Preserving speech dynamics in Parkinson's disease: An acoustic study of the production of glides by Belgian French patients

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Parkinson's disease (PD) is a neurodegenerative disease associated with basal ganglia motor loop dysfunction and impairment of the dopamine pathway. It is mainly characterized with the progressive loss of dopaminergic neurons. The core symptoms may include akinesia as well as bradykinesia, rigidity and/or resting tremor, which may all contribute to a wide variety of speech disorders usually regrouped under the label of 'hypokinetic dysarthria'. Hypokinetic dysarthria manifests in all aspects of speech production, including respiratory, phonatory and articulatory processes, at both segmental and suprasegmental levels. Classical perceptual studies (Darley *et al*., 1975; Logemann *et al*., 1978) and more recent acoustic studies (Hammen & Yorkston, 1996; Gamboa *et al*., 1997; Cheang & Pell, 2007) have repeatedly shown that Parkinsonian speakers display voice quality disorders (hoarseness, breathiness, etc.) as well as reduced overall loudness, limited variation in intensity and fundamental frequency (monotony of pitch and monoloudness), speech dysfluencies including longer, unappropriate pauses and word/syllable repetitions, unappropriate speech rate (mainly: short rushes of speech), and reduced stress.

On the articulatory level, imprecision of consonant production is one of the most reported impairment in individuals with PD who suffer a hypokinetic dysarthria (Ackermann & Ziegler, 1991; McRae & Tjaden, 1998; Wong *et al*., 2011). Stops, affricates and fricatives are most distorted (in the direction of softening, e.g. via spirantization), presumably due to limited range and reduced force of articulatory movement. Actually, Ackermann and colleagues (Ackermann & Ziegler, 1991; Ackermann *et al*., 1995) have hypothesised that PD patients reduce the amplitude of articulatory movement in order to preserve speech tempo, which results in articulatory undershoot. However, physiological studies have yielded mixed findings in terms of amplitude and velocity of jaw, tongue and lips movements (and associated muscle activity) in Parkinsonian speech production (for a recent review, see Walsh & Smith, 2012). For example, Mcauliffe *et al*. (2006) evidenced perceived undershooting of Parkinsonian consonant production, but could not find an associated pattern of reduced tongue-palate contact on EPG examination. Wong *et al*. (2011) even found an increased range of lingual movement (mostly in the release phase of velar and alveolar consonants) in dysarthric PD individuals. Obviously, more studies are needed to fully apprehend the dynamics of supra-laryngeal articulators in PD.

Interestingly, "resonatory" properties of speech production are presumably preserved -but rather understudied- in PD (Goberman & Coelho, 2002), although vowels, diphtongs and approximants certainly need accurate execution of motor plans involving jaw, tongue and lips. The study of vocoïds may be of great interest to research on PD speech, particularly if steady vowels are opposed to dynamic vocalic productions, since it allows to investigate the speakers' ability to control their resonators in maintaining stable articulatory configurations vs. in producing accurate and properly-timed dynamic gestures.

In this paper, in line with prior exploratory research in our laboratory (on palatal French glides in PD speakers: Couvreur *et al*., 1999), we report on an acoustic study of the production of glides and steady vowels by non dysarthric PD and control speakers. Our aim is to explore further the dynamics of supra-laryngeal articulators in PD, and to address specifically the hypothesis that when dysarthria is infraclinic, Parkinsonian speech may be characterized by a preservation of the timing - somewhat at the expense of the accuracy - of articulatory movements. The acoustic study reported here has been carried out in the context of a larger project aiming at investigating the relationships between speech disorders, quality of life and social participation in PD. 9 Belgian French non dysarthric PD speakers (6 male, 3 female, aged 52-77) and 10 control speakers participated in the study. They were administered 3 self-assessment questionnaires (VHI: Jakobson *et al*., 1997; PDQ-39: Auquier *et al*., 2002; MHAVIE 4.0: Fougeyrollas &

Noreau, 2014) as well as speech tasks including the production of sustained oral vowels [a,i,u] and $V1_{[a,u]}C[_{glide}]V2_{[a,i,u]}$ pseudo-words, the repetition of CV(C)CV pseudo-words and the reading of a short text. Acoustic measurements reported here include duration and formant frequencies (all vocoid segments), slopes of F2 trajectories (glides), and time from V1 onset to the point where F2 reaches its extreme within the glide (VCV pseudo-words).

The main results are the following: (i) vocalic triangles obtained from sustained vowels exhibited comparable location for the centers of gravity of single vocalic categories in both speakers groups, but larger within-category variability in Parkinsonian speakers; (ii) in VCV pseudo-words, euclidean distances (in the F1-F2 planes) from reference production in sustained vowels differed across segment and group of speakers, namely: (iia) for both Parkinsonian and control speakers, distance from reference was short in glides, meaning that the acoustic target was achieved with accuracy; however (iib) distance from reference was significantly longer in V1 and V2 vowels for PD speakers as compared to controls; (iii) total VCV duration did not differ across groups of speakers although time from V1 onset to F2 extreme was shorter in PD speech. In short, our results suggest that non dysarthric Parkinsonian speakers maintain an accurate production of glides in VCV pseudo-words at the expense of articulatory undershoot in the surrounding vowels, and some assymetry between the V1-to-glide and glide-to-V2 articulatory movements. We will discuss at the conference how these results both support and challenge the accuracy-timing trade-off hypothesis (Ackermann & Ziegler, 1991), and more generally how laboratory studies of the dynamics of supra-laryngeal articulators in vocoids may shed light on speech motor control in PD, especially when dysarthria is infraclinic.

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