Got the Jitters?
Voice as symptom and treatment measure in Parkinson's Disease

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Outline

• Parkinson's overview
  – etiology
  – progression
• Speech analysis discussion
  – terms
• Voice and speech changes in PD
  – characteristic changes
  – neurochemical pathways involved
• Treatment efficacy of PD as measured by voice and speech changes
  – voice therapy
  – levodopa
  – deep brain stimulation
• Progress towards earlier diagnosis through speech assessment
Parkinson’s Disease (PD)

- chronic progressive neurodegenerative disorder
- characterized by the idiopathic loss of dopaminergic neurons
  - substantia nigra
- associated with dopamine deficiency and derangements in other neuromediator systems
- accounts for a variety of motor and non-motor deficits
Fun Facts About PD

• Described in 1817 by James Parkinson
• Levodopa introduced 45 years ago
  – Still most effective treatment
• Affects 1 million people in North America
• Risk factors
  (1) Age
  (2) Genetics
PD and Age

- Risk factors
  1. Age
  2. Genetics

- With aging population, prevalence will rise
- Usually affects people over 50
  - 1.6% of people over 65 are affected
  - 10% over 80
Pocket Guide to Decoding the Parkinsonian Face...

Joyful  Pensive  Afraid  Bored

Bemused  Overmedicated  Ecstatic  Undermedicated

Irritated  Tickled  Piqued

...and why you should care...

Gleeful

DUNLAP_SOUTH2001
Characteristic Symptoms

• Motor
  – resting tremor
  – bradykinesia
  – muscular rigidity
  – postural instability

• Non-motor
  – disorders of mood, behavior, and cognition
  – distinctive alteration of speech characterized as hypokinetic dysarthria
Etiology

• Characterized by progressive death of neuron populations
  – Dopaminergic neurons: Pars compacta of the substantia nigra
  – cholinergic nucleus basalis of Meynert (learning)
  – hypothalamic neurons
  – small cortical neurons
  – olfactory bulb
  – sympathetic ganglia
  – parasympathetic neurons in the gut
Progression of PD

- Slow and chronic
- Can take decades
- Clinical diagnosis
- Currently monitored by the Unified PD Rating Scale
- Sections include
  - Mentation/Behavior/Mood
  - Activities of Daily Living
  - Motor Exam
  - Complications of Therapy
  - Modified Hoehn and Yahr Staging
    - severity of motor symptoms
  - Schwab and England Activities of Daily Living Scale
Unified Parkinson’s Disease Rating Scale (UPDRS)
comprises three components and 44 sections in total, each section spans the range 0–4.

**Component 1: Mentation, Behaviour and Mood**
Four sections (1–4)
- Includes mentation, thought disorder, depression, and motivation/initiative.

**Component 2: Activities of Daily Living**
13 sections (5–17)
- Ability to complete daily tasks unassisted, e.g., dressing, walking, writing.

**Component 3: Motor (Motor-UPDRS)**
27 sections (18–44)
- Muscle problems e.g., tremor, rigidity, posture, stability, bradykinesia.

- **Section 5:** Speech—the clinician assesses whether the subject’s vocal output is *understandable* during casual discussion.
- **Section 18:** Speech—the clinician assesses whether the subject’s vocal output is *expressive* during casual discussion.
Voice Analysis

• Phonation
  • the vibration of the vocal cords to create sound
    – Fundamental Frequency
      • 1/pitch period
    – Jitter
    – Shimmer
  – Voice onset time
Voice Analysis

- Resonance
- Articulation
  - DDK task
- Prosody
- Dysarthria
  - hypokinetic
Characteristic PD changes of voice and speech

- Parkinsonian dysarthria
- Patients tend to speak in a soft, breathy monotone
- Reduction of fundamental frequency variability leads to “monopitch” intonation
- Feedback mechanism is interrupted and patients feel they are speaking normal volume
- [Link to video, “before” portion] http://www.youtube.com/watch?feature=player_detailpage&v=gNIdxYjGVV8
Parkinsonian Dysarthria

• Affects about 90% of PD patients
• Brain changes in hypokinetic dysarthria do not parallel those of limb movements
• Theory: pathophysiology of PD dysarthria, while related, is different from that of limb dysfunction
Parkinsonian Dysarthria

• Primary: phonatory impairment
  – Can manifest as hoarseness, hypophony, or tremulousness
  – Linked to incomplete closure of vocal folds causing turbulent air flow
  – Measured by jitter, shimmer and their mathematical variants

• Secondary: articulatory impairment
  – Speech rate accelerates initially, then slows with disease progression
Parkinsonian Dysarthria

• Coordination is also impaired between auditory perception
  – Feedback mechanism is uncoordinated
  – impaired motor planning as well as defective ongoing monitoring

• Basal ganglia competence may be challenged in different ways with different results in speech parameters
  – spontaneous speech vs. repeated speech
Neurochemical pathways

- Functional MRIs performed on patients during a reading task
- In mild PD patients compared to controls, there were increased connections between periaqueductal gray matter and other parts of the right brain
  - Right putamen and right supramarginal gyrus connections correlated with pitch control
  - Right posterior superior temporal gyrus and right inferior parietal lobule connections correlated with loudness
- These increased connections may reflect compensatory mechanisms or effects of levodopa
Neurochemical pathways

• Study comparing speech patterns and gait in controls, PD patients on and off treatment
• Found that controls and PD patients that walk faster are also able to talk faster
• Suggests that there are similar control mechanisms, but notes that speech declines earlier than gait
Treatment of Parkinsonian Dysarthria

• Acoustical voice analyses and measurements might provide useful biomarkers for:
  – diagnosis of PD in the early stage of the disease
  – possible remote monitoring of patients
  – providing important feedback in voice treatment
Treatment of Parkinsonian Dysarthria

- Several different treatments have been studied
  - Voice Therapy
  - Levodopa
  - Deep Brain Stimulation
Lee Silverman Voice Therapy

• Creates increased amplitude of motor output during speech production by training increased vocal effort and loudness
• Also trains individuals to monitor their own vocal output
• Has been shown to create statistically significant and long-term therapeutic effects on speech disorders
• Preliminary data also note initial improvements in swallowing and facial expression
• Computer based therapy is being developed
• [Remainder of video clip]
LEVODOPA

TO TREAT MY PARKISON'S DISEASE
Levodopa

• As discussed earlier, recent research has elucidated that a portion of speech production is dependent on non-dopaminergic pathways.
• Research has been equivocal regarding improvement with levodopa treatment.
• Improvements are noted with respiratory function, prosodic pitch and loudness, and intelligibility.
• Internal cueing and feedback mechanisms are not affected, however.
Deep brain stimulation of the subthalamic nucleus (DBS-STN) has been shown to yield dramatic improvement in global motor functions of the limbs and to reduce tremor, but its effects on speech are varied and inconclusive, similar to levodopa.
DBS

- One study found the effects on respiratory and laryngeal control were not uniform across participants and did not correlate with changes in limb-related function.
- High-frequency DBS often resulted in respiratory over-drive and excessive vocal fold closure.
- Less beneficial for speech-related respiratory and laryngeal control than for limb control.
- Low-frequency stimulation may benefit speech more than high-frequency stimulation.
DBS/Levodopa

- There is growing evidence that the course of PD results from neuropathology that progresses by encroaching on a series of brain structures rather than simply increased destruction in a restricted neuroanatomical region.
Earlier Diagnosis and Treatment

- Studies report that approximately 70%–90% of patients with PD show some form of vocal impairment.
- This deficiency may also be one of the earliest indicators of the disease, in addition to one of the most difficult aspects.
- For most elderly people with Parkinson’s disease, frequent physical visits to the clinic for diagnosis, monitoring, and treatment are difficult.
- Another problem is recruiting patients into clinical PD trials when assessment scales such as the UPRDS must be administered clinically in person and usually take at least 15 minutes to perform.
- A test that could be administered quickly and remotely would likely increase clinical trial participation and could improve disease management.
Show TED talk:
http://www.ted.com/talks/max_little_a_test_for_parkinson_s_with_a_phone_call.html
I think you should be more specific here in step two.
Speech Assessment

• The analysis he is referring to is from a repeated phrase task
• They apply signal processing algorithms to voice samples as opposed to simple measurements like jitter and shimmer
• They can replicate clinicians’ UPDRS estimates with accuracy that is considerably greater than the inherent subjective inter-rater variability
• This could consequently lead to the adoption of voice analysis in larger clinical trials
Conclusions

- PD is debilitating and increasing in frequency
- The etiology of parkinsonian dysprosody is not purely dopaminergic, and therefore traditional treatments for motor defects do not address speech problems
- Voice therapy can be helpful and persistent, especially for mild to moderate cases of PD
- Speech assessment appears to be a powerful tool for diagnosis and treatment, but further development is required before it will be widely available
References


12. Meysam Asgari and Izhab Shafran “Predicting Severity of Parkinson’s Disease from Speech” 32nd Annual International Conference of the IEEE EMBS, Buenos Aires, Argentina, August 31 - September 4, 2010


