THE BEAT GOES ON
AUDITORY CUES FOR PEOPLE WITH PARKINSON’S DISEASE

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OBJECTIVES

• Review the pathophysiology and clinical presentation of Parkinson’s disease.
• Describe the theories of auditory cue administration.
• Understand the types of auditory cues and how these cues are delivered.
• Discuss the use of auditory cues in the Parkinson’s disease population.
PARKINSON’S DISEASE

• 2nd leading neurodegenerative disease
• Effects over 2% of the elderly population
• Types
  • Idiopathic
  • Secondary
• Basal ganglia dysfunction
  • Caudate nucleus, putamen, globus pallidus, subthalamic nucleus and substantia nigra
  • Disruption in the neurons that produce dopamine within the substantia nigra
PATHOPHYSIOLOGY

The diagram illustrates the pathophysiology of Parkinson's disease. In the healthy state (A), dopamine stimulates the basal ganglia, leading to controlled muscle activity. In Parkinson's disease (B), there is a lack of dopamine, resulting in increased muscle tension and tremor.
CARDINAL SIGNS

Bradykinesia
Rigidity
Tremor
Postural instability
GAIT

Festinating
Shuffling pattern
Freezing

• Worsens with progression of disease\textsuperscript{1,3}
• Freezing reported to be most disabling\textsuperscript{4}
• All reduce perceived quality of life\textsuperscript{5}

### HOEHN AND YAHRL CLASSIFICATION OF DISABILITY

<table>
<thead>
<tr>
<th>Stage</th>
<th>Physical presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Unilateral involvement</td>
</tr>
<tr>
<td>II</td>
<td>Bilateral symptoms or axial involvement present but not postural instability</td>
</tr>
<tr>
<td>III</td>
<td>Postural instability present but individual remains physically independent</td>
</tr>
<tr>
<td>IV</td>
<td>All symptoms present and severe, individual needs assistance to walk or stand</td>
</tr>
<tr>
<td>V</td>
<td>Individual is wheelchair or bed bound</td>
</tr>
</tbody>
</table>
MEDICAL $^{1,2}$

- **Pharmacological**
- Levodopa | Carbidopa combo = Sinemet
- Mostly targets bradykinesia and rigidity

LIMITATIONS

- End dose deterioration
- “On-off” phenomenon
INTERVENTIONS

THERAPEUTIC

• General exercise\textsuperscript{7-10}
• Virtual reality\textsuperscript{11}
• Tai Chi\textsuperscript{12}
• Aquatic\textsuperscript{13-15}
• Dance\textsuperscript{16-24}
• Lee Silverman Voice Training (LSVT) BIG\textsuperscript{25-27}
• Treadmill training\textsuperscript{28-33}
• External Auditory Cueing

LIMITATIONS

• Therapy access
• Equipment needed
• Community resources
• Hoehn and Yahr stages I - III
AUDITORY INFORMATION

Large part of human life

Adjustment of motor actions & physiological responses\textsuperscript{34,35}

fMRI has shown increased activity in the supplementary motor cortex, mid-premotor cortex and cerebellum even without volitional movement\textsuperscript{36,37}
AUDITORY CUEING$^{38}$
NEUROLOGIC MUSIC THERAPY

Rhythmic Auditory Stimulation
Pattern Sensory Enhancement
MUSIC THERAPY

• Initial leaders in using the auditory sensory system for motor control
  • Michael Thaut, Gerald McIntosh, Robert Rice
• Neurological Music Therapy
  • Incorporates a variety of principles to standardize the clinical techniques used in music therapy
• **Goal of establishing a rhythm**
  • “bodies that can move in stable periodic or rhythmic cycles”
  • Move as separate entities when independent of each other
  • As two different amounts of energy occur together, there will be a period when these two energies are asynchronous and cause a negative energy
  • This negative feedback drives adaptations within each system to reduce the asynchronous environment
ENTRAINMENT

**CLINICAL APPLICATION**

- External stimulus is *fixed* & human system is *plastic*
- Therefore this encourages a change in the human system
RHYTHMIC AUDITORY STIMULATION (RAS)

- **METRONOME**
- Continuous time-based rhythmic beat
- Underlies the sound pattern of all music
- This is the consistent beat that encourages entrainment
RHYTHMIC AUDITORY STIMULATION (RAS)

- **Physiological Theory in Individuals with Parkinson’s disease**
- External cue used to bypass the dysfunctional basal ganglia\(^{35,43,44}\)
  - Using a loop to the cerebellum and thalamus to indirectly activate the premotor cortex
  - Predictable cues promotes temporal expectations to normalize movement
RHYTHMIC AUDITORY STIMULATION (RAS)

• **Physical Presentation**
  • Increase in velocity, step length and cadence during ambulation
  • Immediate effects after a one time trial\(^{45-49}\)
  • Carry over effects after an intervention trial\(^{50-53}\)
  • Increase in muscle activity\(^{35}\)
PATTERN SENSORY ENHANCEMENT

• Use of rhythmic, melodic, harmonic and dynamic-acoustical elements
• Layer onto the rhythmical cue of RAS
• Provides temporal, spatial and force cues for movement
PATTERN SENSORY ENHANCEMENT THEORY\textsuperscript{39}

- Less research on these principles and theories than RAS
- Types of cueing
  - Spatial – pitch, dynamics, sound duration, harmony
  - Temporal – tempo, meter, rhythmic pattern, form
  - Muscular dynamics/force – tempo, dynamics, harmony
- This type of cueing does have the potential to be disruptive if not administered correctly
INTERVENTION TECHNIQUES
ASSESSMENT

• How do we know if our client would benefit from auditory cueing?
• Slow initiation
• Decreased step length
• Decreased velocity
• Cadence issues
• Freezing
ASSESSMENT

• During gait analysis – measure cadence
• Count steps taken in a 15 second period of time X 4
• Results in steps/minute = beats/minute
• Now have a baseline to initiate auditory cueing
INTERVENTION$^{45-47,50,54}$

- Baseline bpm to initiate RAS for those with balance dysfunction
- More common to set tempo 5-10% faster than the preferred walking speed
- 30 minutes of walking per day with cues
- 3-4 week intervention sessions
- Each week increase tempo 5-10%
RAS AS AN INTERVENTION

**PRO**
- Metronomes easy and inexpensive
- Immediate effects
- Facilitates entrainment
- Feasible HEP

**CON**
- Static sound
- Basic in what it impacts
- Must ambulate at a certain level
- Must have decent endurance
- Mostly focused on stepping
PSE AS AN INTERVENTION

PRO

• Musical component could offer more impact on more motor patterns
• Music can impact more than just motor control
• Possibly more enjoyable

CON

• PT are limited in ability to implement independently
• Musical components can have a negative impact just as easily as a positive impact
What is the SOAR strategy?

Single instrument compositional threads
Each instrument meant to impact a particular motion during gait
Developed by music therapists, composer and sound engineer

Purpose
Impact gait in individuals with neurological impairments
Target lower functioning individuals
Wearable and portable technology

SYNCHRONIZED OPTIMIZATION
AUDITORY REHABILITATION (SOAR) STRATEGY
PARTICIPANTS
n = 20

INCLUSION CRITERIA
• Diagnosis of Parkinson’s disease
• Hoehn & Yahr stage I – IV
• Walk independently for ~ 10 minutes

EXCLUSION CRITERIA
• Deep brain stimulator
• Acute orthopedic injury or surgery within 2 months of testing
• Hearing impairment not corrected by a hearing aide
• Complete dependence on an assistive device
• Use of SOAR strategy before in previous pilot study
INDEPENDENT

• Auditory cue

DEPENDENT

• Spatiotemporal parameters of gait
**METHODS**

**DAY 1 – Music therapist**

- Completed an IRB approved informed consent, video consent and demographics
- Given verbal instructions & demonstration for ambulation over Zeno Walkway System
- Gait parameters measured without auditory cueing
- Training and gait parameter measurements with auditory cue | RAS or SOAR
  
  \[\text{Wash out period | one hour}\]

- Training and gait parameter measurements with other auditory cue | SOAR or RAS

**Day 2 – Physical therapist**

- Gait parameters measured without auditory cueing
- Training and gait parameter measurements with SOAR strategy only
<table>
<thead>
<tr>
<th></th>
<th>MT no cue</th>
<th>MT RAS</th>
<th>MT SOAR</th>
<th>PT no cue</th>
<th>PT SOAR</th>
</tr>
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<tbody>
<tr>
<td>Velocity (m/s)</td>
<td>0.89 (0.31)</td>
<td>0.93 (0.32)</td>
<td>0.95 (0.33)</td>
<td>0.94 (0.25)</td>
<td>0.96 (0.28)</td>
</tr>
<tr>
<td>Cadence (step/min)</td>
<td>104.18 (13.27)</td>
<td>106.0 (9.53)</td>
<td>107.49 (11.34)</td>
<td>109.08 (8.79)</td>
<td>106 (8.93)</td>
</tr>
<tr>
<td>L step length (cm)</td>
<td>50.56 (13.02)</td>
<td>52.52 (13.96)</td>
<td>52.92 (13.88)</td>
<td>51.56 (10.92)</td>
<td>54.01 (12.39)</td>
</tr>
<tr>
<td>R step length (cm)</td>
<td>51.50 (12.71)</td>
<td>53.61 (13.32)</td>
<td>53.68 (13.47)</td>
<td>52.12 (10.48)</td>
<td>54.68 (12.23)</td>
</tr>
<tr>
<td>Step Width (cm)</td>
<td>8.36 (2.9)</td>
<td>8.65 (2.41)</td>
<td>8.54 (2.43)</td>
<td>7.86 (2.74)</td>
<td>8.28 (2.82)</td>
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<tr>
<td>L % Stance</td>
<td>67.68 (5.67)</td>
<td>67.17 (6.37)</td>
<td>67.46 (6.33)</td>
<td>67.06 (4.89)</td>
<td>67.09 (5.94)</td>
</tr>
<tr>
<td>R % Stance</td>
<td>67.71 (5.67)</td>
<td>67.29 (6.27)</td>
<td>67.46 (6.38)</td>
<td>69.33 (13.41)</td>
<td>70.38 (19.52)</td>
</tr>
<tr>
<td>L % Swing</td>
<td>32.32 (5.67)</td>
<td>32.83 (6.37)</td>
<td>32.54 (6.33)</td>
<td>32.94 (4.89)</td>
<td>32.91 (5.94)</td>
</tr>
<tr>
<td>R % Swing</td>
<td>32.29 (5.67)</td>
<td>32.71 (6.27)</td>
<td>32.54 (6.38)</td>
<td>30.67 (13.41)</td>
<td>29.63 (19.53)</td>
</tr>
<tr>
<td>% L SLS</td>
<td>32.31 (5.72)</td>
<td>32.59 (6.2)</td>
<td>32.42 (6.21)</td>
<td>32.64 (4.55)</td>
<td>33.05 (4.58)</td>
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<tr>
<td>% R SLS</td>
<td>32.3 (5.61)</td>
<td>32.78 (6.33)</td>
<td>32.45 (6.21)</td>
<td>32.89 (4.92)</td>
<td>33.11 (4.95)</td>
</tr>
</tbody>
</table>
## VALIDITY

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pearson’s</th>
<th>Significance</th>
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<tbody>
<tr>
<td>Velocity</td>
<td>$r = 0.96$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Cadence</td>
<td>$r = 0.86$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Left Step Length</td>
<td>$r = 0.94$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Right Step Length</td>
<td>$r = 0.96$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Step Width</td>
<td>$r = 0.90$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>% Left Stance</td>
<td>$r = 0.98$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>% Left Swing</td>
<td>$r = 0.90$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>% Left SLS</td>
<td>$r = 0.98$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>% Right Stance</td>
<td>$r = 0.90$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>% Right Swing</td>
<td>$r = 0.98$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>% Right SLS</td>
<td>$r = 0.98$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>Variable</td>
<td>ICC</td>
<td>95% CI</td>
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<tr>
<td>---------------------</td>
<td>------</td>
<td>----------------</td>
</tr>
<tr>
<td>Velocity</td>
<td>.093</td>
<td>0.84, 0.97</td>
</tr>
<tr>
<td>Cadence</td>
<td>0.79</td>
<td>0.54, 0.91</td>
</tr>
<tr>
<td>Left Step Length</td>
<td>0.92</td>
<td>0.82, 0.97</td>
</tr>
<tr>
<td>Right Step Length</td>
<td>0.89</td>
<td>0.75, 0.96</td>
</tr>
<tr>
<td>Step Width</td>
<td>0.95</td>
<td>0.87, 0.98</td>
</tr>
<tr>
<td>% Left Stance</td>
<td>0.99</td>
<td>0.97, 0.99</td>
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</tr>
<tr>
<td>% Right Swing</td>
<td>0.70</td>
<td>0.24, 0.88</td>
</tr>
<tr>
<td>% Right SLS</td>
<td>0.70</td>
<td>0.24, 0.88</td>
</tr>
</tbody>
</table>
CONCLUSION

- High correlation between RAS and the SOAR strategy for velocity, cadence and step length
- Interrater reliability between the music and physical therapist was high for velocity, cadence and step length

CLINICAL IMPLICATIONS

- Increased access to PSE techniques
- Portability of the intervention for home use
- Individuals with PD have shown improvements in gait parameters with home self-administration of auditory cues\textsuperscript{54}
RESEARCH QUESTION

• Do participants report a higher level of satisfaction and motivation when using the SOAR tool as compared to RAS or no auditory cue during ambulation?
INTERVIEW QUESTIONS

1) Tell me how you felt when using the metronome during walking?
2) Tell me how you felt when using the music during walking?
3) Tell me how you walked differently when using the metronome as compared to the music?
4) Which method would you be more likely to use when exercising at your own home?
5) Can you think of any reasons why the metronome/music would be hard to use when exercising at home?

1) Tell me how (name of participant) walked differently when using the metronome as compared to the music?
2) Which method (either metronome or music) do you think would be more motivating for (name of participant)?
3) Can you think of any reasons why the metronome/music would be hard to use when exercising at home for (name of participant)?
**RESULTS**

- 17 preferred music
- 3 preferred no auditory cue
- 0 preferred metronome

**AUDITORY EFFECTS**

**Nonmotor Impact**
- Cognitive
- Body awareness
- Past memories
- Emotional
- Mood elevation
- Motivation

**Motor Impact on Walking**
- Metronome influence
- Walking speed
- Stance and stability
- Step length
- Postural impact
- With/without cord

**Testing Issues**
- Clinician
  - Minimal visual feedback
  - No feedback
- Physical Self
  - Cords too long
  - Frequent turns
  - Too small

**Utility**

**Home Use**
- Ease of use
- Disruption of family activities
- Risk of boredom
- Safety

**Other Issues**
- Better walking pattern
- More automatic movements
“…I felt like after a minute or so it changed everything about my body. It [music] helped with rigidity. It helped with fluidity. It changed everything about the way I was moving.”

“Actually, it [music] kind of pulled me along,”

“I felt more comfortable. I felt so ploddy with the metronome and the music felt like a more natural step”

“I feel like I do more heel walking for a longer period of time. With all the laps, that’s unusual for me to walk that long and keep the heel-toe rather than toe-toe”
PARTICIPANT RESPONSES
NONMOTOR IMPACT

“Music makes it more interesting, more entertaining. And it sort of lifts your spirits to hear a melody line or harmony line.”

“So the music actually made me feel, you are going to laugh, but the music made me feel happy. You know, it was like a light, airy melody that made me kind of want to skip along!”

“It [music] definitely makes me feel happier”
“…that without the music he was barely moving his arm, his arm was basically straight. And after that [music] he did it automatically without me saying anything!”

“I think his walking was smoother, if there is such a thing. He looked more natural with the music. With the metronome, and maybe it’s just my perception, was that it was too rigid.”
CONCLUSION

• Participants perceived greater improvements with music
  • Spatiotemporal parameters
  • Balance
  • Coordination
  • Motivation
  • Overall happiness

Clinical Implications

• Music could be the catalyst to stimulate motivation as well as motion
CLINICAL APPLICATION

Auditory cues facilitate immediate and long term changes in motor control
Relatively simple to incorporate into therapy
Easily used as a HEP
People with PD recognize positive changes in ambulation but prefer music
REFERENCES


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