Examining Speakers with Parkinson Disease Under Dual-Task Conditions: Clinical Implications

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Overview

Parkinson Disease
- Neurological Pathology of Parkinson disease (PD)
- Basal Ganglia Function
- Voice and Speech Deficits in Speakers with PD

Dual-Task Performance in PD
- The Dual-task Paradigm
- Effect of Dual-Task Performance on Voice & Speech Deficits

Clinical Considerations
- Assessment Considerations
- Treatment Considerations
Parkinson Disease

Progressive Neurological Disease
- Idiopathic – no known cause

“Disease of Aging”
- Onset after age 40 in 90% of patients
- Average age of onset is between 60 and 65

Affects 1 to 2 per 1000 people at any time

Prevalence increases with advancing age
- Affects ~1% of adults older than 60

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Parkinson Disease

Cardinal Symptoms

Tremor
- Low frequency shaking of extremities
- “Pill rolling” tremor

Rigidity
- Stiffness; resistance to passive movement

Bradykinesia
- Slowness of Movement

Postural Instability
Parkinson Disease

Motor Symptoms

Hypokinesia
- Reduced frequency and range of movement

Akinesia
- Difficulty initiating movement (Freezing of Gait, Stuttering-like Disfluencies)

Gait Abnormalities

Basal Ganglia

The Basal Ganglia are a group of largely inhibitory subcortical nuclei that create a series of re-entrant loops with the cortex

Basal Ganglia Function

Action Selection – Release of desired programs from inhibition

Action Suppression – Suppression of competing programs
Parkinson Disease

**Basal Ganglia Function**

Sensorimotor Region of the Basal Ganglia – Automatic Mode of Control
- Involved with selection of overlearned / habituated motor patterns
- Automatic Components of Movement
  - Range of motion, Velocity of Movement
  - Dopamine facilitates movement selection
  - A resting tonic level of dopamine must be present in the sensorimotor region for normal motor control
  - Loss of these resting levels results in parkinsonian motor symptoms

Parkinson Disease

**Basal Ganglia Function**

Associative Region of the Basal Ganglia – Goal-Directed Mode of Control
- Involved with selection of goal-directed action / decision making
- Interacts with premotor and pre-frontal regions of the cortex associated with cognitive control.

The various basal ganglia loops work in parallel to allow for adaptive completion of activities of daily living (including speech communication).
Parkinson Disease

Pathophysiology

Degeneration of dopamine-producing cells in the Substantia Nigra pars compacta
- Typically 70-90% of these neurons have degenerated by the time of diagnosis

These cells release dopamine in the sensorimotor striatum

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Parkinson Disease

Basal Ganglia Pathophysiology

Loss of dopaminergic input to the Sensorimotor Region of the Basal Ganglia
- Impairments in habitual / automatic mode of behavioral control

The Associative Region of the Basal Ganglia is less affected in PD
- Therefore, individuals with PD are somewhat driven in to a “goal-directed” mode of behavioral control that requires more attentional resources to successfully carryout activities of daily living.
Parkinson Disease

The motor deficits associated with PD extend to the speech motor system

Hypokinetic Dysarthria

- A cluster of speech motor impairments associated with hypokinesia that affects respiration, phonation, articulation, prosody, and fluency.

Logemann et al. (1978) found that out of 200 speakers with PD:

- 89% presented with voice impairments
- 45% presented with articulation impairments
- 20% presented with fluency impairments

Ho et al. (1999) observes a similar trend

- Fluency and articulatory impairment worsened with advancing disease state
Parkinson Disease

Phonatory Deficits associated with PD

Speakers with PD exhibit hypophonia
  • Reduced vocal loudness
  • However, speakers with PD
    can increase speech intensity
    when cued to speak louder or more clearly
Parkinson Disease

Articulatory Deficits associated with PD

Speakers with PD exhibit hypokinesia in the articulatory system
- Reduction in vowel space area
- However, speakers with PD can increase vowel space when cued to speak more clearly
Parkinson Disease

Articulatory Deficits associated with PD

Speakers with PD exhibit hypokinesia in the articulatory system
  ◦ Faster-than-normal speech rate
  ◦ However, speakers with PD can decrease speech rate when cued to speak more clearly

Parkinson Disease

Fluency Deficits associated with PD

Approximately 40 to 50% of speakers with PD exhibit stuttering-like disfluencies that are greater than 3 percent syllables stuttered (Goberman et al., 2010; Whitfield et al., 2017)
  ◦ Cuing speakers to speak more clearly has been shown to reduce the frequency of stuttering in a reading task (Goberman et al., 2010)
Parkinson Disease

Speakers with PD exhibit motor deficits that affect all aspects of speech production.

However, when cued to speak more clearly, speakers with PD exhibit improvements across all speech systems.

- Clear speech cues direct the speakers to attend more closely to speech production, which likely results in a shift from a habitual mode of behavioral control to a more goal-directed mode of control.
- This more effortful, attention-demanding speech style helps speakers with PD bypass the dysfunctional sensorimotor basal ganglia, leading to improvements in speech production.

Claim 1: Speech production is primarily under automatic, rather than goal-directed control.

Claim 2: To some extent, speakers with PD must operate under a more goal-directed mode of control for successful speech communication.

Claim 3: Goal-directed behavior requires attentional resources, which are limited.

Hypothesis: If basic aspects of speech production in PD require attentional resources, speakers with PD will exhibit greater speech impairment when performing a concurrent secondary task while speaking.
Dual-Task Paradigm

Successful performance of two concurrent tasks should relate to the attentional demands of each task.

Divided Attention Example:

Task 1: Driving a Car
- Version 1: Driving to your home of 10 years in rural Ohio
- Version 2: Driving to your new apartment in London

Task 2: Talking on the Phone
- Version 1: Telling a story about what happened at work
- Version 2: Conducting a phone interview for a new hire

Dual-Task Performance in PD

Walking and Talking
- Attention demanding secondary motor tasks affect gait in individuals with PD (e.g., Bond & Morris, 2000)

- Cognitive-linguistic load affects gait in speakers with PD (LaPonte et al., 2010).
Dual-Task Performance in PD

Talking and Postural Stability

- Cognitive-linguistic load affects postural stability in speakers with PD (Holmes et al., 2010).

- Individuals with PD exhibit poorer speech production and postural stability during concurrent performance of speech and postural tasks compared to performing the tasks in isolation (Dromey et al., 2010).

Dual-Task Performance in PD

Talking and Simple Manual Tasks

- Bunton & Keintz (2008) examined the effect of performing a concurrent manual task (turning a nut on a bolt) on speech production in four individuals with PD.

- Our group has expanded this work to test the robustness of the prior findings and to examine the effect of the speech task on dual-task interference.
Dual-Task Performance in PD

Study 1: Effect of speech task on dual-task interference in individuals with PD

- Speech tasks: Reading standard passages (Read) and giving extemporaneous narratives (Nar) aloud.
- Both tasks were performed under single-task (ST; speech only) and dual-task (DT) conditions.
- The secondary task involved drawing continuous counterclockwise circles on a digitizer tablet.
- The study included 13 speakers with PD and 11 healthy controls (OA group).

Dual-Task Performance in PD

Study 1: Bidirectional dual-task interference was observed when speakers with PD perform a extemporaneous speech task that requires generative language, but not during the reading tasks.

- Bidirectional interference indicates that concurrent task performance affected both primary task (speech task) and the secondary task (manual task).
Dual-Task Performance in PD

Study 2: Effect of secondary task demands on dual-task interference

20 college-aged students completed a syllable repetition task (repeating “pa” and repeating “pa-ta-ka”)

- The task was performed in isolation (ST)
- The task was performed while drawing continuous circles (DT-MM; Manual Motor Task)
  - Low Demand
- The task was performed while performing a visuomotor tracking task (DT-VM; Visuomotor Task)
  - Higher Demand

Variability of syllable repetition was examined by measuring the percent variation in the vowel and inter-vowel intervals during each condition

- An increase in variability from the single- to dual-task condition would suggest a dual-task effect
Dual-Task Performance in PD

Our data suggest that...

Study 1: The cognitive-linguistic demands of the speaking task may contribute to the degree of dual-task interference.

Study 2: The attention demands of the secondary task may contribute to the degree of dual-task interference.

Clinical Implications

Speakers with PD exhibit speech deficits associated with a habitual or automatic mode of control

- Speakers can make improvements to speech production when attentional focus is directed toward the speech task

Speakers with PD may exhibit worsening speech deficits when performing a speech task with a secondary task

- Poorer performance indicates that single-task speech production requires attentional resources
Clinical Implications

Assessment Considerations

- If a person with Parkinson disease exhibits only mild deficits in a motor speech exam, consider supplementing the assessment with a more attention demanding context.
- Assessing speech production under dual-task conditions
- Assessing speech production using a task with cognitive linguistic demands

Clinical Implications

Treatment Considerations

- Consider the ecological validity of the conditions in the target behaviors are trained
- Consider adding distractions or cognitive-linguistic demands to the task
- Consider dual-task training
Thank you very much!

Questions?

References


References


References


