assimilatory nature of the change, since there would be no source in the input configuration (23a) for the feature [coronal] to spread from, so as to yield the desired output in (23b) (where fronting to [ø] has applied). This is graphically conveyed in (23b) by the circle around [coronal] plus the question mark:





(23) a. b.




Thus, of the two members of the disjunction (*to* → *tø*, *ko* → *kø*) the former would appear formally to be an assimilation, while the latter would appear dissimilatory, since a dorsal vowel becomes coronal (hence non-dorsal) after a dorsal consonant.

This is an insurmountable problem for such an account. We can therefore conclude that a description in terms of articulatory based features, such as the one proposed by Cox (1997) for Altamurano /w/-deletion, has no chance of grasping the essence of the Altamurano gravity interactions we have elucidated in §2 with crucial reference to the acoustic substance of gravity effects.

### *3.2. Calabrese (2000) on Altamurano back vowel fronting*

In this section, I will briefly summarize Calabrese's (2000) treatment of Altamurano vowel fronting. I will further devote §4 to an in-depth discussion, both of Calabrese's analysis and of the primary phonetic and phonological data. Comparison of Calabrese's account with the one developed above in §2 will turn out to be instructive, since both are specifically concerned with the interplay of form and substance in the explanation of phonological patterns and changes, yet they diverge dramatically in both conception and results. This comparison thus raises the general question of how substantial evidence can be brought to bear in phonological analysis.

Calabrese singles out the allophonic processes (8)-(10) and devotes to them a lengthy article on *The feature [advanced tongue root] and vowel fronting in Romance*. The feature [ATR], which is the successor of the Jakobsonian feature [±tense], plays a central role in these phenomena, according to the author:[21] for this claim, comparative experimental evidence is provided.

The analysis is the product of the application to these data of a general theory of phonological inventories and operations developed