Labialization in Italian Dysarthric Speech by Parkinsonian Speakers

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Hypokinesia and bradykinesia are usually reported as characterizing hypokinetic dysarthria, which often afflicts subjects affected by Parkinson's Disease (PD) [1,2,3]. Specifically, as far as segmental features are concerned, a reduction of the vowel acoustic space and of the amplitude of speech gestures is usually found [4,5], though duration of movements is expected not to change or to decrease with no proportional reduction of amplitude and velocity of gestures [6]. However, some kinematic investigations also reported a greater amplitude in PD speech gestures [7,8], even only on specific axes (such as for horizontal, antero-posterior, displacement [9]). Importantly, intra-speaker analyses showed that, despite reduction, phonological distinctions on the segmental level are preserved as much as possible, thanks to compensation strategies [10].

The main goal of this paper is to reach a better understanding of production strategies related to antero-posterior gestures in Italian dysarthric speech and shed light on previous etherogenous results on Italian [9,10]. This goal is achieved here by devoting specific attention to amplitude, duration and timing of labialization gestures related to posterior vowels as opposed to anterior vowels. The main hypothesis is that, in line with the literature, measurements regarding PD speech usually show reduced values in comparison to those regarding healthy speech. However, due to the interplay of linguistic factors, inducing speakers to maintain linguistic unit identity, and the impairment due to the disease, we expect to find also increased values concerning anterior-posterior gestures, in line with results observed in relation to tongue movements in Italian speech.

The corpus is composed of three word nominal phrases, such as *Lu/i X blu* 'The blue X', where Xs are ˈCVCV disyllables, Vs are /i/ - /u/ or /u/ - /i/, and initial or intervocalic Cs may be voiced or unvoiced bilabial stops (/p/, /b/). Disyllables are [ˈpu.pi], [ˈpi.pu], [ˈbu.bi], [ˈbi.bu], and the preceding determiner may be Lu/Li (singular and plural masculine, respectively), as allowed by the local Italian variety. The target short sentences were presented as answers to questions to elicit broad focus utterances. Four mild-to-severe dysarthric PD speakers from Lecce – Southern Italy (age 65-80) and four peer healthy controls (CTR) from the same geolinguistic area (matching age) participated in the study. The same severity level was reported for PD speakers according to clinical assessment; no relevant clinical issue was reported by CTR speakers. Each speaker read the corpus 7 times at a comfortable speech rate.

Acoustic and articulatory data were collected synchronously by an EMA 3D AG501 (Carstens Med., GmbH) in a quiet room at CRIL (Lecce, Italy). The articulatory data were recorded by means of 7 sensors, glued on subjects: 2 on tongue mid-sagittal plane (dorsum and tip), 2 on lips vermillion border (upper and lower), 1 on the nose and 2 behind the ears for normalization.

The acoustic signal was manually labelled in PRAAT as for consonant (C) and vowel (V) boundaries. Duration of the consonant and vowel (C0,V0) composing the syllable carrying the (prenuclear) pitch accent (that enhance segmental characteristics, i.e., the opposition between front/back Vs, as well as that between voiced/unvoiced Cs), as well as the duration of the other segment, were then automatically extracted together with first and second formant (F1, F2) values in the central 50 ms of the vowels. Articulatory data labeling was performed by means of MAYDAY [11]. For both tongue dorsum (TD) and lower lip (LL) track, and along both the vertical and the horizontal (anterior-posterior) axes, we labelled gesture targets, located at the zero velocity; for each tracked segment, the maximum velocity was labelled at the velocity peak of the relevant coil. The duration and amplitude of lower lip/tongue dorsum gestures were calculated. For instance, for each closing gestures, the duration was calculated as the time interval between the maximum aperture and the maximum closure of the articulators; the amplitude was calculated as the vertical/horizontal component of the articulator displacement during gesture. As for statistical analysis, mixed models were implemented in R (lme4 [12,13]. Fixed effects, with interaction terms, regarded linguistic factors such as *Voicing* (voiced vs. unvoiced) and *Vowel cycle* (Vcycle IU vs. UI, for, respectively, the /i-u-i/ and the /u-i-u/ cycle);

Population (PD vs. CTR) and *Repetition* (7 levels) were rather introduced to take into account the impact of impairment. Intercepts for subjects, as well as by subjects random slopes were set in order to account for inter-subjects variability as for the realization of repetition. Visual inspection of residual plots did not reveal any obvious deviations from homoscedasticity or normality. In order to test the significance ($p<0.05$) of each fixed effect a *Likelihood Ratio Test* was used.

Regarding segmental measurements, acoustic results confirm expectations, showing that front /i/ and back /u/ vowels are significantly different, and, at least in the anterior-posterior dimension, PD speakers exploit a reduced vowel space. However, articulatory results put a different light on the abovementioned picture. The tongue horizontal gestures turned out to be wider in PD than in CTR subjects (Fig.1, left). Light on he matter is shed by the analysis of lower lip horizontal movement, due to protrusion. Besides an influence of Vcycle on gestures, an interesting impact of Population is also found. Specifically, a smaller lip horizontal gesture (to the accented consonant) is found in PDs (Fig.1, right), in comparison to CTRs, pointing to the existence of a compensatory effect.

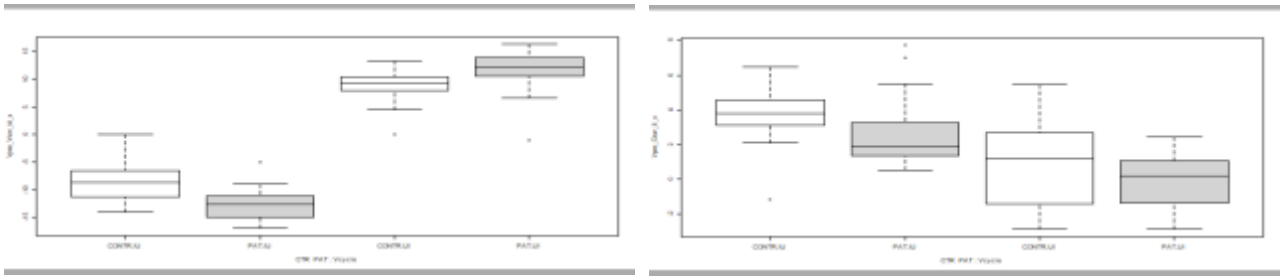

Figure 1: *Amplitude of tongue (left panel) and the lower lip (right panel) horizontal gestures: gesture to accented /u/ (left) and to accented /i/ (right) in PD (grey) and CTR speakers (white)*

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