

# On the Influence of the Parkinson Disease in Vowel Production

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## Motivation

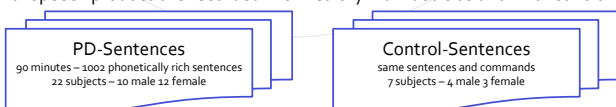
- Parkinson's disease (PD): a neurodegenerative condition with muscle-related symptoms: bradykinesia, tremor, rigidity, progressive dysarthria (difficulty with articulation).
- Ability to handle common technological devices is reduced.
  - Speech technologies may provide important alternatives.
  - Dysarthric speech needs to be taken into account.

## Objective

- To identify the acoustic-phonetic characteristics that distinguish Parkinsonian speech from normal speech, in European Portuguese.
  - To explore the first and second formant frequencies of vowels in continuous speech.
- To build a speech recognizer adapted to PD patients (long term objective).

## Corpus and Methodology

- Corpus collected with PD Patients (50–80 years old). Recordings at the neurology service of the Hospital of the University of Coimbra.
- Similar speech productions recorded with healthy individuals as a form of control.



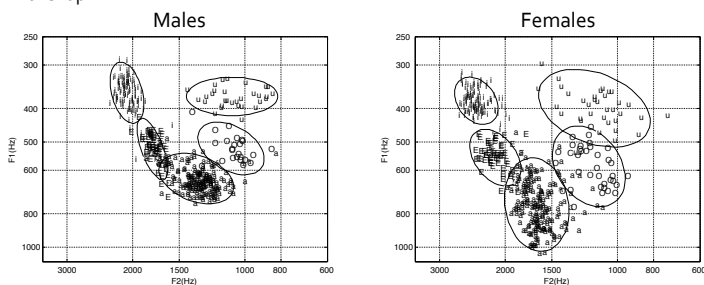
- Two levels of dysarthria discerned through perceptual classification: **Low-PD** and **High-PD**.
- Automatic phone segmentation through forced alignment.
- Difficulty to calculate formant frequency of every vowel in continuous speech.
  - Only stressed position vowels with a duration above 50 ms were selected; low energy parts of the segments were cut.
- Praat tool used to calculate F1 and F2 formant frequencies, with an iterative process with different formant ceilings, choosing the one providing lowest variance.

Number of vowel samples analyzed for Males (M) and Females (F) of the three different groups considered

Vowel	Control M	Control F	Low-PD M	Low-PD F	High-PD M	High-PD F	Total
[i]	523	306	109	121	103	71	1233
[E]	285	167	63	63	51	37	666
[a]	783	532	188	192	148	98	1941
[O]	160	108	24	36	26	22	376
[u]	151	79	31	36	21	21	339

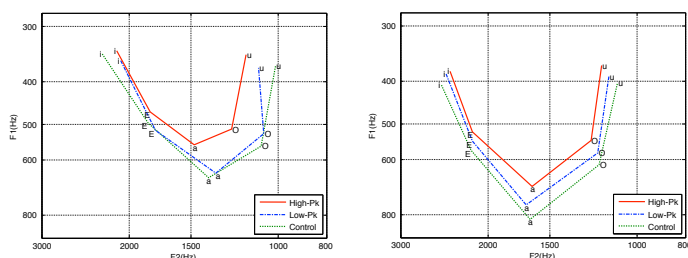
## Formant analysis

- Vowels [i], [E], [a], [O] and [u]: F1 and F2 values show large variations but little overlap.



F2 and F1 for vowels [i], [E], [a], [O] and [u] of Males of the Low-PD group (left) and Females of the Low-PD group (right).

- [u]: often displaced to a centralized position, not given enough time or emphasis to reach a very low F2 value. All of the vowels may partially suffer from this centralization during continuous speech.



F2 and F1 median values of [i], [E], [a], [O] and [u] for males (left) and females (right) in Control, Low-PD and High-PD groups.

- As the dysarthria progresses the triangle of the vowels reduces.
- Lower F1 values for PD, mainly for vowels [a] and [O], and with a slight centralization of F2 values.

## Formant metrics

Common indicators of dysarthric speech using F1 and F2 of [i], [a] and [u]:

- Vowel Space Area (VSA)  $\frac{F_i \times (F_{i,a} - F_{i,u}) + F_{i,a} \times (F_{i,u} - F_{i,j}) + F_{i,u} \times (F_{i,j} - F_{i,a})}{2}$
- Vowel Articulation Index (VAI)\*  $\frac{F_j + F_a}{F_i + F_{i,u} + F_{i,a}}$

Means and standard deviations of formant metrics for the three groups considered

Gender	Control	Low-PD	High-PD
Male			
VSA (Hz <sup>2</sup> ×10 <sup>-5</sup> )	1.84 ± 0.73	1.33 ± 0.31	1.02 ± 0.42
VAI	0.92 ± 0.07	0.85 ± 0.06	0.80 ± 0.07
Female			
VSA (Hz <sup>2</sup> ×10 <sup>-5</sup> )	2.95 ± 0.31	2.32 ± 0.49	2.26 ± 0.62
VAI	0.95 ± 0.05	0.88 ± 0.02	0.89 ± 0.03

Smaller area and lower articulation for PD as expected.

However, only statistical significance on Male VAI for Control vs. High-PD with p=0.038

\* Another metric is the Formant Centralization Ratio (FCR), which is the inverse value of VAI.

## Conclusions

- F1 and F2 formant frequency changes in PD speech show centralization and closeness of vowel articulation.
  - Confirming the difficulty of PD patients with the movement of the tongue's body.
  - Specially evident in open central vowel [a] for both male and female speakers.
- Large speaker variability: articulation of Control vs. High-PD group the only significant result from the usual metrics to evaluate dysarthria.
- PD speech is less dynamic. Confirmed by ranking several acoustic-prosodic features.