ATR and Tense features in Romance: acoustic-articulatory evidence from Tricase Metaphony

Background: Southern Salento varieties show a metaphonic process that raises the stressed mid-vowels /ɛ/, /ɔ/ to tense [e], [o] when followed by high vowels [i], [u] (Grimaldi 2003; Grimaldi & Calabrese *in press*). This process is characterized by microvariation: i.e., while the raising of /ɛ/→[e]/__[i] is always present in all speakers, varying applications of the process are found in all other conditions: /ɛ/→[e]/__[u]; /ɔ/→ [o]/__[i]; /ɔ/ → [o]/__[u]. Acoustically, the allophone [e] generated by the /ɛ/→[e]/__[i] pattern displays significant F1 lowering and F2 increasing (so, it is raised and fronted in the acoustic space), while the allophones [e], [o] generated by all the other patterns show only significant F1 lowering (then, they are raised).
F1 lowering is the main correlate of the ATR feature, whereas F2 increasing seems not a stringent cue for set of [±ATR] vowels (Archangeli & Pulleyblanck 1994). In African languages, which have harmony processes generating similar patterns found for southern Salento, [+ATR] front and back vowels are raised and advanced, [-ATR] front vowels are lowered and centralized, and [-ATR] back vowels are always further back than their [+ATR] counterpart (Ladefoged & Maddieson 1996). Articulatorily, it seems that [+ATR] vowels in African language are generated by the solely advancement of the tongue root (with no involvement of the tongue height), while in English and German tense and lax vowels are distinguished using a variety of tongue height and tongue root differences (Ladefoged & Maddieson 1996; Tiede 1996; Gick et al. 2006; Kirkham & Nance 2017).
What happens in Romance languages? We performed an acoustic-articulatory study in the southern Salento Tricase variety to understand what are the features characterizing the [ɛ]-[e] and [ɔ]-[o] allophonic pairs generated by metaphony.

Methods: 6 Tricase native speakers (2 females; mean age 21.6, range, SD 1,21) were recorded by an Ultrasound systems. The subjects were seated in a soundproof room and were asked to read out at a normal rate word stimuli embedded in a carrier phrase *Ieu ticu __moi* 'I say __now' which appeared on a computer screen. The US video stream was synchronously acquired together with the audio signal, by means of an external a/v analog-to-digital acquisition card, and then recorded in real-time on a dedicated PC. The probe was rigidly locked into a fixed position on plastic helmet. For each segmented sentence, looking at the acoustic waveform the operator manually placed some labels around the time intervals where the relevant vowels occurred, so that the corresponding US pictures could be identified and processed with EdgeTrak. For each vowel, total duration as well as F0, F1, F2 and F3 were measured in the vowel steady tract (0,025 s) centered at the midpoint. An independent t-test was carried out to examine the assimilatory effect of the final vowels [i], [u], [e], [a] on the stressed mid-vowels /ɛ/ and /ɔ/ (alpha level $p<0.05$). To compare tongue curves, we used the Smoothing Spline ANOVA (SS ANOVA).

Results and discussion: the acoustic analysis of data showed the following metaphonic patterns for the Tricase speakers:

(1) a. MB: /ɛ/→[e]/__[i]
b. CR, MM: /ɛ/→[e]/__[i]; /ɔ/→[o]/__[u]
c. GC: /ɛ, ɔ/→[e, o]/__[i]; /ɔ/→[o]/__ [u]
d. LG, GE: /ɛ, ɔ/→[e, o]/__[i, u]

When the pattern is /ɛ/→[e]/__[i], [e] is always raised and fronted; in the other cases [e], [o] are only raised, except for LG and GE, who show a posteriorization of [o] for the /ɔ/→[o]/__ [u] pattern. The [ɛ], [ɔ] allophones are always lowered but neither centralized nor further back than their [e], [o] counterpart. Hence, the Tricase variety shows different patterns both from African and Germanic languages. Again, differently from what happens for African and Germanic languages, the Tricase articulatory data showed that difference between mid-open and mid-close vowels does not involve systematic tongue root advancement and/or tongue body displacement. Conversely, the articulatory gesture systematically involved is the bunching of the tongue body, due to tongue body raising, which, through muscular tension, generates a *tongue shape convexity* (cf. Table 1).
We propose to use the feature [Tense] for the Tricase variety system, where [+Tense] vowels are characterized by an increased tongue convexity involving the tongue body, and optionally the tongue root. However, the feature [tense] in addition to [ATR] creates an over-generation problem: the existence of languages where the features [tense] and [ATR] can freely combine, leading to systems with four height distinctions in the high or

mid vowels, which of course are not on record. Thus, tongue root advancement or retraction can be seen as configurations enhancing or reducing the convexity requirements associated with vowel tensing (cf. Calabrese & Grimaldi forthcoming for a deep discussion of this issue).
In conclusion, languages may use different articulatory strategies to reach ATR and Tense vowels contrasts.

Subject groups	Metaphonic patterns	Root advancement Interaction effect	Body raising Interaction effect	Acoustic effect
C.R. (female)	/ɛ/→[e]/__[i]	*	*	Raising + Front
	/ɔ/→[o]/__[u]	*	*	Raising
M.M. (male)	/ɛ/→[e]/__[i]	*	*	Raising + Front
	/ɔ/→[o]/__[u]	*	*	Raising
L.G. (male)	/ɛ/→[e]/__[i]	*	*	Raising + Front
	/ɛ/→[e]/__[u]	n.s.	*	Raising
	/ɔ/→[o]/__[i]	n.s.	*	Raising
	/ɔ/→[o]/__[u]	n.s.	*	Raising + Posterior
G.E (male)	/ɛ/→[e]/__[i]	*	*	Raising + Front
	/ɛ/→[e]/__[u]	n.s.	*	Raising
	/ɔ/→[o]/__[i]	*	*	Raising
	/ɔ/→[o]/__[u]	*	*	Raising + Posterior.
G.C. (male)	/ɛ/→[e]/__[i]	*	*	Raising + Front
	/ɔ/→[o]/__[i]	*	*	Raising
	/ɔ/→[o]/__[u]	n.s.	*	Raising
M.B. (female)	/ɛ/→[e]/__[i]	*	*	Raising + Front

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