Motor Learning in Individuals with Parkinson Disease: Implications for Rehabilitation

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Overview

Parkinson disease
- Description of Parkinson disease (PD)
- Speech & Voice Deficits in PD
- Neurology of PD
- Role of Dopamine in normal motor learning and control

Motor Skill Learning
- Early Stages of Learning: Acquisition & Retention
- Later Stages of Learning: Automatization

Speech Motor Learning in PD
- Review of our research
- Implications for Rehabilitation
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

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

Pathophysiology

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

These cells release dopamine in the sensorimotor region of the basal ganglia
Parkinson Disease

**Basal Ganglia Physiology**

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

![Cortex Basal Ganglia](image)

The Basal Ganglia are involved with the regulation of action

- **Sensorimotor Region**: Motor Control
- **Associative Region**: Goal-directed Action / Choice
- **Limbic Region**: Motivation and Hedonic Reward

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Parkinson Disease

**Basal Ganglia Physiology**

Sensorimotor Region of the Basal Ganglia

- Action Selection – Release of desired motor programs from inhibition
- Action Suppression – Suppression of competing motor programs
- Dopamine facilitates movement
  - Enhances action selection and inhibits action suppression
- For normal motor control there must be a resting tonic level of dopamine
  - Loss of these resting levels results in parkinsonian motor symptoms
Parkinson Disease

**Basal Ganglia Pathophysiology**

Loss of Dopamine input to the sensorimotor region of the Basal Ganglia

- Impaired Action Selection
- Increased Action Suppression

Tonic levels of dopamine are needed in the sensorimotor basal ganglia for normal movement

- Loss of Dopamine leads to parkinsonian symptoms (hypokinetic movement disorder)

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Parkinson Disease

**Role of Dopamine in Behavior**

As new behaviors are overlearned or habituated, neural activity moves from the more associated / limbic regions to the sensorimotor regions

- Associated regions – goal-directed behavior
- Sensorimotor regions – habit / overlearned motor response

Dopamine signaling (the teaching signal) facilitates consolidation of this transition

- PD affects habitual motor behavior
- PD affects the later stages of motor learning
Parkinson Disease

Summary

Basal Ganglia Pathophysiology associated with PD
  - Impairments in action selection
  - Impairments in motor learning and implicit learning

The Associative and Limbic Regions of the Basal Ganglia are less affected in PD

Motor Skill Learning

Motor Sequence Learning (Doyon et al., 2009)

Stages of motor learning
  - Acquisition Stage – fast and large gains in accuracy and speed of skill performance (Cognitive Stage)
  - Autonomous Stage – skill performance becomes automatic / requires little attention
    - Assessed using a dual-task paradigm

Other Terms
  - Retention – preservation or gains in performance following a no-practice interval
  - Consolidation – stabilization of a newly acquired skill into a permanent memory trace
    - May or may not be sleep dependent
Motor Skill Learning

Motor Sequence Learning (Doyon et al., 2009)

Stages of motor learning
- Acquisition Stage
- Autonomous Stage

Other Terms
- Retention
- Consolidation

Speech Motor Learning in PD

Speech Motor Sequence Learning

Our group has examined the effect of PD and normal aging on early stages of speech motor sequence
- Acquisition and Retention (Whitfield & Goberman, 2017a)
- Automatization (Whitfield & Goberman, 2017b)
Speech Motor Learning in PD

Method

45 speakers: 15 with PD; 15 older adult controls (OA); 15 younger adult controls (YA)

6-element nonword sequence
- “toop gite bap pawp koys deek”
- Familiarization:
  - Participants were asked to repeat each nonword element given an auditory and visual model
  - Errored production were corrected

Main Task: 30-second training blocks each followed by 30-second rest periods
- “...repeat the sequence as rapidly as possible while still being accurate.”

Speech Motor Learning in PD

Method

Day 1
- Participants completed 12 30-second blocks

Day 2
- The participants complete 3 addition blocks to re-test the sequence 24 hours later
Speech Motor Learning in PD

**Acquisition and Retention** (Whitfield & Goberman, 2017b)

All groups exhibited a similar pattern of acquisition

Retention patterns differentiated groups

- Younger adults exhibited offline gains in speed and accuracy
- Older adults retained savings in speed and accuracy made on day one
- Speakers with PD exhibited offline losses in speed at the retention interval
  - Consolidation and retention of new learning may be compromised
  - Likely relates to dysfunction of the sensorimotor basal ganglia

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Speech Motor Learning in PD

**Method: Automatization**

Day 2 – sequence was retested under single- and dual-task conditions

- 3 Single-task Blocks (1 to 3)
- 3 Dual-task Blocks (4 to 6)
- 3 Single-task Blocks (7 to 9)

Secondary Task was a visuomotor pursuit rotor task
Speech Motor Learning in PD

**Automatization** (Whitfield & Goberman, 2017b)

Individuals with PD exhibited dual-task interference when performing a recently learned speech task with a concurrent visuomotor task

- Speakers with PD performed the recently learned speech task slower and with a lower degree of accuracy than in the single-task condition
- For the secondary task, participants were on target less of the time in the dual-compared to the single-task condition.
- There were clear patterns that suggest individual differences in performance strategy for individuals in the PD Group
  - Speed-Accuracy Trade offs

Implications for Rehabilitation

Basal ganglia dysfunction associated with PD leads to deficits in both motor control and motor learning.

These deficits extent to the speech production and speech motor learning systems.

Deficits in motor learning are primarily associated with impairments in the later stages of motor learning when skill performance moves to a more automatic mode of control.
Implications for Rehabilitation

Though clients with PD may exhibit improvements within a session, they may not fully retain these gains from session to session.

Successful performance of newly learned tasks often requires more attentional resources for an individual with PD than other clients.
- Clients with Parkinson disease may exhibit breakdowns when the newly learned behavior is used in attention demanding contexts
- Help clients develop self-cueing strategy to maintain clear loud speech

Implications for Rehabilitation

Principles of motor learning may promote longer-term retention of rehabilitation targets.
- Use a high intensity, variable practice schedule (e.g., LSVT)
- Providing delayed, summary feedback after several trials
  - High frequency feedback (i.e., feedback after every trial) may hurt retention
- Increase complexity of the target behavior
  - Consider training targets under attention demanding conditions (i.e., dual-task training)
Thank you very much!

Questions?

References


References


References


