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.

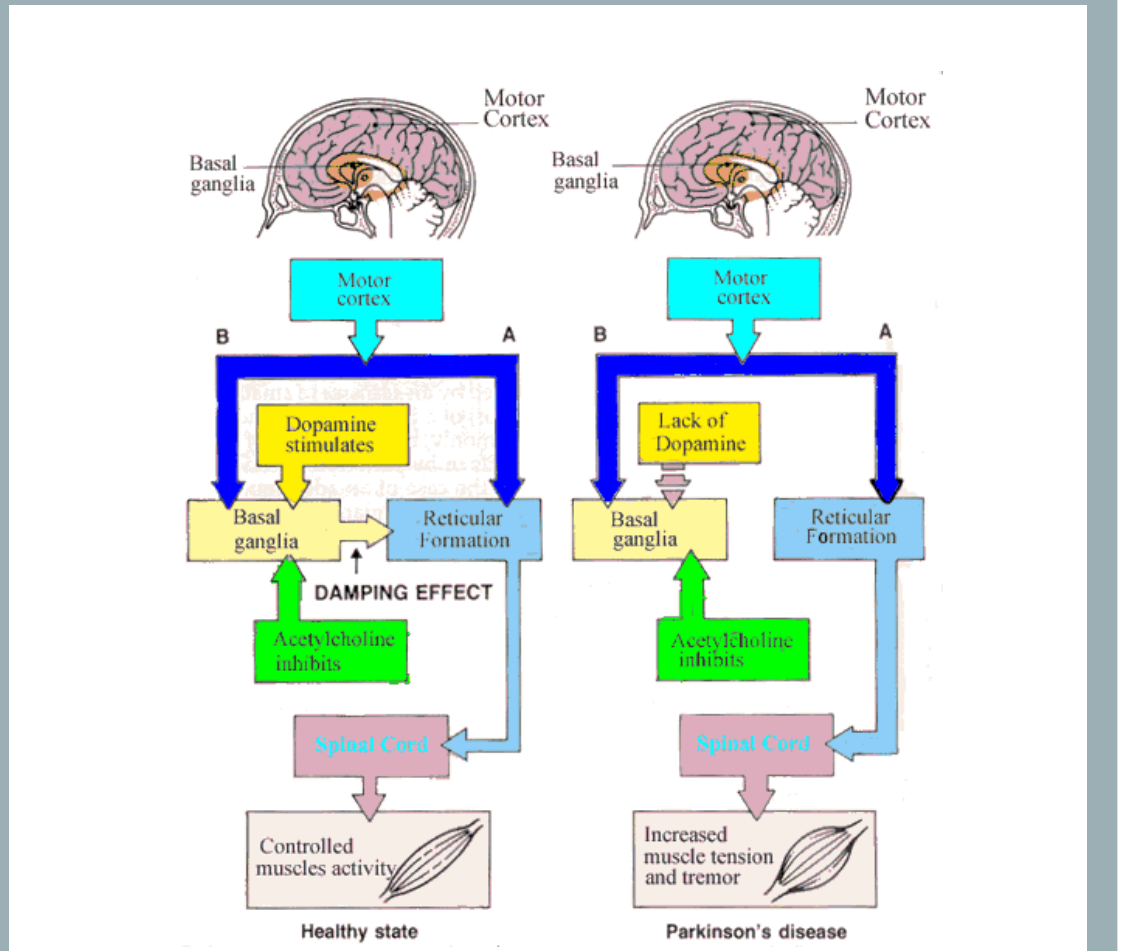
PARKINSON'S DISEASE[1]

- 2nd leading neurodegenerative disease
- Effects over 2% of the elderly population
- Types
  - Idiopathic
  - Secondary

PATHOPHYSIOLOGY[1]

- **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[1]



CARDINAL SIGNS[2]

Bradykinesia

Rigidity

Tremor

Postural instability

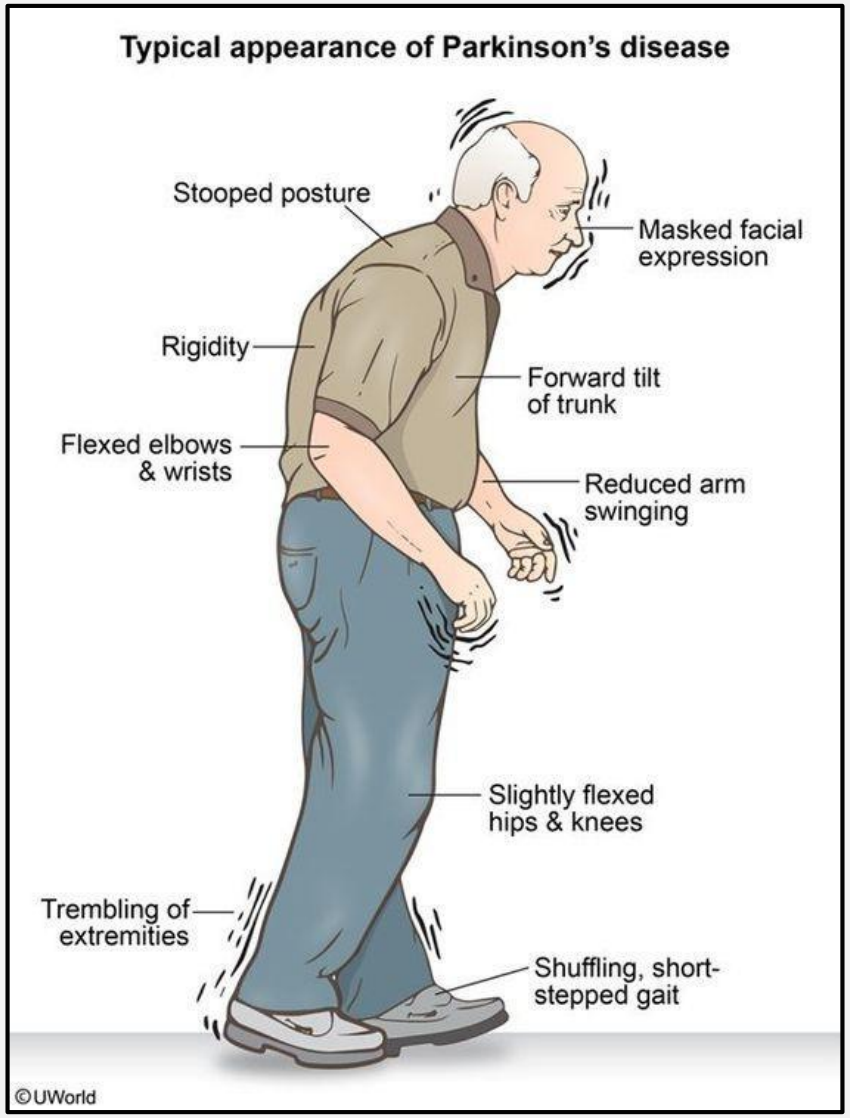
GAIT

Festinating

Shuffling pattern

Freezing

- Worsens with progression of disease[1,3]
- Freezing reported to be most disabling[4]
- All reduce perceived quality of life[5]



https://www.quora.com/What-are-the-symptoms-of-parkinsons

HOEHN AND YAHR CLASSIFICATION OF DISABILITY[6]

Stage	Physical presentation
I	Unilateral involvement
II	Bilateral symptoms or axial involvement present but not postural instability
III	Postural instability present but individual remains physically independent
IV	All symptoms present and severe, individual needs assistance to walk or stand
V	Individual is wheelchair or bed bound

INTERVENTIONS

MEDICAL[1,2]

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

LIMITATIONS

- End dose deterioration
- "On-off" phenomenon

INTERVENTIONS

THERAPEUTIC

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

LIMITATIONS

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

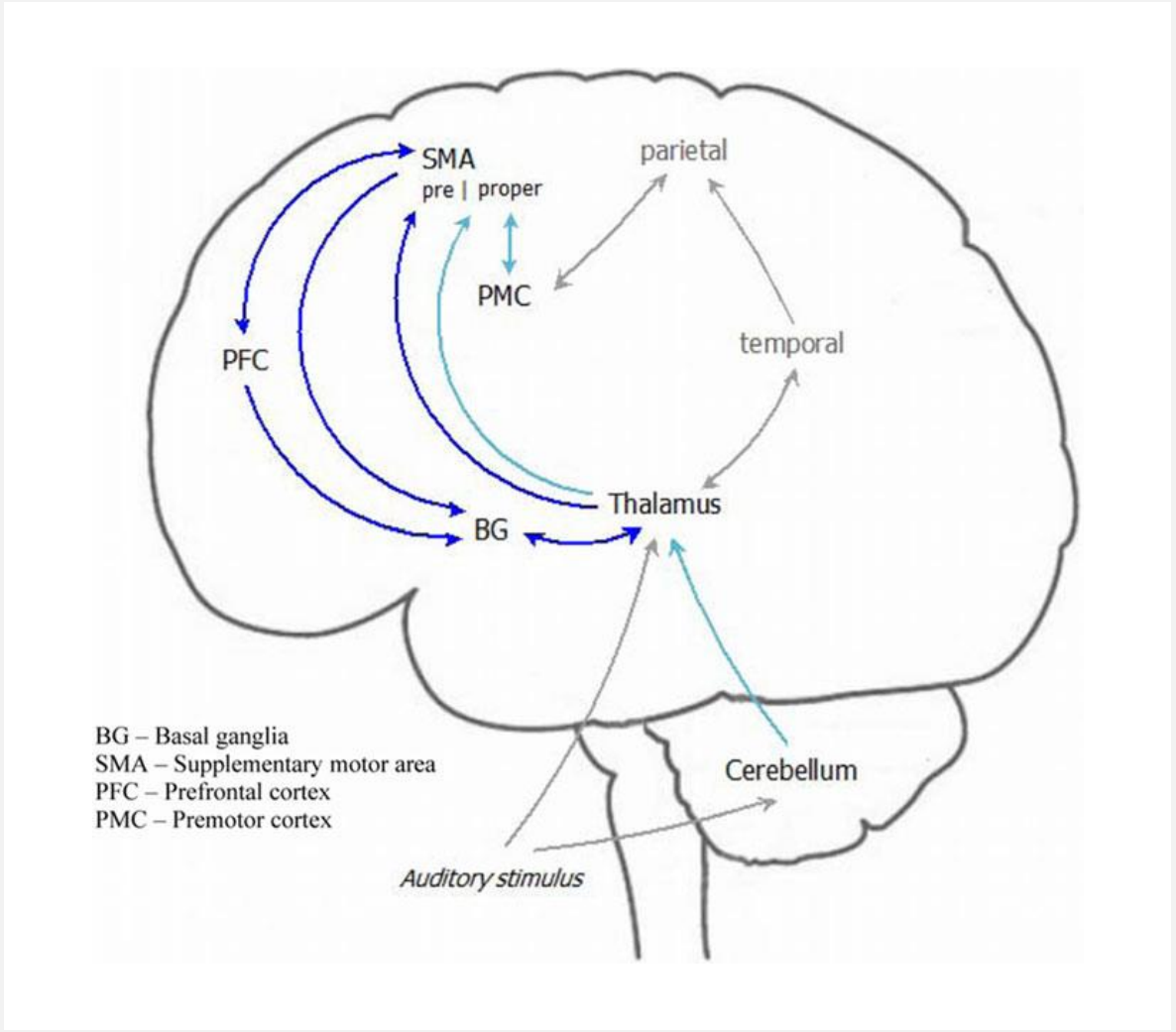
AUDITORY INFORMATION

Large part of human life

Adjustment of motor actions & physiological responses[34,35]

fMRI has shown increased activity in the supplementary motor cortex, mid-premotor cortex and cerebellum even without volitional movement[36,37]

AUDITORY CUEING[38]



NEUROLOGIC MUSIC THERAPY[39]

Rhythmic Auditory Stimulation
Pattern Sensory Enhancement

MUSIC THERAPY[39]

- 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

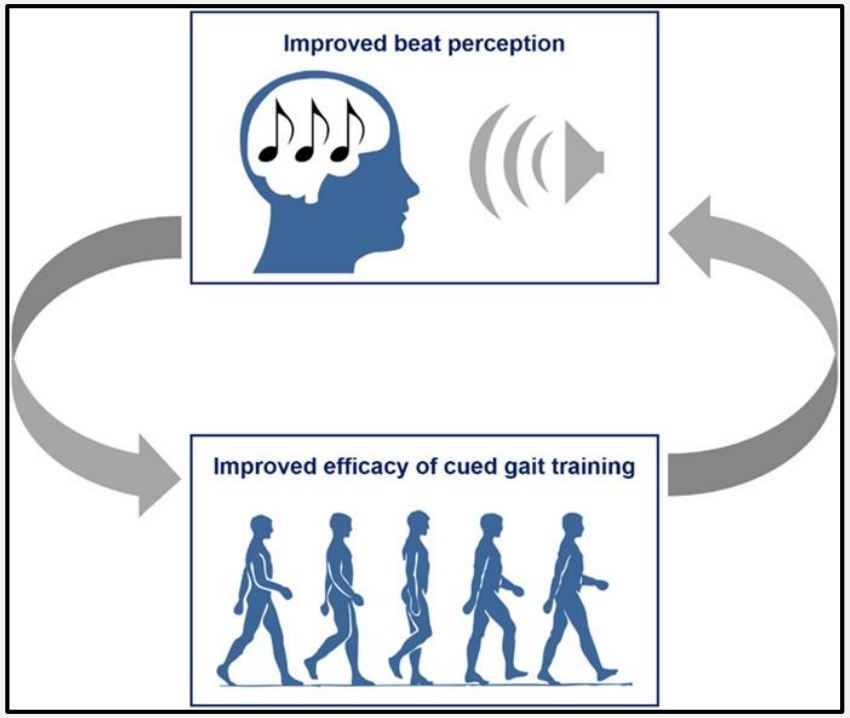
ENTRAINMENT[40]

- **<u>Goal of establishing a rhythm</u>**
  - "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[41]

- **CLINICAL APPLICATION**
  - External stimulus is *fixed* & human system is *plastic*
    - Therefore this encourages a change in the human system

RHYTHMIC AUDITORY STIMULATION (RAS)



- <u>METRONOME</u>
- Continuous time-based rhythmic beat[42]
- Underlies the sound pattern of all music
- This is the consistent beat that encourages entrainment

RHYTHMIC AUDITORY STIMULATION (RAS)

- **<u>Physiological Theory in Individuals with Parkinson's disease</u>**
- 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[39]

- 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[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 vs PSE

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

VARIABLES

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

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

RESULTS

	MT no cue	MT RAS	MT SOAR	PT no cue	PT SOAR
Velocity (m/s)	0.89 (0.31)	0.93 (0.32)	0.95 (0.33)	0.94 (0.25)	0.96 (0.28)
Cadence (step/min)	104.18 (13.27)	106.0 (9.53)	107.49 (11.34)	109.08 (8.79)	106 (8.93)
L step length (cm)	50.56 (13.02)	52.52 (13.96)	52.92 (13.88)	51.56 (10.92)	54.01 (12.39)
R step length (cm)	51.50 (12.71)	53.61 (13.32)	53.68 (13.47)	52.12 (10.48)	54.68 (12.23)
Step Width (cm)	8.36 (2.9)	8.65 (2.41)	8.54 (2.43)	7.86 (2.74)	8.28 (2.82)
L % Stance	67.68 (5.67)	67.17 (6.37)	67.46 (6.33)	67.06 (4.89)	67.09 (5.94)
R % Stance	67.71 (5.67)	67.29 (6.27)	67.46 (6.38)	69.33 (13.41)	70.38 (19.52)
L % Swing	32.32 (5.67)	32.83 (6.37)	32.54 (6.33)	32.94 (4.89)	32.91 (5.94)
R % Swing	32.29 (5.67)	32.71 (6.27)	32.54 (6.38)	30.67 (13.41)	29.63 (19.53)
% L SLS	32.31 (5.72)	32.59 (6.2)	32.42 (6.21)	32.64 (4.55)	33.05 (4.58)
% R SLS	32.3 (5.61)	32.78 (6.33)	32.45 (6.21)	32.89 (4.92)	33.11 (4.95)

VALIDITY

Variable	Pearson's	Significance
Velocity	r = 0.96	$p < 0.001$
Cadence	r = 0.86	$p < 0.001$
Left Step Length	r = 0.94	$p < 0.001$
Right Step Length	r = 0.96	$p < 0.001$
Step Width	r = 0.90	$p < 0.001$
% Left Stance	r = 0.98	$p < 0.001$
% Left Swing	r = 0.90	$p < 0.001$
% Left SLS	r = 0.98	$p < 0.001$
% Right Stance	r = 0.90	$p < 0.001$
% Right Swing	r = 0.98	$p < 0.001$
% Right SLS	r = 0.98	$p < 0.001$

RELIABILITY

Variable	ICC	95% CI	Significance
Velocity	.093	0.84, 0.97	$p < 0.001$
Cadence	0.79	0.54, 0.91	$p < 0.001$
Left Step Length	0.92	0.82, 0.97	$p < 0.001$
Right Step Length	0.89	0.75, 0.96	$p < 0.001$
Step Width	0.95	0.87, 0.98	$p < 0.001$
% Left Stance	0.99	0.97, 0.99	$p < 0.001$
% Left Swing	0.99	0.97, 0.99	$p < 0.001$
% Left SLS	0.97	0.91, 0.99	$p < 0.001$
% Right Stance	0.97	0.93, 0.99	$p < 0.001$
% Right Swing	0.70	0.24, 0.88	$p < 0.006$
% Right SLS	0.70	0.24, 0.88	$p < 0.006$

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[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 when the metronome/music would be hard to use when exercising at home for (name of participant)?

RESULTS

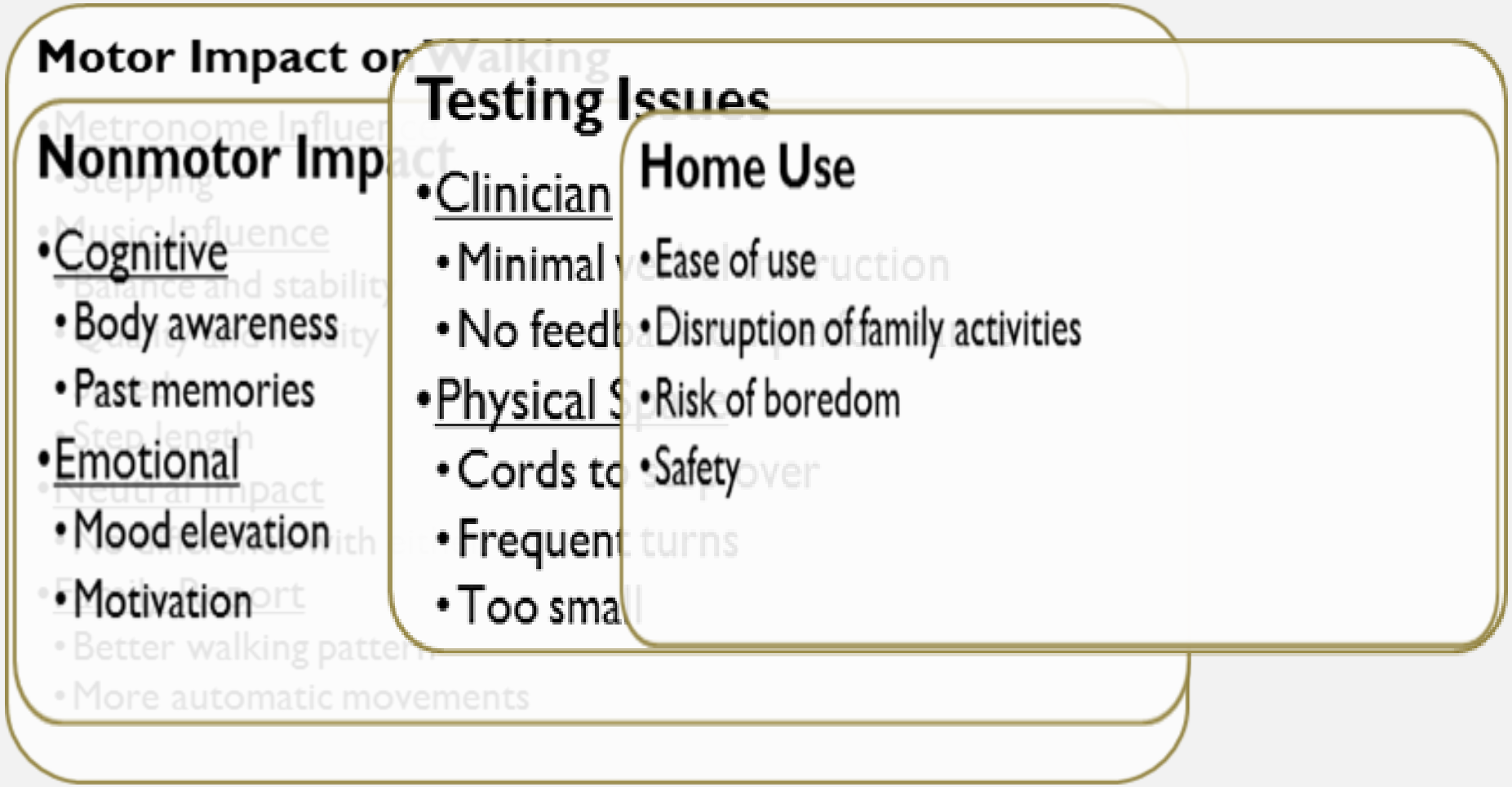
17 preferred music

3 preferred no auditory cue

0 preferred metronome

AUDITORY EFFECTS

UTILITY



PARTICIPANT REPORTS MOTOR IMPACT

"…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"

CAREGIVER RESPONSES

"…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

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