ACOUSTIC CORRELATES OF PHONOLOGICAL MICROVARIATIONS
THE CASE OF UNSUSPECTED MICRO-PARAMETRIC METAPHONETIC
PROCESSES IN A SMALL AREA OF SOUTHERN SALENTO (APULIA)*

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1. Introduction
Recent field researches in a small area of Southern Salento by means of an
appropriate questionnaire, acoustic analysis and statistic treatment of the data
have pointed out the existence of micro-parametric metaphonetic processes never
noticed before. These processes cause the raising of the stressed mid vowels /E/
and /O/ to the counterpart mid-high vowels [e] and [o], when followed by the
unstressed high vowels -i and -u. In order to incorporate coherently phonetics in
phonological analysis (within an autosegmental phonological framework), we
tried to extract the phonetic out of the phonological properties. The results suggest
that the phonological microvariation is mastered by the interplay of acoustic-
articulatory, and probably perceptive features of the stressed and unstressed
vocalism involved in the processes, supporting a research perspective in which
distinctive features have and important role not only in articulatory actions, but
also in all intermediate representations, and, furthermore, in perceptive processes.

2. The stressed phonological system of Salento
The Sallentinian area, located in Southern Apulia, embraces the province of
Lecce and part of the provinces of Brindisi and Taranto. These dialects share, in
stressed syllables, a five-vowel phonological system. This is a particular
consequence of the Latin quantitative system evolution in the romance qualitative
one (Stehl 1988, Mancarella 1998)\(^1\):

\(^*\) Acknowledgements: I would like to thank Andrea Calabrese for his continuous and stimulating
comments and suggestions, and two anonymous reviewers for their fruitful and valuable remarks
on earlier version of the paper.
\(^1\) See Figure 1 in \textit{http://www.cril.unile.it/grimaldi/acoustic_correlates_docs/Figure1.pdf}
Nevertheless, the simplex system in (1), named Sicilian system, is made opaque in reason of some differentiated phonological phenomena, typical of Northern Apulia, where there is a four-height system with seven vowels (Neapolitan system), and, consequently, the phonological opposition between /e/-/e/ and /o/-/o/. Basically, they are metaphonetic assimilation processes triggered by unstressed high vowels -i and -u, which produce diphthongization of /e/-/e/ (usually in /je/-/je/ or /we/, but with some variants) and the raising of /e/-/o/ into the high counterpart vowels /i/-/u/, as shown in (2a-b):

(2) a. diphthongization of /e/, /o/
   a1. Nouns
      sing. plur.
      /ˈpete/ /ˈpjeti/ ‘foot / feet’
      /dente/ /djeti/ ‘tooth / teeth’
      /fweku/ /fweki/ ‘fire/-s’
      /ˈnɔːliː/ /ˈnwetːiː/ ‘night/-s’
   a2. Adjectives
      sing. m. plur. m. sing. f. plur. f.
      /ˈljentʰuː/ /ˈljetʰiː/ /ˈlentʰa/ /ˈlentʰe/ ‘slow’
      /krwesːu/ /krwesːi/ /krɔːːː/ /krɔːːː/ ‘big’
   a3. Verbs
      /ˈmjɛtʊ/ /ˈmjɛtːi/ /ˈmeːtɛ/ ‘I/you/he mow/-s’
      /ˈtwɛrmʊ/ /ˈtwɛрːiː/ /ˈtwɛrmːe/ ‘I/you/he sleep/-s’

b. vowel raising of /e/, /o/
   sing. plur.
   /ˈpaːsɛ/ /ˈpaːsiː ‘country/-ies’
   /ˈmesɛ/ /ˈmisiː ‘month/-s’
   /ˈpetːe/ /ˈpiːːiː ‘fish/-es’
   /duˈlɛɾe/ /duˈluri ‘pain/-s’
   /kuˈlɛɾe/ /kuˈluri ‘color/-s’
   /ˈmonte/ /ˈmuntːi ‘rock/-s’

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2 Here, the reorganization of quantity in Latin, the principle of ‘opening fusion’ (with I-Ú that converge into /e/ and /o/ together with the outcomes of E-Ö), whereas the area of Salento follows the principle of ‘closing fusion’ (with I-Ú that converge into /i/ and /u/ together with the outcomes of E-Ö.)
However, we have to note that the stressed vowels in (2b) are open, and not closed.\(^3\) This is due to the fact that the phonological competence of Salentine speakers doesn’t contemplate the contrastive phonological opposition between mid-high vowels and mid-low vowels, therefore all mid vowels are realized as open vowels, i.e. using the only mid phonemes the system includes. This means that these forms are lexicalized, i.e. penetrated, by in different periods and by means of contact through the dialectal varieties of Northern Apulia into the Central-southern Salento. In confirmation of this, they are quantitatively distributed in a differentiated way throughout the territory: as a matter of fact, in northern Salento there is the greatest number of diphthongizations and of metaphonetic raising, both for /el/-/a/ and /el/-/ol/, which gradually diminish, becoming few examples, the nearer one gets to the far end of Southern Salento, in the area of S. Maria di Leuca. (Grimaldi 2003, Garrapa 2005).

Within this outline, it’s interesting to point out some peculiar and rare examples, which apparently seem to recall the typical metaphonetic phenomenon of stressed mid vowels that end as mid-high vowels because of the following unstressed -i e -u.\(^4\) They are cases pointed out in two different occasions (at 40 years one from the other) by Gerhard Rohlfs for the AIS researches\(^5\) and by Luciano Graziuso\(^6\) during the researches for the CDI, in Salve and Tiggiano respectively, two towns in the far end of Southern Salento:

\[
(3) \quad /\text{pete}/ \quad /\text{peti}/ \quad \text{‘foot / feet’} \\
/\text{jenka‘requ}/ \quad /\text{jenka‘reqi}/ \quad \text{‘calf / calves’}
\]

As it can be seen, it seems to be a typical case of height harmony triggered, in this case, only by the anterior high post-tonic vowel -i. These are the only examples of metaphony in all the dialect studies of Salento (Grimaldi 2003:1-21), unless we include – as I would do – the cases of stressed mid-closed vowels registered by Melillo (1986), again in Southern Salento, in Castrignano del Capo, which should be considered, according to the author, as due to idiosyncratic variability of the participants, and not to peculiar phenomena of these varieties:

\[
(4) \quad /\text{b:onu}/ \quad \text{‘good’ (a. sing. m.)} \\
/\text{servi}/ \quad \text{‘domestics’} \\
/\text{morju}/ \quad \text{‘I die’}
\]

Finally, another important feature of the dialect studies of Salento must be underlined, i.e. the fact that there is no complete agreement about the acoustic-articulatory nature of the mid vowels of the area (probably because of habit to

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\(^3\) See Garrapa (2005) who shows, by means of an acoustic analysis of data collected during field researches in two towns of Central Salento (Cutrofiano and Collepasso), that in these cases the stressed vowel is open, as the vowel of the metaphonetic diphthong.

\(^4\) See Maiden (1991) for a detailed outline of the phenomenon in Italian dialectal varieties.

\(^5\) Cf. AIS: I 163, VIII 1704, VI 1046.

describe dialectal data phonetically on the basis of the perception of the researchers and of their personal impressions). Actually, some scholars considered the stressed mid phonemes as mid-low vowels (Morosi 1878, Panareo 1903, Rohlfs 1966), others considered them simply as mid vowels, neither open nor closed (Parlangeli 1953, ALI, Sobrero & Romanello 1981).

3. **Our research in Southern Salento: aims, methods and acoustic analysis**
   Between 1996 and 1999, we have conducted a thoroughly microareal field research in 36 localities of Southern Salento, including small towns, with the aim to analyze their stressed vocalism and to better verify the cases of metaphonetic influence pointed out in (3), (4) (cf. Grimaldi 2003). For each variety we analysed 1 male participant aged between 50-80. The data were elicited on the base of a questionnaire of about 600 stimuli, containing representative samples of the Salento stressed vowels either in open or in closed syllable in all classes of words (nouns, verbs, adjectives, etc.). In order to obtain as natural as possible data, we used the following survey methodology: we produced some brief utterances in Italian – which contained a word with the target phoneme – and then we asked the participants to translate them orally in their dialect. The people were asked to say the verbs in all the persons of the simple present tense, the names in singular and plural forms and the adjectives in every number and gender. The words containing the target phoneme could be found at the beginning or at the end of the sentence, and they were always affirmative. (ES: *I denti mi fanno male*; *Mi cadono i denti*, etc.).

   The acoustic signal was recorded by means of a digital system (DAT *Sony*) and a unidirectional microphone (*Shure* SM86), placed at a 20 cm distance from the speaker. The target vowel segments were first analysed in *Computerized Speech Lab* (CSL) by Kay Elemetrics, measuring each vowel to extract the first two formants: F1 and F2. We analysed 10 vocalic segments for each of the five stressed phonemes present in the Salento system (5 phonemes contained in words at the beginning and 5 at the end of the sentence), and measured three points of each stressed vowel: (1) in the steady state of the formant frequencies; (2) 25ms on the right towards the onset; (3) 25ms on the left towards the offset.

   Given that we wanted to study the acoustic nature of the stressed vowels of Salento (particularly the mid ones), and, in the meantime, to understand if the cases of metaphonetic influence in (3)-(4) are productive in the studied area, we decided to extract 10 vowel utterances for every phoneme from the questionnaire (contained in words: verbs or adjectives). Given that stressed mid vowels can be influenced in a different way whether the following unstressed vowels are high or not, the mid vowel productions (front and back) have been distinguished in the ones followed by -i, -u and the ones followed by -e, -a, as it can be seen in Table 1:

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7 See Figure 2 in [http://www.cril.unile.it/grimaldi/acoustic_correlates_docs/Figure2.pdf](http://www.cril.unile.it/grimaldi/acoustic_correlates_docs/Figure2.pdf)
8 See the data in [http://www.cril.unile.it/grimaldi/acoustic_correlates_docs/Questionnaire.pdf](http://www.cril.unile.it/grimaldi/acoustic_correlates_docs/Questionnaire.pdf)
ACOUSTIC CORRELATES OF PHONOLOGICAL MICROVARIATIONS

Vowels | Sample | Post-tonic context
-------|--------|-------------------
/i/ | 10 | –
/i/ | 10 | followed by post-tonic -i
/e/ | 10 | followed by post-tonic -u
/e/ | 10 | 5 followed by post-tonic -e and 5 by -a
/a/ | 10 | –
/o/ | 10 | followed by post-tonic -i
/o/ | 10 | followed by post-tonic -u
/u/ | 10 | 5 followed by post-tonic -e and 5 by -a
/a/ | 10 | –

Table 1: Vowel phonemes and unstressed contexts, acoustically analysed for each inquiry variety (in all 90 utterances for each point, for a total amount of 3240 analysed vowels)

The analysed phonemes are located in the following contexts: (a) Coronal+V+Coronal; (b) V+Coronal; (c) Bilabial (labiodental)+V+coronal; (d) Coronal+V+bilabial (labiodental). The final formant ic data obtained through this analysis process have undergone statistics analysis in order to point out systematic and probabilistic regularities present in the sample (see Table 2). 9

4. The stressed vowels of Southern Salento and their internal processes

Let’s start with the problem regarding the acoustic nature of the stressed mid vowels. The question raised in literature was (see section 2): are they mid or mid-low vowels? Crucially, as one can see in Chart 1 and Table 2, the mid vowels are collocated in an intermediate position in the acoustic space compared to the front/back high vowels /i/, /u/, and the low vowel /a/. In contrast with most of the classical literature, this observation induces us to state that these mid vowels cannot be phonetically identified with the lax mid vowels /ɛ/, /ɔ/: the lack of phonological opposition in tenseness, [ɛ] vs. [ɛ] and [o] vs. [ɔ], has given rise to an adjustment on the acoustic-articulatory mid level, the only present stressed vowels.

Comparing our F1/F2 mean values with those reported for the Italian area (Ferrero et al. 1979, Leoni & Maturi 1995), for the UCLA Phonological Segment Inventory Database (Vallée et al. 1991), and for others stressed five-vowel systems, as for example Japanese (Akamatsu 1997), we can say that the point of articulation of these vowels is intermediate among the high mid vowels /ɛ/, /ɔ/ and lax mid vowels /ɛ/, /ɔ/, and we will transcribe them with the symbols /E/, /O/. Identical results are obtained converting Hz formantic values of the acoustic

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9 We refer to the classical statistical descriptive analysis, which allow us to understand, thanks to the so-called Dispersion Indexes, how significant a calculated mean value is: (a) the Standard Deviation gives a realistic rating of the probable error contained in the mean value; (b) the Coefficient of Variation identifies the exact Standard Deviation percentage in comparison with the mean value; (c) the Range determines the difference between the maximum and the minimum value of the examined data.
scale in the Bark perceptive scale (Zwicker-Terhardt 1980), as displayed in Chart1:

![Formant charts](image)

Chart 1-2: Formant charts of the acoustic scale in Hz on the left and in the perceptive scale in Bark on the right. First (F1) and second (F2) Formant for the five Southern Salentinian vowels produced by the 36 speakers

<table>
<thead>
<tr>
<th>Vowels</th>
<th>Hz</th>
<th>M</th>
<th>DS</th>
<th>CV</th>
<th>MN</th>
<th>MS</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>/i/</td>
<td>F1</td>
<td>326</td>
<td>31</td>
<td>5</td>
<td>262</td>
<td>407</td>
<td>145</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>2244</td>
<td>92</td>
<td>15</td>
<td>2040</td>
<td>2416</td>
<td>376</td>
</tr>
<tr>
<td>/E/</td>
<td>F1</td>
<td>505</td>
<td>48</td>
<td>8</td>
<td>414</td>
<td>599</td>
<td>185</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>1871</td>
<td>123</td>
<td>20</td>
<td>1643</td>
<td>2110</td>
<td>467</td>
</tr>
<tr>
<td>/a/</td>
<td>F1</td>
<td>704</td>
<td>72</td>
<td>12</td>
<td>581</td>
<td>881</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>1425</td>
<td>75</td>
<td>12</td>
<td>1269</td>
<td>1563</td>
<td>294</td>
</tr>
<tr>
<td>/O/</td>
<td>F1</td>
<td>541</td>
<td>43</td>
<td>7</td>
<td>413</td>
<td>633</td>
<td>220</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>1051</td>
<td>67</td>
<td>11</td>
<td>870</td>
<td>1187</td>
<td>317</td>
</tr>
<tr>
<td>/u/</td>
<td>F1</td>
<td>368</td>
<td>30</td>
<td>5</td>
<td>291</td>
<td>428</td>
<td>137</td>
</tr>
<tr>
<td></td>
<td>F2</td>
<td>867</td>
<td>83</td>
<td>13</td>
<td>720</td>
<td>1071</td>
<td>351</td>
</tr>
</tbody>
</table>

Table 2: Mean (M), Standard Deviation (SD), Variance (V), Minimum (MN), Maximum (MS) formant values and their Difference (DF)

As already said, the second aim of this work was to verify if the presence of the isolated cases of vowel harmony discussed in (3)-(4) is widespread or not. The carpet-investigation and the large questionnaire, combined with the acoustic and statistic analysis, allowed us to discover a very complex phenomenon of vowel harmony, caused exactly by the influence of the unstressed high vowels -i and -u on the stressed mid vowels, both in open syllables (V1CV2) and in closed syllables (V1CCV2). Particularly, it has been verified that, within the 36 studied localities, only 19 have a systematic vowel harmony process: this process causes the rise of the mid-low front /E/ into the counterpart mid-high /e/, when followed by -i, as one can see in (5):

(5)
This means that the varieties of 19 localities agree in anticipating some features of the unstressed high vowel on the stressed mid-front one. These speakers belong to a precise area, more precisely to the far end of Salento. However, besides this common harmony process in (5), this small area reveals a more diversified situation, considering the vowel harmony triggered also by -i on the stressed vowel /O/ and by -u on both mid vowels /E/ and /O/. As a matter of fact, from this point of view the 19 varieties can be subdivided into 4 sub-areas: in one of them (referred to as Area A), made up of 11 localities, there is only the type of vowel harmony described in (5), while in the other three (referred to as Area B, C, and D, respectively), besides the process in (5), there are also the processes illustrated in (6-8):  

10 See Figure 3 in http://www.cril.unile.it/grimaldi/acoustic_correlates_docs/Figure3.pdf
This typology of the metapthonetic processes has been obtained through an in-depth inferential statistical analysis. On the vowel productions of every speaker, particularly on the mid vowels, a Student t-test has been carried out. It’s the most appropriate test to answer the following question: are two sets of data really different?\(^\text{11}\) That is to say, is there a statistically relevant difference between the stressed mid vowels of the metapthonetic area depending on the type of unstressed high vowel that follows? Basing itself on the analysis of mean vowels and Standard Deviation, the tTest calculates if two different measurements in the same subject are random (in our case, due to idiosyncrasy of the speaker) or if there are high probabilities that they are due to a systematic phenomenon (Holl 1990: 133-156). In this study, the different measurements refer to the same vowel, acoustically measured in different contexts, therefore we need to understand if the stressed mid vowels change systematically depending on the final unstressed high vowels, and if this modification is further differentiated because of the different action of the following unstressed high vowels. Therefore, it is necessary to compare in couples the values (F1/F2) in Hz for /E/ followed by -i with those for /E/ followed by -e, -a; the values for /E/ followed by -i with those for /E/ followed by -u, and, finally, the values for /E/ followed by -e, -a with those for /E/ followed by-u, and the same for the values for /O/ (see Table 3)\(^\text{12}\).  

<table>
<thead>
<tr>
<th>Couples of vowels compared with t-test</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Sample</td>
<td>Vocalic context</td>
<td>vs.</td>
<td>Vocalic context</td>
</tr>
<tr>
<td>F1 / F2</td>
<td>/E/ for -i</td>
<td>vs.</td>
<td>/E/ for -e, -a</td>
</tr>
<tr>
<td>F1 / F2</td>
<td>/E/ for -i</td>
<td>vs.</td>
<td>/E/ for -u</td>
</tr>
<tr>
<td>F1 / F2</td>
<td>/E/ for -e, -a</td>
<td>vs.</td>
<td>/E/ for -u</td>
</tr>
<tr>
<td>F1 / F2</td>
<td>/O/ for -i</td>
<td>vs.</td>
<td>/O/ for -e, -a</td>
</tr>
<tr>
<td>F1 / F2</td>
<td>/O/ for -i</td>
<td>vs.</td>
<td>/O/ for -u</td>
</tr>
<tr>
<td>F1 / F2</td>
<td>/O/ for -e, -a</td>
<td>vs.</td>
<td>/O/ for -u</td>
</tr>
</tbody>
</table>

Table 3: Vowel types compared with t-test

\(^\text{11}\) The t-test is the appropriate test for small samples, as opposed to samples with greater than 30 or more observations. As a matter of fact, in our case we have 10 samples for each mid vowel.

\(^\text{12}\) In order to do this, we must formulate two hypotheses that exclude each other, from now on referred to as H\(_0\) e H\(_1\): H\(_0\) is the so-called zero Hypothesis, which expresses the lack of a significant differentiation between groups of variables, while H\(_1\) is the alternative hypothesis, which expresses the opposite idea, i.e. the existence of a significant difference between variables. In order to decide which hypothesis to accept, we must choose a level of significance \(\alpha\), i.e. the maximum error we accept to commit when stating that there actually is a difference: in other words, \(\alpha\) indicates the maximum probability that the difference is due to chance. In order to avoid that in H\(_1\) also idiosyncrasy cases could be included, we decided to assign to \(\alpha\) a value of 0.005 (i.e. 5‰), which allowed us to sketch a final outline of the vowel system of the studied area. Making the test, besides a series of statistical values, we obtain the probability \(p\) that there is a difference between the interviewed groups: if \(p\) is less (<) than \(\alpha\) i.e. less than 0.005, the error risk in refusing the initial H\(_0\) is smaller than we stated at first, therefore we can refuse H\(_0\) i.e. assert that there actually is a certain significant difference between the compared vowel groups.
The test results allowed us to divide the single participants into homogeneous groups, depending on the type of influence the unstressed high vowels have on the stressed mid vowels. The acoustic situation of these finely parameterized metaphonetic processes can be represented using a Cartesian diagram with the existence areas of the mid vowels produced in metaphonetic context, as shown in Chart (3-6), whereas in Chart (7) the Area (E) is represented, where the acoustic analysis, together with the Student T-Test, didn’t reveal significant levels of vowel harmonies:

Chart 3: Area (A): [e] for -i

Chart 4: Area (B): [e] for -i; [o] for -i

Chart 5: Area (C): [e] for -i; [o] for -i and -u

Chart 6: Area (D): [e] for -i; [o] for -u

Chart 7: Area (E): no height vowel harmony
In Table 4 we can see synthesized the different action of the unstressed high vowels on the stressed /E/ and /O/:\(^{13}\)

<table>
<thead>
<tr>
<th>Vowels</th>
<th>Different action of unstressed high vowels</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>-i</td>
</tr>
<tr>
<td>V2</td>
<td>-i</td>
</tr>
<tr>
<td>/E/</td>
<td>[e]</td>
</tr>
<tr>
<td>/O/</td>
<td>[o]</td>
</tr>
<tr>
<td>Areas</td>
<td>Area A</td>
</tr>
</tbody>
</table>

Table 4: Height harmonies areas on the base of different action of the unstressed high vowels (V2) on the stressed one (V1).

5. \textit{A possible phonological analysis of the micro-parametric variation}

We could try to account for these phenomena along the lines of the analysis developed by Calabrese (1985, 1995, 1998:7-12) for local vowel harmony alternations – traditionally referred to with the name Metaphony\(^ {14}\) – found in the Southern Italian dialects. In these dialects, mid stressed vowels undergo a harmonic change when followed by a high unstressed vowel. Crucially the change is different depending on the specification for the feature [ATR] of the vowel. If the vowel is [+ATR] the mid vowel is raised to [+high] (e.g. [+ATR] e, o → i, u /\_ i, u); if the vowel is [-ATR], there is dialectal variation. In some dialects, it is diphthongized (e.g. [-ATR] e, o → æ, ø /\_ i, u); in other dialects it is tensed to [+ATR] (e.g. [-ATR] e, o → æ, ø /\_ i, u); in other dialects it is just raised to [+high] (e.g. [-ATR] e, o → æ, ø /\_ i, u). Calabrese proposes that these alternations are due to a single assimilatory process spreading the feature [+high] of a high vowel onto a preceding stressed mid vowel. It is given in (9):

\[(9)\]

\[
\begin{array}{c}
\text{N} \\
X1 \\
\text{[-cons]} \\
\text{Place} \\
\text{Dorsal} \\
\text{[-low]} \\
\text{[+high]}
\end{array}
\quad
\begin{array}{c}
\text{N} \\
X2 \\
\text{[-cons]} \\
\text{Place} \\
\text{Dorsal} \\
\text{[-high]} \\
\text{[+high]}
\end{array}
\]

If the target is [+ATR], it simply raises to [+high]. When this process affects mid [-ATR] vowels, however, it creates the configuration [+high, -ATR]. This

\(^{13}\) See more details in http://www.cril.unile.it/grimaldi/acoustic_correlates_docs/Tabelle_Grafici.pdf

\(^{14}\) See Maiden (1991) for a detailed study of metaphony in its diachronic development, synchronic phonological and morphological aspects.
configuration, according to Calabrese, is disallowed by a markedness constraint characterizing [+high, -ATR] vowels as phonologically complex. Languages vary in their acceptance of complex segments, and some languages may simply not accept the cost of having them. Now, Southern Italian dialects do not accept the cost of having [+high, -ATR] vowels. This “non acceptance” is formally represented with the active markedness constraint * [+high, -ATR]. Furthermore, Calabrese proposes that UG provides a number of repair strategies – simplification procedures – that eliminate configurations disallowed by markedness constraints:

(a) fission: it’s an operation that splits a bundle of features containing a disallowed configuration into two successive bundles, each containing only one of the features of the disallowed configuration. It is an operation that breaks a complex disallowed sound into two simpler allowed sounds;
(b) delinking: is an operation by which one of the incompatible features of a disallowed configuration is delinked and replaced with a compatible feature;
(c) negation: is an operation that takes the values of the incompatible features of the disallowed configuration and changes them into their opposites.

The change that we observe in the case of the [-ATR] vowels in a metaphonic context are instances of these simplification procedures. The metaphony rule first creates the disallowed vowels [+high, -ATR] I, U. These vowel are then repaired on a language specific basis as follows (see Calabrese (1998) for detail and more discussion:

(10) a. I, U \rightarrow j, w (by fission)
    b. I, U \rightarrow i, u (by delinking [-ATR])
    c. I, U \rightarrow e, o (by negation)

The above analysis could be extended to the alternations of southern Salentino as follows. The feature composition of the Southern Salento vocalic system is given in (11). As proposed in Calabrese (1995, 2005), I assume that the featural representations of segments are always fully specified:

(11)

\[
\begin{array}{cccccc}
  \text{high} & + & - & - & - & + \\
  \text{low} & - & - & + & - & - \\
  \text{back} & - & - & + & + & + \\
  \text{round} & - & - & - & + & + \\
  \text{ATR} & + & - & - & - & + \\
\end{array}
\]

We have noted that in our data the [-ATR] mid-vowels [E], [O] are tensed to the counterparts [+ATR] [e], [o] when they are followed by high vowels -i, -u. We could assume that the same rule in (9) is active in these dialects. When the rule in
(9) is applied to mid [-ATR] vowels, it would produce a [+high, -ATR] vowel, as shown in (12):

(12) \[ \begin{array}{ccc} p & e & t-I \\ X & X_1 & X \\ \text{[-cons]} & \text{[-cons]} \\ \text{Tongue Root} & \text{Dorsal} & \text{Dorsal} \\ \text{[-ATR]} & \text{[-back]} & \text{[-low]} & \text{[+high]} \end{array} \rightarrow \text{[peti] “feet”} \]

Application of the *negation rule* would convert the disallowed feature configuration [+high, -ATR] into the allowed configuration in (13):

(13) \[ [+\text{high}, -\text{ATR}] \rightarrow - ( [+\text{high}, -\text{ATR}]) > [-\text{high}, +\text{ATR}] \]

This would account for the changes we observe in Southern Salentino (I put aside the issue of the variation between the action of unstressed -i and -u for the moment). The problem is that there is no evidence in this dialect to assume an analysis involving a rule of raising to [+high] followed by a repair rule, as in the other southern Italian dialects. Whereas in these latter dialects we observe a differentiation between [+high] mid vowels, which are indeed raised to [+high] vowels and [-ATR] vowels that may undergo different changes as discussed above, this is not the case in Southern Salentino where we simply observe a tensing of the mid [-ATR] vowels and no other changes. A much simpler analysis can be proposed for Southern Salentino: it simply involves a rule assimilating mid stressed vowel to the [+ATR] feature of the following high vowel (see (14). Processes involving a rule such as (14) are quite common (see Hualde 1989, 1992 and Kenstowicz 1994, for examples):

(14) \[ \begin{array}{ccc} N & X_1 & X_2 \\ \text{[-cons]} & \text{[-cons]} \\ \text{Place} & \text{Place} \\ \text{Dorsal} & \text{Dorsal} \\ \text{[-low]} & \text{[+ATR]} & \text{[+high]} \end{array} \]
An analysis based on this rule is therefore preferable to an analysis based on the rule in (9). This solution raises the question if there is any historical connection between the rule in (14) and the rule in (9). On the basis of Grimaldi (2003: 115-139), through the cross-analysis of data of Italian dialectal varieties, it is assumed that the metaphonetic processes identified in Salento are an innovation dating back to the beginning of modern age; it could also be assumed that the rule in (14) is an innovation which characterizes the Southern Salentino.

Nevertheless, the rule in (14) would account in a much simpler manner for a metaphonetic process in which both the unstressed high vowels would produce vocalic assimilation on both the stressed mid vowels, i.e. if the feature [+ATR] would spread automatically on the stressed mid vowels. Unfortunately, in our case the spreading process of [+ATR] shows a high degree of asymmetry, both for the type of vowel that spreads it and for the type of stressed vowel that assimilates it. To treat these highly diversified processes within any grammatical model – even recurring to the well-known Optimality Theory (OT) – we need to identify a plethora of output markedness constraints that capture the blocking in some conditions of the [+ATR] feature spreading. As we know, although the blocking and triggering relationships between the processes and the output constraints are easy to grasp at an intuitive level, it is not obvious how to express these relationships formally in linguistic theory.

Probably there are still many efforts to be made and many possibilities to be explored before phonological theory is able to absorb the phonetic substance of natural languages within its formalism.

6. An attempt to incorporate phonetics in phonological analysis

See Franceschi (2004: 61-74) for an exhaustive analysis of this issue.

See Hayes & Steriade (2004) for important critical remarks concerning the Markedness concept within OT.

See Calabrese (1998:48-59), who discusses the problems when dealing with the metaphonetic processes of the southern dialects within the OT framework. Calabrese shows that an OT metaphor treatment, although potentially successful, does not appear to be completely satisfactory. Furthermore, see Walker (2005) for an interesting analysis of the height harmony in Veneto Italian dialects, which feature the raising of stressed mid-high vowels into high vowels caused by the postonic high vowels within OT. Walker’s analysis is based on the claim «that the functional origins of Veneto metaphony lie in improving the perceptibility of a distinctive height property which is perceptually difficult. [...] Metaphony accomplishes improved perceptibility by extending the height feature to overlap multiple syllables, including the stressed syllable. [...] the phonetic motivation does not represent an intention on the speaker’s part but rather it exerts influence on language change and shapes certain synchronic phonological processes through phonetically grounded constraints» Walker (2005:931). See, instead, Sanchez Miret (1998a), (1998b) and (1999), Sluyters (1990), and Van Der Veer (2006) where is hypothesised that diphthongs are the result of a spontaneous (i.e. context-free) diphthongization process, not conditioned by ‘metaphony’, due to the fact that the stressed vowels affected by this process, most in open syllables, have a greater duration and intensity than unstressed vowels, so that speakers have greater difficulty to maintain equal sonority and/or position along the total duration of the vowels.

In fact, phonological and syntactic theory, which developed along parallel lines until the 1970s, diverged exactly on this point.
Following Anderson (1981:497), we could state that the best way to gain a better comprehension of phonological properties is to learn to extract the phonetics out of it:

[...] the reason [to look for phonetic explanations] is to determine what facts the linguistic system proper is not responsible for: to isolate the core of features whose arbitrariness from other points of view makes them a secure basis for assessing properties of the language faculty itself.

In our case a possible way is that to exploit the tension emerged between theory and empirical data as stimulus for a coherent integration of phonetics in the phonological analysis. In order to do this we can assume that in the Southern Salentino varieties not all high unstressed vowels always have acoustic and articulatory characteristics – in terms of features – such as to cause a metaphonetic process, i.e. to spread the feature [+ATR] onto the stressed mid-vowels. The only way to verify this hypothesis is to acoustically analyze the unstressed vowels of the area under investigation, with the same criterions used to measure the stressed ones (see Section 3). Consider that the Southern Salentinian unstressed vowel system has four phonemes, as in (15):

\[(15) \quad i \quad u \quad E \quad a\]

An effective method to illustrate the relationship between the unstressed high vowels and stressed ones consists in overlapping the existence areas of stressed and unstressed vocalism on Cartesian diagrams. For this purpose we chose five sample localities representative of the different action of unstressed high vowels on stressed ones, as shown in Charts (8)-(12):
The results suggest a very complex situation. Let’s try to analyse in an in-depth way the relationship between the existence areas of the stressed and of the unstressed vocalism, particularly of the unstressed high vowels which are responsible for the metaphonetic assimilation process, as it emerges in every single graph (Table 5 shows the mean values for the first two formants compared, together with the Standard Deviation):

- Chart 8 – Area (A): the unstressed -i tends to be slightly lower than the stressed /i/, and shows an elliptical inclination towards the left lower part, i.e. towards the outside of the acoustic space. Probably the height and the elliptic direction allow the unstressed -i only to influence the front mid vowel. The unstressed -u, besides being lower both than the stressed /i/ and the stressed /u/ itself, has an elliptic inclination slightly towards the outside of the acoustic space, but, most of all, tends to centralize itself, and therefore is hardly able to act on its own axis (notice the slight raising of /O/ followed by /u/).

- Chart 9 – Area (B): the unstressed -i tends to be higher than the counterpart stressed one, and has, this time, an elliptic inclination towards the right and towards the inside of the acoustic space: therefore, it is able to act both on the front and on the back axis. Instead, the unstressed -u even has the same height of the stressed back mid-high vowel; therefore,
even if its elliptic inclination is perpendicular to the ordinate, it isn’t able to cause any coarticulatory process.

- **Chart 10 – Area (C):** -i shows an almost vertical elliptical direction, and its height is comparable to that of the stressed /i/; therefore it can influence both the front and the back stressed mid vowels. -u, though high enough – and with a vertical elliptic inclination - tends to move towards the centre of the space; therefore it can only influence the back mid vowel.

- **Chart 11 – Area (D):** -i is fairly high, but the elliptic inclination isn’t sufficiently oriented towards the right, i.e. towards the inside of the space (on the contrary, it seems to tend towards the outside of the front axis); therefore it only succeeds in acting on /E/. -u, instead, though showing a vertical elliptic direction, is not sufficiently high; therefore it can only influence /O/.

- **Chart 12 – Area (E):** -i, though with an elliptic direction oriented towards the inside of the space, isn’t as high as the counterpart stressed vowel; therefore it doesn’t even influence /E/. The same happens for -u: the height (with formant values that would identify a back mid-high vowel) and the tendency to an elliptic direction towards the outside of the space do not allow any action on /O/.

At this point we must return to the analysis developed in section 5, where the rule (14) describes the assimilation of the feature [+ATR] of the unstressed high vowels by the stressed mid vowels. In literature it is widely agreed that the value of the first formant (F1) is the most reliable measure of ATR feature. [+ATR] vowels have consistently lower F1 values than their [-ATR] counterparts. As pointed out in Table 5, if we examine the formant values of -i, comparing them to the counterpart stressed /i/, it can be easily noticed that a low F1 systematically characterizes -i, i.e. the vowel which causes, in the entire metaphonetic area, the assimilation process of the stressed mid vowel /E/ into [e]. The unstressed -u, instead, seems to have this formant height feature only in two cases – Areas (B) and (C) – but it succeeds in spreading the feature [+ATR] only on the counterpart stressed mid vowel, and in no way it succeeds in activating the assimilation process by the stressed front mid vowel.

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Areas | Fhz | /i/ | -i | /u/ | -u |
-----|-----|-----|-----|-----|-----|
Area (A) | F1 | 355 (±37) | 364 (±23) | 377 (±23) | **397** (±41) |
| F2 | 2375 (±102) | **2323** (±139) | 1071 (±162) | 1199 (±162) |
Acquarica del Capo | [E] → [e] for -i | [E] | | | |
Area (B) | F1 | 364 (±26) | 353 (±40) | 391 (±21) | **510** (±47) |
| F2 | 2383 (±96) | 2247 (±156) | 808 (±93) | 1049 (±107) |
Patù | [E] → [e] for -i, [O] → [o] | | | | |
Area (C) | F1 | 352 (±35) | 330 (±47) | 383 (±31) | 363 (±49) |
| F2 | 2251 (±138) | 2138 (±85) | 969 (±75) | 1102 (±87) |
Alessano | [E] | [e] for -i, [O] | [o] | for -i, -u | | |
Area (D) | F1 | 262 (±18) | 267 (±27) | 299 (17) | 312 (±46) |
| F2 | 2224 (±98) | 2221 (±116) | 849 (±86) | 986 (±127) |
Andrano | [E] | [e] for -i, [O] | [o] | for -u | | |
Area (E) | F1 | 303 (±41) | **349** (±38) | 391 (34) | **471** (±42) |
| F2 | 2065 (±102) | 1954 (±107) | 841 (±114) | 1004 (±162) |
Spongano | No metaphonetic processes | | | | |

Table 5: values of F1 and F2 in Hz of the stressed /i/ ed /u/ in comparison with the counterpart unstressed –i and –u.

However, these remarks cannot entirely justify the high parameterization of the assimilative mechanism in Southern Salento. As a matter of fact, when -i succeeds in spreading the feature [+ATR] on the back axis, even the position occupied by the unstressed high vowels inside the acoustic space in comparison with the existence area of the stressed vowels seems to play a role. In fact, at the base of the Salentine microvariation, there seem to be the following restrictions:

- if -i is characterized only by sufficiently low F1 values, it can influence exclusively the mid front stressed vowel: Area – A.
- if -i, besides having sufficiently low F1 values, also has F2 values so as to be posteriorized in comparison with the stressed /i/, it can also influence /O/: Area B.
- if -u, besides having sufficiently low F1 values, also has F2 values so as to be anteriorized in comparison with the stressed /u/, it can also influence /O/: Area C.

This description is confirmed – and further defined – by Area D, where -i is only sufficiently high, but not posteriorized in comparison with /i/, and therefore it can influence only /E/, whereas -u, besides being sufficiently high, is also anteriorized in comparison with the counterpart stressed vowel, and therefore it can influence /O/. In brief, in the assimilation processes present in Southern Salento the unstressed high vowels that cause them seem to be governed by differentiated acoustic-articulatory restrictions:

1. -i, in order to spread the feature [+ATR] on the stressed mid /E/ only needs to have sufficiently low F1 values, whereas -u, in order to spread the
same feature on the stressed mid /O/, i.e. on the same axis, also needs to be uttered in an anteriorized position in comparison with the stressed /u/.

2. on the contrary, when -i has a combination of sufficiently low F1 values and a posteriorized position in comparison with /i/, it can spread the feature [+ATR] also onto the stressed mid back /O/.

It isn’t impossible to exclude that this particular position within the vocalic space could be linked to the auditory and to the perceptive space, according to which the unstressed high vowels must be articulated in optimal points of the vocal tract in order to have enough auditory salience to trigger the assimilation process, therefore spreading the feature [+ATR] on the stressed mid vowels.

7. Conclusions

Which theoretical implications can the acoustic data related to the above described assimilation processes have? A well-known problem related to the phonetic-phonology interface within linguistics is: how can the discrete form of linguistic competence be linked to its continuous expression in the shape of articulatory gestures, i.e. with its phonetic substance? Our data seem to suggest that the relation between discreteness and continuity is basically a dynamic one: this assumes that phonological representations and the grammar restrictions which rule their organization must emerge within a dynamic system, which should foresee phonetically parameterized regularities. This means that the phonological competence of the speakers of this varieties must include information related to the micro-parameterization that rules the metaphonetic processes. In other words, the phonological competence has to contain instructions concerning the differentiated physical articulation of the sounds and their auditory perception: therefore the speakers of these varieties know that only a fine under-determinated configuration of the articulators can be extended from a sound to its neighbour.

As consequence, the analysis carried out on this data provides further research perspectives supporting the idea that distinctive features non only have the role to provide information to articulatory actions, but also have a very important role in “[…] the representations of words and morphemes in speaker’ memories and [in] all intermediate representation that arise in course of the computation of the surface representations” (Halle 2002: 8), and, furthermore, in the perceptive processes of speech. As a matter of fact, recent neurophysiological findings have demonstrated that production and perception processes share a common base of articulatory information, that guide the articulatory gestures during speech production, whereas they are extracted from

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20 The role the formant frequencies seem to have, also at a perceptive level, could be linked to the Center of Gravity effect, a process embedded in the perceptual representations of vowels: when two spectral prominences fall within a certain critical distance, the auditory system effectively averages the two prominences, resulting in a percept that is intermediate in frequency (cf. Delattre et al. 1952, Chistovich et al. 1979).

21 For a detailed debate about this questions see: Dehaene-Lambertz & Pena (2001); Clements (2005) and Calabrese (2005).
the acoustic signal as a sort of discrete motor information during speech perception (cf. Fadiga et al. 2002), producing mental articulatory representations.

References


ALI = Atlante Linguistico Italiano. Istituto dell’Atlante Linguistico Italiano (ed.), Centro di ricerca dell’Università degli Studi di Torino, Istituto Poligrafico e Zecca dello Stato: Libreria dello Stato, voll. I-IV.


