

Inter-Syllabic Interval as an indicator of fluency in Parkinsonian French speech

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Fluent speech is characterized by appropriate tempo and rhythm, and a reduced number of disruptions. Disfluencies may happen between words or within words. Between-word disfluencies are silent pauses, full pauses and fillers, false starts/repairs, and repetitions of words and sentences. They are common in spontaneous speech. When unusually frequent, they signal issues in linguistic planning and/or monitoring (e.g. in non fluent aphasia), in relation with cognitive and psycho-affective factors. Within-word disfluencies consist in part word (single syllables or phonemes) repetitions/repairs and disrhythmic phonations, i.e. within-word silent pauses and sound prolongations. Compared to between-word disfluencies, within-word disfluencies are considered as more motoric-based. Although they are also observed in healthy speakers, they are viewed as characteristic of developmental stuttering and their presence is often considered necessary for a diagnosis of stuttering (Goberman *et al.*, 2010).

Hypokinetic dysarthria typical of Parkinson's disease (PD) manifests in all aspects of speech production, including respiratory, phonatory and articulatory processes, at both segmental and suprasegmental levels. Impaired motor coordination and reduced speed of articulation may have diverse, sometimes antagonistic effects on speech timing, such as slower overall speech rate (Gräber *et al.*, 2002), preserved tempo at the cost of hypoarticulation (Ackerman & Ziegler, 1991), faster articulation rate within short rushes of speech (McRae *et al.*, 2002) interspersed with longer, more frequent pauses. Moreover, motoric-based disfluencies have been reported in parkinsonian speech (e.g. Goberman *et al.*, 2010; Shahed & Jankovic, 2001).

Thus, the concepts of rhythm and tempo (articulation rate, speech rate) on one hand, and fluency/disfluencies on the other hand, interrelate in complex ways. One of the consequences is the methodological challenge of setting measures and indicators: Which (types of) disfluencies to include/exclude before computing articulation rate (see e.g. Logan *et al.*, 2011 vs. Tjaden & Wilding, 2011)? How to select thresholds to define silent pauses and prolongations? Methodological differences between studies are considered as partly responsible for conflicting results on speech timing in dysarthrias (Goberman *et al.*, 2005; Duez *et al.*, 2012).

Our team has recently introduced the Inter-Syllabic Interval (ISI) as a potential indicator of fluency in French-speaking healthy and pathological speakers (Piccaluga *et al.*, 2007; Leclercq *et al.*, 2010). ISI is defined as the time interval between the intensity peaks characterizing consecutive syllabic nuclei in any spoken utterance. ISI's computation is free from the necessity to a priori exclude portions of the speech signal as potential disfluencies and/or classify them into a large number of underpopulated sub-categories, unsuited for statistical analysis. Mean ISI is close to the notion of speech rate: low ISI signals quick tempo and/or short silent pauses while high ISI is expected in slow speech. The overall and time-evolving variance of ISI should allow to characterize more or less fluent speech, e.g. according to how severely syllabic rhythm is affected by disfluencies.

The aim of our research program is to assess the potential of ISI as an indicator of (dis)fluency in French with respect to: other acoustic measures based on conventional syllabic segmentation; other physiological and articulatory measures; subjective assessments from expert and naive listeners. Targeted populations are healthy speakers, persons who stutter and Parkinsonians performing

speech production tasks with and without time/cognitive pressure. We will present at the conference the results of a first acoustic study on 2 groups of Belgian French speakers, i.e. 12 participants with Parkinson's disease, 6 male, 6 female, aged 55-80, and 12 age- and gender-matched healthy participants. Data have been collected using the "MonPaGe" protocol (Fougeron *et al.*, 2016; in this case, the picture description, text reading and speech diadochokinetic tasks). We analyse speech productions as a function of group (PD vs. healthy participants) and task, comparing in terms of robustness and cost/benefit ratio statistics on ISI (mean, variance) with more conventional measures requiring the a priori detection and classification of disfluencies (articulation rate and speech rate including and excluding disfluencies, speech/pause ratio; percent between-word and within-word disfluencies).

Keywords: fluency, disfluencies, Inter-Syllabic Interval, Parkinson's disease, articulation rate, speech rate, pauses

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