Speech and Voice Impairments in Individuals with PD

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Parkinson’s Disease

• Progressive disorder which affects about 1 million people in the U.S.
  – About 60,000 new cases are diagnosed per year
• One of the most common neurodegenerative diseases
• Has far reaching effects on the brain, resulting in motor, speech, language, and cognitive impairments
Causes of Parkinson’s Disease

Aggregation of α-synuclein and mitochondrial damage are potential causes of neuronal death in PD, including dopamine producing cells.

Images taken from: niehs.nih.gov; larasfriends.com
Causes of Parkinson’s Disease

Images taken from: Braak et al. (2004); Obeso et al. (2010)
Adapted from the Parkinson’s Associated Risk Syndrome (PARS) Study
Stern MB, Siderowf A., 2010; Stephenson, R., 2008, Slide courtesy of Cynthia Fox

Pre-Physiological

Genetic mutations high risk for PD; no motor or non-motor features of PD

Pre-Clinical

Abnormalities on imaging markers (SPECT); imaging abnormalities precede neural symptoms

Pre-Motor

Non-motor features: olfactory loss, depression, cardiac, visual, gastrointestinal function, REM disorder

Pre-Diagnostic

Subtle neurological features: small, slow movements, soft, monotone voice, tremor

PD

PD progression
Common Speech Impairments

• Alterations to muscle tone and control affect the muscles which underlie speech
  – 89% will develop voice problems
  – 45% will develop articulation problems

• Perceptual features:
  – Reduced loudness (hypophonia)
  – Breathiness
  – Monotone (reduced pitch and loudness variation)
  – Disordered rate and short rushes of speech
Examples of Speech Impairments

• Mild female: hoarse voice quality, monotone
• Mild male: breathy voice quality, some disfluencies, slightly fast rate
• Severe female: hoarse voice quality, fast rate, hypophonia, monotone, slurred articulation
  – Talking about making a turkey
• Severe male: breathy voice quality, fast rate, hypophonia, monotone, slurred articulation
  – Talking about rehab hospitals he has been in and therapy he has received
Does this speech problem matter?

“if I have no voice, I have no life”  - Natalie

“No one listens to me anymore”  - Shirley

“... my struggle with my voice has been the most challenging, caused me more heartache and frustrations.”

- Mike

“People talk over me as if I am not talking”  - Mary
Hypophonia

- Sound pressure level (SPL) is the physical correlate of loudness
- Some individuals with PD have a lower SPL
- Impact: Communication partners are hearing impaired, exponentially increasing the effect on communication

Darling and Huber (2011)
Monotone Voice

- Fundamental frequency (F0): physical correlate of pitch
- Reduced F0 range and variability
- Reduced marking of stressed words or focus of sentences

Holmes, Oates, Phyland, and Hughes (2000)

F0 Variability

- Controls
- Early PD
- Late PD

n=30 in each group
Monotone Voice

- Reduced distinction between questions and statements
- Reduced marking of final and non-final clause boundaries
- **Impact:** Reduces listeners ability to parse incoming speech signal

![Bar chart showing percent of falling contours with error bars for Controls and PD groups, with n=16 in each group.](image)

MacPherson, Huber, and Snow (2011)
Changes to Speech Rate with Disease Progression

- Shorter utterances
- Faster speech rate
- **Impact:** Harder for listeners to distinguish sounds and words, less time to comprehend incoming speech

Data from Huber and Darling (in prep)

n=8 in each group
PD: Self-Perception

- May not perceive their speech and voice problems as severely as their communication partners
- Individuals with PD have difficulty accurately perceiving their own loudness
- Do not perceive speech errors as accurately as control subjects
- **Impact:** Therapy is difficult because we need to teach them that their speech is impaired
Cueing

• External cues: visual or auditory feedback to perform a task
• Internal cues: unconscious information or self-cueing guides task performance

• Improvements in gait patterns have been shown in response to both external and internal cues
  – Internal cues did not generalize as well as external ones
• Similar findings for handwriting and speech as in gait
Cueing

• Some cues work better than other cues for achieving a specific goal
• Most speech therapy for people with PD aims to improve loudness or rate
• **Impact:** The cues used in therapy will affect the outcome

Sadagopan and Huber (2007)
Example Effect of SpeechVive™

• SpeechVive™ is a voice-activated device which uses a natural external cue, noise (Lombard effect), to elicit and louder, clearer speech.

• Patient with Parkinson’s disease
  – Comfortable and then with the SpeechVive™
  – Is currently on medication for PD and uses a deep-brain stimulator.
Causes of Speech Impairments

• Do not know the underlying cause or neurophysiology for changes to speech

• Do not know which patients are more likely to develop speech impairments
Causes of Speech Impairments

• Speech impairments are not remediated by the treatments which improve limb motor symptoms
  – L-dopa therapy does not improve speech
  – DBS often causes a worsening of speech and cognition symptoms

• The causes of speech impairments are likely to be distinct from those of limb motor symptoms
  – The effectiveness of behavioral therapies for speech improvements informs us regarding underlying causes
  – Need animal models to begin to elucidate the causes of speech changes and to determine which patients are at greatest risk
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