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.

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

Formant metrics
Common indicators of dysarthric speech using F1 and F2 of [i], [a] and [u]:
- Vowel Space Area (VSA)
  \( \frac{F_{2}(i)F_{2}(a) + F_{2}(i)F_{2}(u) + F_{2}(a)F_{2}(u)}{2} \)
- Vowel Articulation Index (VAI)
  \( \frac{F_{1}/F_{2}}{F_{2}/F_{1}} \)

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

<table>
<thead>
<tr>
<th>Gender</th>
<th>Control</th>
<th>Low-PD</th>
<th>High-PD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSA</td>
<td>1.84 ± 0.73</td>
<td>1.33 ± 0.31</td>
<td>1.02 ± 0.42</td>
</tr>
<tr>
<td>VAI</td>
<td>0.92 ± 0.07</td>
<td>0.85 ± 0.06</td>
<td>0.80 ± 0.07</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSA</td>
<td>2.95 ± 0.31</td>
<td>2.32 ± 0.49</td>
<td>2.26 ± 0.62</td>
</tr>
<tr>
<td>VAI</td>
<td>0.95 ± 0.05</td>
<td>0.88 ± 0.02</td>
<td>0.89 ± 0.03</td>
</tr>
</tbody>
</table>

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
- F2 and F3 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.