

Imprecision of vowel production as a potential subclinical marker in Parkinson's disease

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Parkinson's disease (PD) is a neurodegenerative disease affecting the neuromotor system. PD is characterized with the progressive loss of dopaminergic neurons. The motor symptoms may include bradykinesia associated with rigidity and/or resting tremor. A wide variety of speech disorders usually regrouped under the label of "hypokinetic dysarthria" may come with PD (Postuma et al., 2015; Sapir, 2014). They affect different aspects of speech production involving respiration, phonation and articulation (e.g. Duffy, 2012; Kent et al., 1999). On the articulatory level, most of previous studies have focussed on imprecision in consonants (e.g. Ackermann & Ziegler, 1991), although vowel production can also be altered, in particular at moderate and advanced stages of the disease (Mollaei et al., 2016; Skodda et al., 2011).

In this paper, we present the results of an acoustic study of vowel production by dysarthric PD, non dysarthric PD and control speakers. Our aim is to characterize vowels produced in isolation in PD, and to explore whether vowel-related descriptors can be used as subclinical markers of dysarthria.

Three groups of speakers participated in the study. There were 63 participants diagnosed with idiopathic PD. They were Belgian French native speakers aged 38-85 years (mean: 70), with an average disease duration of 7 years (1 – 25 years), who covered all stages of PD on the Hoehn and Yahr (1967) disability scale. Out of 63 participants with PD, 43 were dysarthric (DPD) and 20 were nondysarthric (NDPD) following expert perceptual assessment. The third group of speakers was made of 35 healthy controls aged 41-84 years (mean: 66) with no speech-language pathology.

Participants were presented with various speech tasks including the production of multiple repetitions of oral vowels /a, i, u/ in isolation. Acoustic measurements were performed manually using PRAAT. F1 and F2 were extracted from the stable part of each vowel. Three acoustic metrics were calculated from all the vowels produced by each participant: (1) the triangular vowel space area (tVSA, in Hz²) which represents the maximum working space of each individual, (2) the vowel articulation index (VAI, in Hz), which is the reciprocal of the formant centralization ratio (Roy et al., 2009) and (3) the PHI index (PHI, in Hz) which characterizes vowel space organization by computing the ratio between inter- and intra-categorical dispersion of the vocalic system (Huet & Harmegnies, 2000). Results are illustrated in Fig.1.

Results showed more scattered vowel productions for PD speakers, in particular for the vowel [a]. Individual triangle areas (tVSA) revealed that mean areas were significantly smaller for DPD vs. control speakers ($U = 1400$; $p = .027$), except for the first repetition, suggesting that DPD speakers transiently resorted to hyperarticulation, but could not maintain it throughout a sequence of vowels. Significant differences in terms of VAI were also found between these groups ($U = 1519$, $p = .001$), suggesting more centralization thus reduced vocalic contrasts for DPD speakers. PHI values were significantly lower for DPD (mean: 150) than for control speakers (mean: 1477) ($U = 1960$, $p < .001$), suggesting a lower degree of vocalic system organization in PD.

Interestingly, the PHI index was the only metric to show significant differences between *nondysarthric* PD and healthy controls ($U = 639$, $p < .001$). This was mainly due to a significantly higher intracategorical dispersion in NPD speakers presumably resulting from larger imprecision in vowel production ($U = 86$, $p < .001$). Thus, what was significantly reduced for nondysarthric PD speakers was not as much the total articulatory range/working space (indexed

by tVSA), as the internal organization of the vocalic system itself due to lack of accuracy around vowel targets. We will discuss at the conference how the PHI index might be viewed as a potential candidate as a subclinical marker of dysarthria in Parkinson's disease.

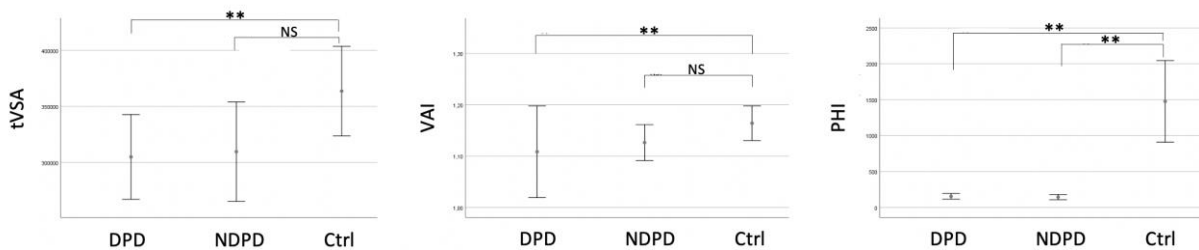


Fig.1: tVSA, VAI, PHI mean values and 95% confidence interval for Dysarthric PD (DPD), Nondysarthric PD (NDPD) speakers and healthy controls (Ctrl).

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