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Variamu Workshop, Aix-en-Provence
Parkinson’s disease

As a neurolinguistic pathological model to understand

→ The relationship between cortical and sub-cortical speech areas

→ The impact of specific voice/articulation deficits on communication across languages
Dopamine regulation of human speech and bird songs: A critical review.
*Brain Lang* 122 : 142-150
Parkinson’s disease

Continuous degeneration of the dopamine producing nerve cells in the substantia nigra, leading to impaired neuromuscular function

- Tremor
- Rigidity
- Bradykinesia
- Gait impairment

James Parkinson (1755-1824)
Rest tremor

Akinesia
- Slowness of movement initiation (akinesia)
- Slowness of movement execution (bradykinesia)
- Reduction of movement amplitude (hypokinesia)

Hypertonia/Rigidity

Gait impairment
- Postural instability
- Freezing of gait
- Hypomimia
- Speech impairment
- Hypersialorrhea
- Dysphagia
- Micrographia
- Orthostatic hypotension
- Depression
- Cognitive decline...
Dysarthria

Collective name for motor speech disorders resulting from damage to central or peripheral nervous system

- Hypophonia
- Articulatory imprecision
- Monotony of speech
- De-/ increased articulation rate
70 % of patients experienced impairment of speech and voice after the onset of their disease

41% indicated impairment of chewing & swallowing abilities

29% reported speech disorder as one of the major problems

3% only had received any speech therapy

Speech and swallowing symptoms associated with Parkinson's disease and multiple sclerosis: a survey.
_Folia Phoniatr Logop_ 46: 9-17
Dysarthria classification

Darley et al. (1969)
Parkinson’s disease

- Basal ganglia
- Cerebellum
- Premotor & motor cortices
- Brainstem
- Speech production musculature

Darley et al. (1969)
Role of the basal ganglia

Basal ganglia contribute to motor learning, timing, and control

Basal ganglia contributions to motor control: a vigorous tutor.
Curr Opin Neurobiol 20 : 704-716
Compensation of motor function

- Premotor & motor cortices
- Frontal, temporal, parietal cortices
- Basal ganglia
- Cerebellum

Flowchart:
- Generation – Selection - Planification
- Execution
- Regulation

Note: The cerebellum is included in the flowchart, but its role in the motor function process is not specified in the text.
Speech motor control

- Premotor & motor cortices
- Generates - Selects - Plans
- Execution leads to
  - Altered speech production

Regulation from:
- Temporal regions
- Basal ganglia

Cerebellum also involved in regulation.
Motor speech control

Dissociation between motor control of limbs and speech

1. Compensation mechanisms for hand movements differ from those used for speech (e.g., Pinto et al, 2011)

2. Beneficial Levodopa effects on limb control, but no effects on speech (e.g., Maillet et al, 2012)
What is dysarthria in Parkinson’s disease?

The 32 patients in the parkinsonism group presented phenomena constituting what may be called “hypokinetic dysarthria” (Table 10). All four of the neurologic groups previously reviewed displayed monopitch and monoloudness, but the severity of these dimensions is decidedly greater in parkinsonism; together with reduced stress they comprise the most striking phenomena. Related prosodic changes distinctively present here are inappropriate silences, short rushes of speech, and variable rate. It will be seen that this is the only type of dysarthria in which rate is not characteristically slow; it is typically quite variable and, considering the group as a whole, is rated as slightly fast (mean scale value of 1.34) rather than on the slow side. Imprecise consonants is prominent, apparently being the result of reduced excursion of the articulators rather than simply the rate of articulation. Both harsh voice and breathy voice are heard.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Dimension</th>
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<tbody>
<tr>
<td>1</td>
<td>Monopitch</td>
</tr>
<tr>
<td>2</td>
<td>Reduced stress</td>
</tr>
<tr>
<td>3</td>
<td>Monoloudness</td>
</tr>
<tr>
<td>4</td>
<td>Imprecise consonants</td>
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<tr>
<td>5</td>
<td>Inappropriate silences</td>
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<tr>
<td>6</td>
<td>Short rushes</td>
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<tr>
<td>7</td>
<td>Harsh voice</td>
</tr>
<tr>
<td>8</td>
<td>Breathy voice (continuous)</td>
</tr>
<tr>
<td>9</td>
<td>Low pitch</td>
</tr>
<tr>
<td>10</td>
<td>Variable rate</td>
</tr>
</tbody>
</table>

Differential diagnostic patterns of dysarthria.
J Speech Hear Res 12: 246-269
Speech in Parkinson’s disease

Speech production requires smooth coordination of orofacial, laryngeal, and respiratory muscles → lower-level motor disorder (articulatory processes)

- **Laryngeal deficits (Dysphonia)**
  - Pitch, loudness, timbre
- **Supra-segmental deficits (Dysprosody)**
  - Monopitch & - loudness, rhythm, speech rate
- **Supra-laryngeal deficits (Arthric)**
  - Imprecise consonants, vowel space reduction
a diminished “energization” underlies voice symptoms
striato-prefrontal hypo-connectivity during cognitive preparation for action may eventually result in motor initiation deficits but is compensated in early PD by subcortical plasticity

a reduced monitoring of external auditory feedback
together with the diminished drive to act results in hypophonia
this could also induce dysarthria on the basis of...

a fading speech motor representations
once the prefrontal cortices are neuropathologically involved in the progressive disease, the therapeutic effects may vanish and speech intelligibility may deteriorate to incomprehensible levels due to fading speech motor representations or insufficient executive control
Voice/articulation deficits lead to alteration of intelligibility and daily communication abilities.

How does this depend on the language one speaks?

Does the cultural background also influence communication deficits?
FralusoPark project

Large-scale evaluation of speech production and psychosocial aspects in PD dysarthria

Considering disease duration and effects of medication

In two languages: French and Portuguese
### French
- Syllable-timed
- Stress occurs systematically on the last syllable
- Stress is linked to prosodic boundaries

### Portuguese
- Stress-timed
- Stress is flexible
- Stress contributes to meaning
- Vowel reduction
Experimental setup

Speech production tasks:

- sustained vowel /a/
- maximal phonation time
- diadochokinesis task
- reading aloud words, sentences, paragraph
- semi-spontaneous and spontaneous speech

- Assessment of speech organs, motor and cognitive functions
- Auto-questionnaires to assess psychosocial impact
FralusoPark project

Outcome variables:
- Acoustic measures
- Prosodic markers
- Intelligibility
- Psychosocial impact and quality of life

→ Medication (on/off)
→ Disease duration
FralusoPark project

Outcome variables:
- Acoustic measures
- Prosodic markers
- Intelligibility
- Psychosocial impact

Similar across languages
FralusoPark project

Outcome variables:
- Acoustic measures
- Prosodic markers
- Intelligibility
- Psychosocial impact

Similar across languages

Different across languages
Acquisition phase

Number of participants

- < 4 years
  - Female: 2
  - Male: 1

- 4 to 10 years
  - Female: 8
  - Male: 12

- > 10 years
  - Female: 4
  - Male: 5

- Control
  - Female: 33
  - Male: 26

Mean age

- < 4 years
  - Female: 73
  - Male: 68

- 4 to 10 years
  - Female: 72
  - Male: 65

- > 10 years
  - Female: 72
  - Male: 65

- Control
  - Female: 73
  - Male: 68
FralusoPark network
FralusoPark project

**French**
- Syllable-timed
- Stress occurs systematically on the last syllable
- Stress is linked to prosodic boundaries

**Portuguese**
- Stress-timed
- Stress is flexible
- Stress contributes to meaning
- Vowel reduction

**Cantonese**
- Syllable-timed
- Simpler syllable structure
- Tones contribute to meaning
Vivian Lee Hiu Yee
The relationship between diadochokinetic rate and the voice handicap index in Cantonese patients with Parkinson’s disease

Karen Yiu Ka-lam
Cross-linguistic comparison of acoustic performance measures in Cantonese and French Parkinson's patients
HK project

Translation of Materials and psychosocial questionnaires

Cross-linguistic differences between French and Cantonese
HK project

Participant recruitment:
→ 6 patients ($M = 67\text{ y}$) and 6 controls ($M = 63\text{ y}$)

1: < 4 years of disease duration
2: 4-10 years of disease duration
3: > 10 years of disease duration
Preliminary results: Mean f0

<table>
<thead>
<tr>
<th>Group</th>
<th>M</th>
<th>F</th>
<th>M</th>
<th>F</th>
<th>M</th>
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<tbody>
<tr>
<td>CONTROL</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>PATIENT OFF</td>
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<tr>
<td>PATIENT ON</td>
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</table>
Preliminary results: Mean f0

Language effect: HK > FR
Preliminary results:

**Maximum Phonation Time**

<table>
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<tr>
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<th>Time (sec)</th>
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<tr>
<td>FR</td>
<td>15.30</td>
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<td>14.33</td>
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<tr>
<td>FR</td>
<td>11.77</td>
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<tr>
<td>HK</td>
<td>13.29</td>
</tr>
<tr>
<td>FR</td>
<td>13.02</td>
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</tbody>
</table>

**Legend:**
- **HK**
- **FR**
Preliminary results: diadochokinetic rate
Preliminary results: diadochokinetic rate & VHI

VHI index correlates with art.rate in OFF state
Thank you for your attention