Cueing to Maximize Movement and Outcomes in Individuals with Parkinson’s Disease

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Objectives

• Identify common movement deficits related to Parkinson’s disease
• Understand goals and administration of auditory, visual, tactile, and combination cueing for Parkinson’s disease
• Identify advantages and disadvantages for use of auditory, visual, and tactile cueing to improve movement
Motor Characteristics of Idiopathic Parkinson’s Disease (IPD)

- Resting Tremor
- Rigidity
- Postural instability
- Bradykinesia
- Hypokinesia
Motor Characteristics of PD

- Hypokinesia
  - Reduced amplitude of movement
    - Seen with hypophonic speech and micrographia
    - Decreased stride length and arm swing
    - Decrease in amplitude duration with repetitive movements of limbs

- Bradykinesia
  - Slowness of movement

Koop, Hill, and Bronte-Steward 2013
Mechanism of Motor Dysfunction in IPD

• Loss of Dopamine producing cells in the substantia nigra of the basal ganglia (BG) which leads to neural degeneration
  → Problem is that the BG plays important role in self-generated and well-learned tasks

• PD is a progressive, neurodegenerative disease
Movement Dysfunction Cycle of PD

1. **Reduced amplitude of motor output**
2. **Self-cueing deficits**
   - Continue scaling reduced amplitude of movement patterns
3. **Problem in self perception/awareness**
   - Do not recognize movements are small or slow
4. **Produce slow, small movements**
   - Continue scaling reduced amplitude of movement patterns

Diagram showing the cycle: Reduced amplitude of motor output leads to self-cueing deficits, which in turn affects self-perception/awareness, leading to the production of slow, small movements, which then continue the cycle.
What else interferes with Movement?

• Sensory deficits
  – Sensory proprioceptive processing issues
  – Perceived sensory-motor mismatch
    • Indicates why difficulty with self monitoring or self correcting movement
• Cognitive functioning and attentional deficits
  – Difficulty changing strategies and adapting to changing environments
  – Poor preparatory set for movement
• Motivational and emotional deficits
• Medication effect
<table>
<thead>
<tr>
<th>Stage</th>
<th>Hoehn and Yahr Scale</th>
<th>Modified Hoehn and Yahr Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unilateral involvement only usually with minimal or no</td>
<td>Unilateral involvement only</td>
</tr>
<tr>
<td></td>
<td>functional disability</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td>Unilateral and axial involvement</td>
</tr>
<tr>
<td>2</td>
<td>Bilateral or midline involvement without impairment of</td>
<td>Bilateral involvement without impairment of</td>
</tr>
<tr>
<td></td>
<td>balance</td>
<td>balance</td>
</tr>
<tr>
<td>2.5</td>
<td></td>
<td>Mild bilateral disease with recovery on pull test</td>
</tr>
<tr>
<td>3</td>
<td>Bilateral disease: mild to moderate disability with</td>
<td>Mild to moderate bilateral disease; some</td>
</tr>
<tr>
<td></td>
<td>impaired postural reflexes; physically independent</td>
<td>postural instability; physically independent</td>
</tr>
<tr>
<td>4</td>
<td>Severely disabling disease; still able to walk or stand</td>
<td>Severe disability; still able to walk or stand</td>
</tr>
<tr>
<td></td>
<td>unassisted</td>
<td>unassisted</td>
</tr>
<tr>
<td>5</td>
<td>Confinement to bed or wheelchair unless aided</td>
<td>Wheelchair bound or bedridden unless aided</td>
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Directed Attention and Cueing

• Often observed that increased attention or effort may improve magnitude of movements in pts with PD
• Hypothesis: Individuals with PD don’t have appropriate internal cues from the BG, thus activation of the premotor cortex might be best facilitated by external means
Attention and Cueing

• External cues act as pace-makers taking the place of additional cognitive control and reduce the amount of attention needed to maintain stable gait
• Cueing allows attention to be directed to other tasks
• Cueing may help focus attention on gait
  – Cues may compete for attentional resources and reduce quality during complex or attention-damaging environments (Peterson 2015)
Types of Cueing

- Visual
- Auditory
- Tactile
- Combination
Visual Cueing
Visual Cueing

• Use of visual cueing has long history back to 1962, with placement of horizontal lines on the floor

• Hypothesis:
  – Horizontally placed lines might function to supply the deficient well-learned motor program with external visual information on appropriate stride length (Rubinstein 2002)
Visual Cueing

• Morris 1994 found that horizontal lines on the floor allowed pts to normalize stride length, velocity and cadence
  – Parallel or zig-zag lines did not change performance

• Carryover effect observed in some studies when visual cues removed showing training effect (Bagely 1991, Morris, 1994)

• Visual cues found beneficial to provide a cue to break freezing
• Maarten et al (2016) examined if weight shifting could be improved with a visual cue in subjects with PD
  — Looked at mediolateral weight shifting without visual feedback (VF), congruent or real time VF, or delayed VF
  — Results: Real time helped patients with PD better coordinate their motion while incongruent feedback task performance worsened
Visual and Attentional Cue

• Morris 1996 showed that gait improvements could also occur with attentional strategy of pts visualizing stride length while walking.
  – Conversely noted benefit is reversed when pt given any additional tasks to do while walking.
Best way to set up visual cuing

• Recommended the intervals be placed at 40% of the patients height
• Horizontal lines
• High contrast
Visual Cueing- Pro’s and Con’s

**Pro’s**
- May be useful to help train and have the patient learn what “normal” feels like
- May help to model size of movement to improve internalization for patients
- Shown to be effective in helping individuals with FoG initiate steps

**Con’s**
- Often times encourages the patient to direct gaze downward versus up and scanning their environment
- Depending on the cue provided it may not always be available
Auditory Cueing
Auditory Cueing

• Achieved by:
  – Musical beats
  – Metronome
  – Clapping
Auditory Cueing

- An added external auditory cue decreased initiation and execution time and improved motor sequence in a UE button pushing task (Georgiou et al 1993, Kritikos et al 1995)

- More forceful, more efficient and more stable movement associated with single auditory cue vs when patient was “ready” (Ma 2004)
Auditory Cueing

• Metronome found to reduce the number of steps and time it takes to complete walking course compared to uncued in patients with PD (Gracies 2007, Enzensberger 1997)

• McIntosh found gait improvements occur regardless of on or off medication
Auditory Cueing

• Metronome cueing
  – Must be slightly faster than baseline walking cadence
  – Rates between 107.5 -115% of baseline walking cadence is indicated (Howe 2003, Suteerawattananon 2004)
  – Metronome set at baseline cadence slowed ambulation and increased walking time (Cubo 2004)
  – Less successful when patient self-generates a faster speed (Dibble 2004)
Auditory Cueing

- Auditory Cue with Attention
  - Behrman (1998) found that patients verbally cued to increase arm swing, step length, or walking speed were able to improve; hearing only 1 instruction improved all other domains
  - Addition of secondary cognitive or motor task worsens gait
## Auditory Cueing-Pro’s and Con’s

<table>
<thead>
<tr>
<th>Pro’s</th>
<th>Con’s</th>
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<tbody>
<tr>
<td>• Easily accessible devices (phone, metronome, music etc)</td>
<td>• May impact interaction with environment if wearing headphones</td>
</tr>
<tr>
<td>• Can be used unobtrusively with headphones</td>
<td>• Requires attention to the beat</td>
</tr>
<tr>
<td></td>
<td>• May not be as useful with initiation of stepping</td>
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Tactile Cueing
Tactile Cueing

• Tactile cueing may be processed subconsciously faster than visual inputs
• Van Wegan et al. (2006) looked at use of a wearable vibrating stimuli on the wrist to provide rhythmic somatosensory cuing (RSC) and effects on gait
  – Resulted in lower stride frequency and thus larger steps regardless of walking speed
  – Interference of visual flow did not impair use of RSC
Tactile Cueing

• Tactile cues were provided using smartphone attached to lateral aspect of less affected upper arm using velcro strap (Ivkovic 2016)
  – 100Hz intervals based on comfortable walking speed
  • Patient with PD were able to partially to synchronize performance to TC at longer intervals and less able at shorter intervals
  • In dual task walking condition PD did better with the TC than without the TC
Tactile Cueing-Pro’s and Con’s

**Pro’s**
- Only few studies exist currently
- May be apps that can be used for this cue
- May require less cognitive demand than vision or auditory cues

**Con’s**
- Only few studies exist currently
- May be unobtrusive
- Sensory deficits would impact performance
Combination of Cues
Combination: Visual and Auditory Cues

• Suteerawattanananon et al 2004
  – Auditory cue was metronome beat 25% faster than patients fastest cadence
  – Visual cues were brightly colored lines at intervals equal to 40% of patients height
  – Result: Auditory cue improved cadence, visual cue improved stride length, simultaneous use of visual and auditory did NOT improve gait significantly more than each cue alone
Combination Cueing

• Son et. al 2015 assessed cueing effects on arm swing amplitude and trunk rotation
  – Each subject performed all four conditions in random order
    • Visual cue = bright yellow colored tape on floor equal to 40% of patients height
    • Auditory cue = metronome at 20% faster walking speed
    • Combined and no cue conditions
  – Significant differences in arm swing amplitude but not trunk rotation between groups
    • Significant difference between no cue vs. auditory cue
      – Auditory -> visual -> combined -> no cue
Visual Cueing and Treadmill Training

- Visual cues and treadmill vs. treadmill training (Schlick 2016)
  - Visual cues - projected onto treadmill belt using shapes of each person's shoes
  - Increased by 10% for first training session and continually increased based on progress
- Gait speed and stride length improved in both groups
- Timed Up and Go and motor portion of UPDRS decreased only with addition of visual cues
  - At 2 month follow up both groups had a decline in gains but the TM only group had greater decline than TM with visual cue group
  - Improved those with freezing of gait
Amplitude Specific Training

• Use of modeling, visual, tactile and verbal cues to encourage increased amplitude and size of movements
• Target bradykinesia/hypokinesia and kinesthetic awareness
• Reduces cognitive load for patients allowing for redundant practice of amplitude (Farley et al 2008)
Amplitude Specific Training

• LSVT BIG® and LOUD® are trademarked interventions to work on amplitude training
• Ebersbach 2014 looked at 3 groups: BIG, nordic walking, and HEP
Amplitude Specific Training

• Assessment for a reaching task and gait was completed pre and post the LSVT BIG® program (Farley 2005)
  — Reaching task: Subjects asked to reach at arms length, and + or – 10 cm. Reached at either preferred velocity and a max velocity
    • Wrist velocity increased for all distances but was significantly change at the largest distance
  — Gait task: Subjects asked to walk normal speed and as fast as possible
    • Following BIG®, Gait velocity was increased by increasing stride length, not cadence
Pre and Post training LSVT BIG®
Cognitive Considerations

• Most studies are on patients with mild to moderate deficit (H&Y II-III)
• Cognitive deficits often present in more advanced disease
• Advanced disease also associated with: more pronounced gait deficits, postural decline, freezing of gait, and dual task costs during gait
Cognitive Considerations

• Rochester et al. (2009) looked at individuals with mild to moderate cognitive impairments—Cueing was feasible and effective however study did not report performance of secondary task

• Willems et al. (2006) noted that individuals with freezing of gait only benefitted from cues matching their step frequency—Non-freezers benefited from all cue presentations
Effects of Cueing on Dual Tasks

- Rochester et al. 2010 looked at individuals during a dual task under 4 conditions
  - No cue
  - Auditory cue was beep delivered into earpiece
  - Visual cue was light flashes delivered to a pair of glasses
  - Somatosensory cue was vibrations delivered at wrist
- All cues, especially auditory, immediately enhanced dual task performance prior to training
- After training, single task and dual task walking speed increased due to increased step length
- Greater transfer of training to non-cued dual task trials
Considerations for Cue Selection

• Cognition will be a factor
  – Individuals with greater cognitive deficits may benefit from more proprioceptive cues

• Patient preference
  – Auditory has generally been preferred over other types of cuing

• Ease of utilizing with daily activities, outside of the clinic in order to improve carryover
Take Home Message

• A variety of different types of cuing are available for use in patient care
• There is not one type of cuing that is consistently superior to another however one cue vs. use of combination of cues is more beneficial
• All cues will improve short term function but long term functional change and carryover is challenging
• Cues must be individualized for your patient with respect to patient preference, and settings for the cue
• Cognitive abilities may be a barrier to all cues
• Working to identify a cue that will allow training and transfer to community related activities is key
References


Farley B, Fox Cynthia, Ramig L et al. Intensive amplitude-specific therapeutic approaches for Parkinson’s Disease. Topics in Geriatric Rehabilitation 2008; 24(2) 99-114.

Farley B, Koshland G. Training BIG to move faster: the application of the speed-amplitude relation as a rehabilitation strategy for people with Parkinson’s Disease. Exp Brain Res 2005


References


References


