

Influence of metronome cueing on articulatory kinematics in Parkinson's disease

Valentine Lucquiault¹, Teja Rebernik^{2,3}, Jidde Jacobi⁴, Defne Abur¹, Martijn Wieling^{1,3}

¹Center for Language and Cognition Groningen, University of Groningen, Groningen, NL. ²Laboratoire de Phonétique et Phonologie, CNRS & Sorbonne Nouvelle, Paris, FR. ³Brussels Centre for Language Studies, Vrije Universiteit Brussel, Brussels, BE. ⁴Netherlands Forensic Institute, The Hague, NL

Background: Parkinson's disease, the most common motor disorder in the world [1], is characterized by a number of speech impairments including changes in speech rate. Although earlier studies of speech rate in Parkinson's disease (PD) found a rather wide range of performance compared to typical speakers (e.g., [2, 3]), more recent investigations of within-task rate variations reported a tendency for speakers with PD to increase their pace across the duration of the task (e.g., fast syllable repetition), and to produce more temporally variable syllables overall [4, 5]. A high temporal variability in speech rate is thought to derive from impairments to the internal pacing system [4], a hypothesis consistent with the classification of PD as a rhythm disorder [5]. Furthermore, similar comparative assessments of external compared to internal pacing have shown that external pacing aided speakers with PD to exceed their maximum self-paced speech rate [4]. Temporal variability in speech rate has also been suggested to be a strategy to maintain speech intelligibility under time pressure [6]. However, it is still unknown how external cues affect speech rate variability in challenging articulatory combinations that are more prone to error at higher repetition rates (e.g. [7, 8]). Thus, the present study compares the ability of speakers with PD to produce alternating articulatory motions (i.e. *kop top*, /kɔp/ /tɔp/) in different pacing conditions: comfortable self-pacing, as-fast-as-possible self-pacing, and accelerated external pacing using a metronome. Based on existing work [3, 4], we expected that speakers with PD would exhibit lower and more variable speech rates than typical speakers in both self-paced conditions. We further hypothesised that with external cues, speech rate variability would decrease and the difference in speech rate between PD and control speakers would be reduced; we also predicted that the number of speech errors would increase along with the increase in metronome rate for both groups.

Methods: a total of 50 native speakers of Dutch equally split between speakers with Parkinson's disease and age- and sex-matched typical speakers participated in the study. Speakers were considered eligible if they successfully completed all three tasks at least twice, leading to a final sample of 10 speakers with PD and 17 control speakers. As analysis is ongoing, we only report on the results for the accelerating metronome task for a subset of 6 speakers with PD (age mean $M = 68.2$, standard deviation $SD = 5.6$ years; 5 males, 1 female) and 6 control speakers (age $M = 70.7$, $SD = 5.4$ years; 5 males, 1 female). Acoustic production was recorded simultaneously with movements of the tongue and lips using electromagnetic articulography (NDI WAVE EMA; [9]) while the participants produced alternating syllables *kop / top*. For the accelerating metronome condition, participants were asked to align their alternate productions of *kop* and *top* with an accelerating auditory metronome. Speech rate was operationalised through interpeak intervals (IPIs), defined as the time (in milliseconds) between the articulatory targets of the tongue back (/k/ in *kop*) and of the tongue tip (/t/ in *top*). Peaks were numbered for each trial separately, to ensure comparability across speakers.

Results: Averaging IPIs per group, as shown in Figure 2, suggests a potential effect of group on the temporal evolution of speech rate. Similarly, the boxplots in Figure 2 show the significant effect of speaker group on the number of syllables produced overall (t -test on independent samples, $p < 0.01$). At present, all data has been collected and analysis is ongoing. Additional results will be presented at the conference. Specifically, we will report on results for all eligible participants and tasks, regarding both IPIs and speech errors. This will allow for the investigation of potential relationships between cueing modes, temporal accuracy, and articulatory precision. The results of this study will inform our understanding of rhythm control and associated compensatory strategies in Parkinson's disease.

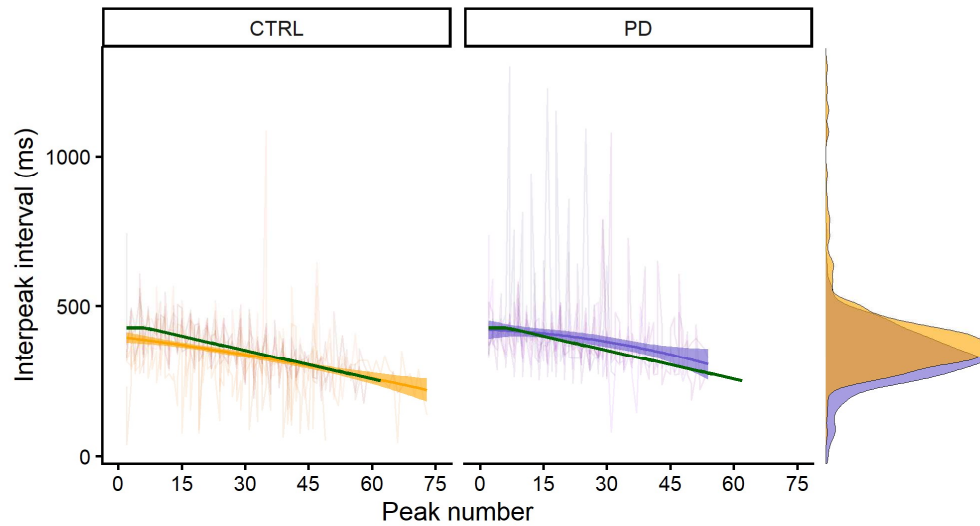


Fig. 1. Individual and group-averaged trajectories of interpeak intervals (IPI, in ms) across speaker-relative peak numbers (solid line: mean, shaded region: 95% confidence interval). Green = metronome IPIs over time.

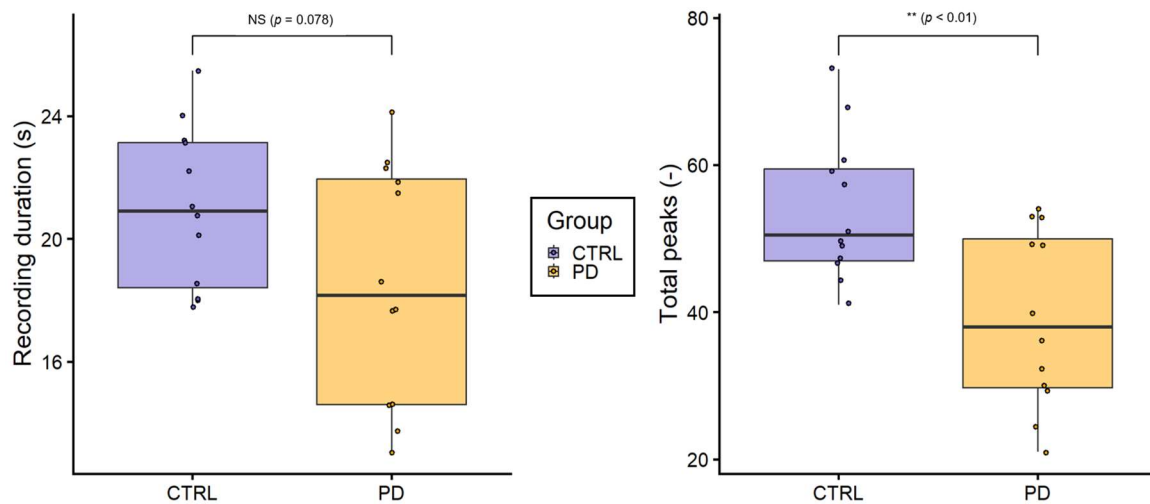


Fig. 2. Boxplots for recording duration (left; i.e. duration for which the participant produced *kop/top*) and total number of produced syllables (right; i.e. the number of *kops* and *tops* produced during the recording). Significance levels refer to the p -values for independent t -tests performed on normal, homoscedastic variables.

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