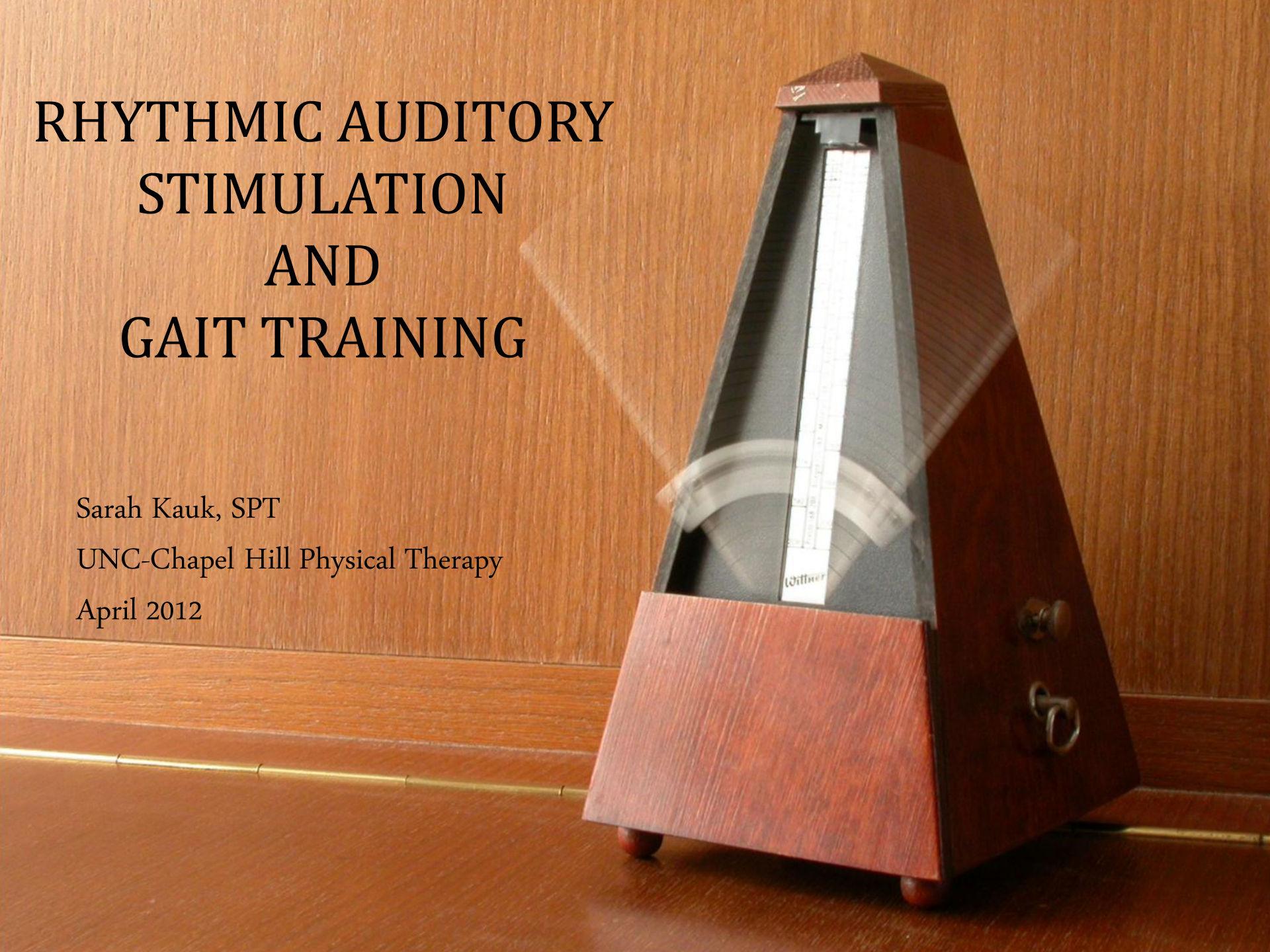
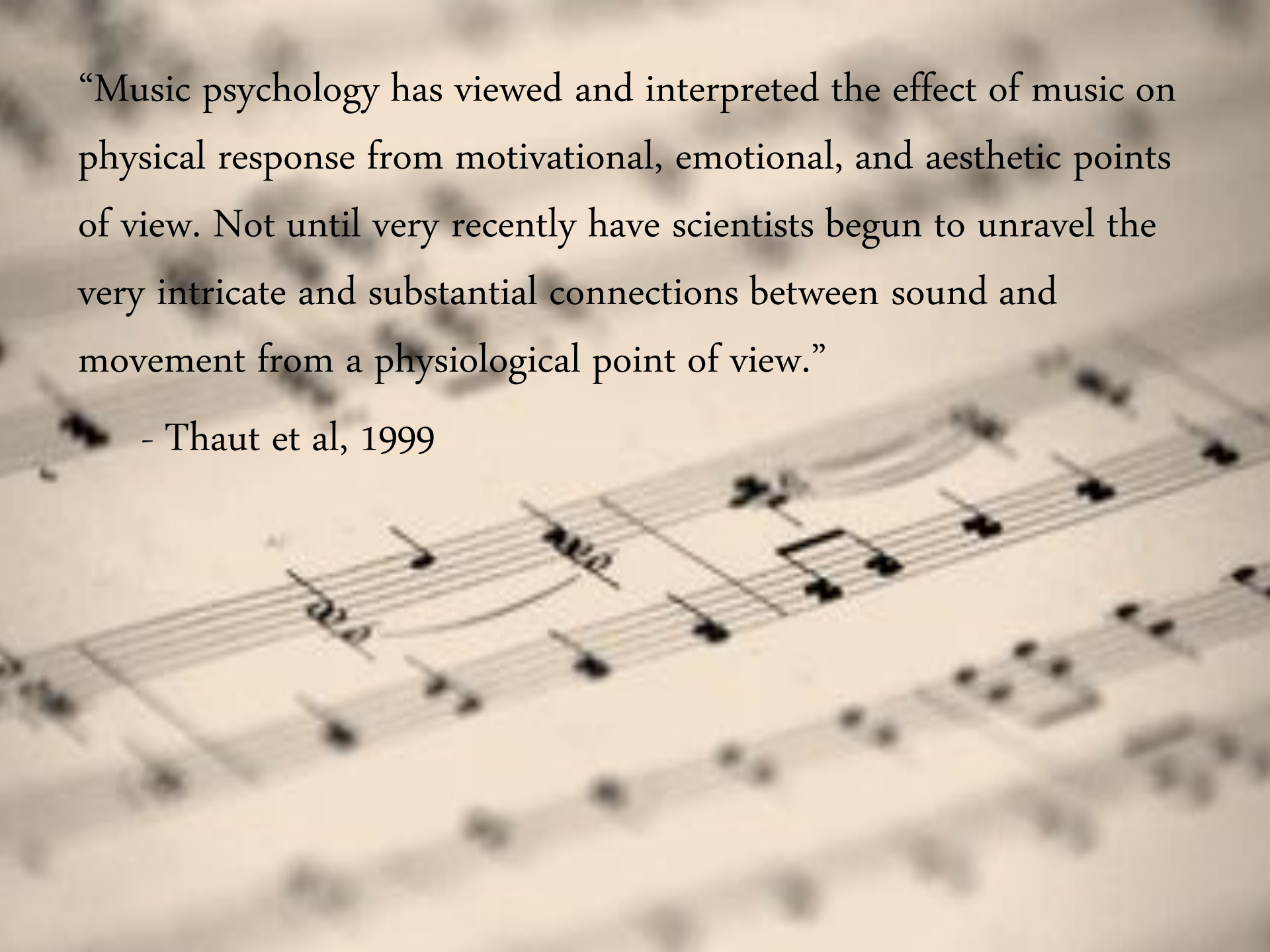
RHYTHMIC AUDITORY STIMULATION AND GAIT TRAINING



Sarah Kauk, SPT

UNC-Chapel Hill Physical Therapy

April 2012



"Music psychology has viewed and interpreted the effect of music on physical response from motivational, emotional, and aesthetic points of view. Not until very recently have scientists begun to unravel the very intricate and substantial connections between sound and movement from a physiological point of view."

- Thaut et al, 1999

Objectives

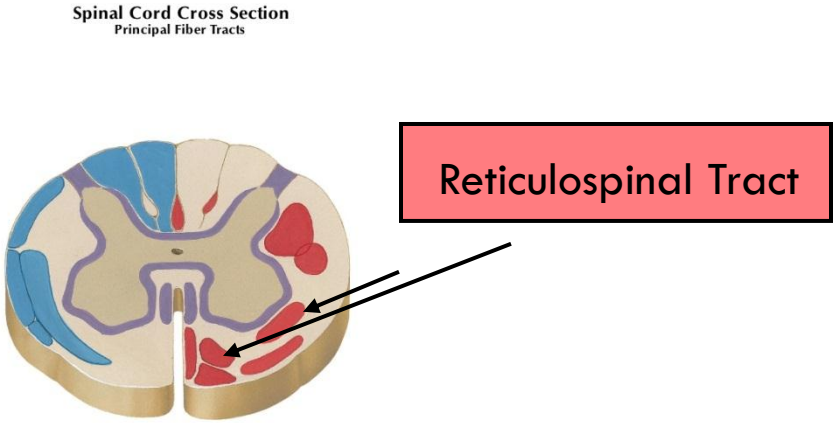
- Understand the theory behind and research supporting rhythmic auditory stimulation.
- Identify individuals appropriate for rhythmic auditory stimulation.
- Demonstrate understanding of the implementation and proper progression of rhythmic auditory stimulation.
- Demonstrate ability to calculate appropriate speed of cuing.

Rhythm and Movement

- Auditory information is processed very fast
- Auditory information is unable to be stopped like visual information
  - Inherently connected to time
- Individuals respond to auditory stimuli faster than to tactile or visual stimuli

Rhythm and Movement

- Theory
  - Reticulospinal tract
  - Not dependent upon upper level cognitive processing
  - Individuals show instant changes in movement quality with rhythm cues
  - Not learned

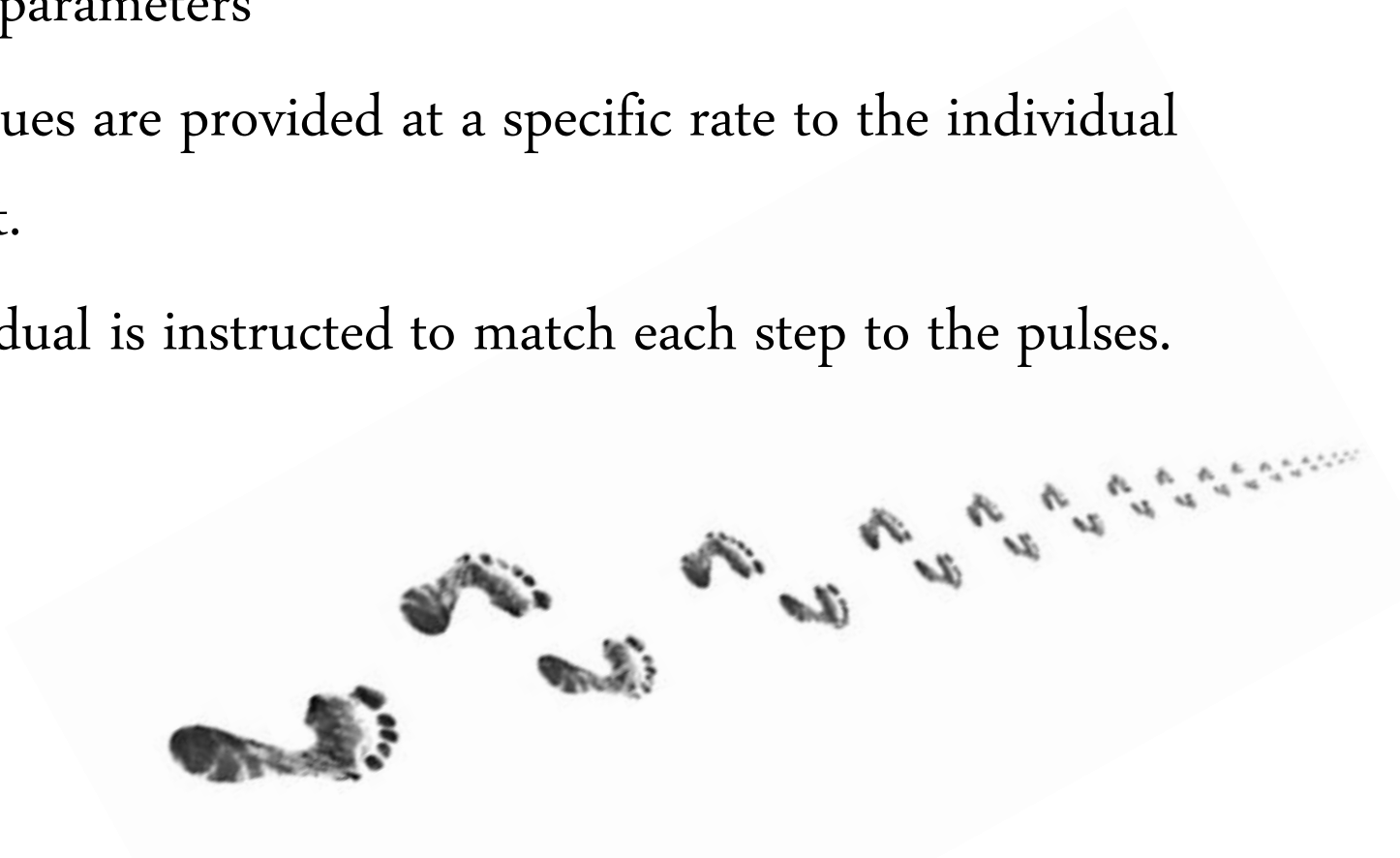


History of Rhythmic Auditory Stimulation

- Speech – To improve fluency in individuals who stutter
  - Silverman, 1971
  - Braton and Conture, 1978
- Gait – To address asymmetries and improve velocity
  - Thaut and colleagues, 1996

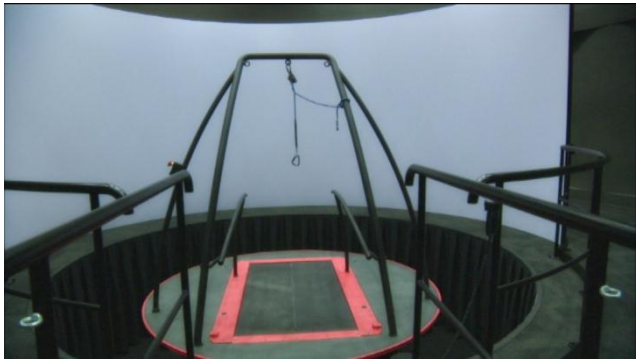
RAS and Gait

- Definition: The use of auditory cues during gait training to improve gait parameters
  - Auditory cues are provided at a specific rate to the individual during gait.
  - The individual is instructed to match each step to the pulses.



Why Auditory Cuing?

- Studies have detected improvements in gait with other sensory feedback or cuing
  - Visual
  - Proprioceptive



- Auditory cuing
  - Less equipment necessary
  - Much less expensive

Auditory Cuing

- Therapists often do this verbally
  - "Step, step, step"
- Limitation
  - Do not know if cuing is rhythmically symmetrical

Current Application of RAS

- Parkinson Disease
- Cerebral Palsy

- Improvements for both populations after training with RAS
  - Gait velocity
  - Cadence
  - Stride Length

Ford et al, 2010; Kim et al 2012

Expanded Application

- Stroke
- Brain Injury
  - Focus on improving asymmetrical gait resulting from hemiparesis

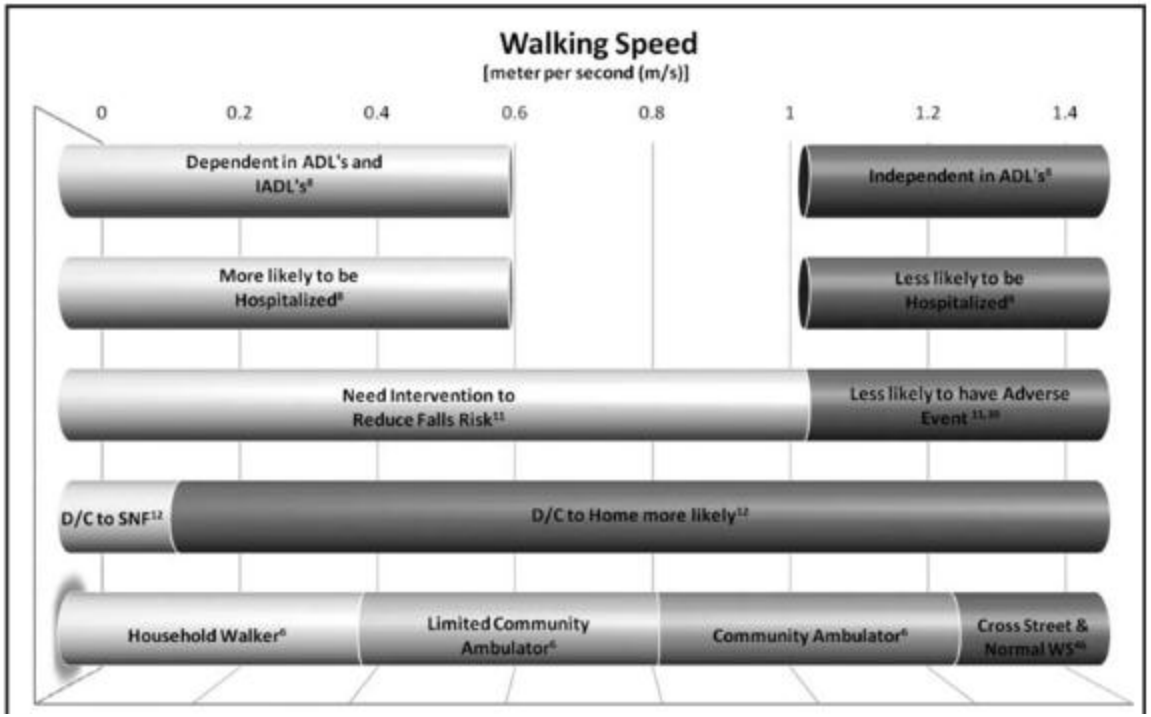
Gait Differences Post-stroke

- When compared to healthy controls, individuals with post-stroke hemiplegia are characterized by the following:
  - Slower gait speed
  - Increased asymmetry
    - Spatial
    - Temporal
  - Decreased stride frequency
  - Decreased stride length
  - Increased stride time
  - Increased stride width

Shumway-Cook et al, 2000; Roerdink et al, 2007; Roerdink et al, 2009; Chen et al 2005

Gait Differences Post-stroke

- Compensatory patterns result in increased energy expenditure
- Why this matters:
  - Slower gait speed is correlated to increased risk of falls



Fritz and Lusardi, 2009

RAS and Stroke

- Individuals who received gait training with RAS displayed improvements in the following gait parameters:
  - Gait velocity
  - Stride Length
  - Stride Width
  - Cadence
  - Temporal Asymmetry
  - Spatial Asymmetry
  - Medial Gastrocnemius EMG variability

Thaut et al, 1997; Thaut et al, 2007; Roerdink et al, 2007; Roerdink et al, 2009

RAS and Stroke

- Other improvements after RAS
  - Ankle extension
  - Flexibility
  - Mood States
  - Interpersonal relationship scores

Jeong and Kim, 2007

RAS and Brain Injury

- Very limited research
  - Case study
  - Intervention not gait-specific
  - Individual demonstrated improvement in gait
    - No longer needed assistance with gait
    - Able to perform stair climbing
    - Increased gait speed
    - Increased cadence

Goldshtrom et al, 2010

Implementation

- Is it better to train overground or on a treadmill?
- How much cuing should be provided?
  - Bilateral
  - Unilateral
- At what speed should RAS be conducted?

Overground vs. Treadmill

- Controversy whether treadmill walking and overground walking are the same
  - Some research shows no significant difference between the two while other research identifies a difference
  - An adaptation period for the treadmill may exist

Overground Training

- Advantages
  - Able to use an assistive device
  - Able to integrate visual step length cues
  - Individual may be more comfortable
  - The most similar to the target activity
- Disadvantages
  - May perform fewer steps per session
  - Not able to control speed

Treadmill Training

- Advantages
  - Usually able to perform more steps per session
  - Can control speed
  - Can force faster than comfortable speed
- Disadvantages
  - May not have access to equipment
  - Individual may not feel comfortable on treadmill
  - May require adaptation period

Cuing: Motor Learning Principles

- Initial: bilateral
  - One pulse for every step
  - Research reports more improvement with bilateral than unilateral

Speed

- Initial
  - Begin near self-selected walking speed
- Later
  - As able, increase speed to encourage faster than self-selected walking speed
  - Study found participants able to match cuing even at faster speeds

Indications

- Impaired gait parameters
- Able to walk independently with step-through gait pattern
  - All participants in the research walked independently
  - However, overground training with an assistive device may be appropriate
- Cognitive ability to understand instructions and follow cues
- Hearing
  - Verify the individual is able to hear the cues

Precautions/Contraindications

- Unable to safely perform reciprocal step-through gait pattern
- Limited hearing ability
- Cognitive impairments limiting ability to follow instructions

Determining Cuing Rate

- 10 Meter Walk Test
  - Measure comfortable overground walking speed and cadence
  - Measure fastest walking speed and cadence
- Convert Units
  - Meters per second to miles per hour if using treadmill training
  - Cadence to beats per minute for metronome

Example: Comfortable Speed

- 10 Meter Walk Test
  - Comfortable = **20 seconds**
- Calculate speed in meters/second
  - 10 meters / 20 seconds = **0.50 m/s**
- Calculate speed in miles per hour
  - Multiply m/s by **2.2** to determine mph
    - 0.5 m/s x 2.2 = **1.1 mph**

Example: Fast Speed

- 10 Meter Walk Test
  - Comfortable = **18.8 seconds**
- Calculate speed in meters/second
  - 10 meters / 18.8 seconds = **0.53 m/s**
- Calculate speed in miles per hour
  - Multiply m/s by **2.2** to determine mph
    - 0.53 m/s x 2.2 = **1.17 mph**

Example: Comfortable Cadence

- 10 Meter Walk Test
  - Comfortable = **28 steps**

- Convert steps in test to steps per second
  - Divide number of steps in test by number of seconds needed to complete test
    - 28 steps / 20 seconds = **1.4 steps/second**

- Convert steps per second to steps per minute
  - Steps per minute will equal beats per minute setting on metronome
  - Multiply steps per second by **60**
    - 1.4 x 60 = **84 steps/minute = 84 beats/minute**

Example: Fast Cadence

- 10 Meter Walk Test
  - Fast = **30 steps**

- Convert steps in test to steps per second
  - Divide number of steps in test by number of seconds needed to complete test
    - 30 steps / 18.8 seconds = **1.6 steps/second**

- Convert steps per second to steps per minute
  - Steps per minute will equal beats per minute setting on metronome
  - Multiply steps per second by **60**
    - 1.6 x 60 = **96 steps/minute = 96 beats/minute**

Community-Based RAS

- For higher-level individuals, walking and performing rhythmic movements to music with a strong and appropriately paced beat
- Encourages symmetry and movement
- May be an option for individuals unable to participate in therapy or for continued reinforcement post-rehabilitation

Specificity of Training

- If you want to train walking….

WALK!

Resources

- Free Internet-Based Metronomes
  - Metronome Online: *www.metronomeonline.com/*
  - Web Metronome: www.*webmetronome.com/*
    - Mobile app available
  - Best Metronome: www.*a.bestmetronome.com/*
    - Mobile app available

References

1. Thaut MH, Kenyon GP, Schauer ML, McIntosh GC. The connection between rhythmicity and brain function. IEEE Eng Med Biol Mag. 1999; 18(2):101-108.
2. Feasel J, Whitton MC, Kassler L, Brooks FP, Lewek MD. The integrated virtual environment rehabilitation treadmill system. IEEE Trans Neural Syst Rehabil Eng. 2011; 19(3):290-297.
3. Lim I, van Wegen E, de Goede C, et al. Effects of external rhythmical cueing on gait in patients with parkinson's disease: A systematic review. Clin Rehabil. 2005; 19(7):695-713.
4. Kim SJ, Kwak EE, Park ES, Cho SR. Differential effects of rhythmic auditory stimulation and neurodevelopmental treatment/Bobath on gait patterns in adults with cerebral palsy: A randomized controlled trial. Clin Rehabil. 2012; .
5. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the timed up & go test. Phys Ther. 2000; 80(9):896-903.
6. Roerdink M, Lamoth CJC, Kwakkel G, van Wieringen PCW, Beek PJ. Gait coordination after stroke: Benefits of acoustically paced treadmill walking. Phys Ther. 2007; 87(8):1009.
7. Roerdink M, Lamoth CJC, van Kordelaar J, Elich P, Konijnenbelt M, Kwakkel G, Beek PJ. Rhythm perturbations in acoustically paced treadmill walking after stroke. Neurorehabil Neural Repair. 2009; 23(7):668.
8. Chen G, Patten C, Kothari DH, Zajac FE. Gait differences between individuals with post-stroke hemiparesis and non-disabled controls at matched speeds. Gait Posture. 2005; 22(1):51-56.
9. Thaut MH, McIntosh GC, Rice RR. Rhythmic facilitation of gait training in hemiparetic stroke rehabilitation. J Neurol Sci. 1997; 151(2):207-212.

References

10. Thaut MH, Leins AK, Rice RR, et al. Rhythmic auditory stimulation improves gait more than NDT/Bobath training in near-ambulatory patients early poststroke: A single-blind, randomized trial. Neurorehabil Neural Repair. 2007; 21(5):455-459.
11. Jeong S, Kim MT. Effects of a theory-driven music and movement program for stroke survivors in a community setting. Appl Nurs Res. 2007; 20(3):125-131.
12. Goldshtrom Y, Knorr G, Goldshtrom I. Rhythmic exercises in rehabilitation of TBI patients: A case report. J Bodyw Mov Ther. 2010; 14(4):336-345.
13. Damiano DL, Norman T, Stanley CJ, Park H. Comparison of elliptical training, stationary cycling, treadmill walking and overground walking. Gait Posture. 2011; 34(2):260-264.
14. Wass E, Taylor NF, Matsas A. Familiarisation to treadmill walking in unimpaired older people. Gait Posture. 2005; 21(1):72-79.
15. Carr J SR. Brain Reorganization, the Rehabilitation Environment, Measuring Outcomes. In: Stroke Rehabilitation: Guidelines for Exercise and Training to Optimize Motor Skill. London: Butterworth-Heinemann, 2003:3-31.
16. Shumway-Cook A WM. Motor Learning and Recovery of Function. In: Motor Control: Translating Research into Clinical Practice. 3rd ed. Balitmore, Maryland: Lippincott Williams and Wilkins, 2007:21-45.
17. Metronome Online. Available at: www.metronomeonline.com. Accessed March 10, 2012.
18. Web Metronome. Available at: www.webmetronome.com. Accessed on March 10, 2012.
19. Best Metronome. Available at: www.a.bestmetronome.com. Accessed on March 20, 2012.
20. Lewek MD. The value of overground gait training for improving locomotion in individuals with chronic stroke. J Neurol Phys Ther. 2009; 33(4):187-188.
21. Fritz S, Lusardi M. White paper: "walking speed: The sixth vital sign". J Geriatr Phys Ther. 2009; 32(2):46-49.

References

22. Silverman FH. The effect of rhythmic auditory stimulation on the disfluency of nonstutterers. J Speech Hear Res. 1971; 14(2):350-355.
23. Brayton ER, Conture EG. Effects of noise and rhythmic stimulation on the speech of stutterers. J Speech Hear Res. 1978; 21(2):UNKNOWN.
24. Thaut MH, McIntosh GC, Rice RR, Miller RA, Rathbun J, Brault JM. Rhythmic auditory stimulation in gait training for parkinson's disease patients. Mov Disord. 1996; 11(2):193-200.
25. Wittner metronome. Metronome. Available at: www.Wikipedia.org. Accessed on March 14, 2012.
26. Netter FH. Atlas of Human Anatomy. Philadelphia: Saunders Elsevier; 2006.
27. Electric Metronome. Available at: http://banjoteacher.com/Gear/Metronomes/index.htm. Accessed on April 7, 2012.
28. Foot Steps. Istock Photo. Available at: http://www.istockphoto.com/stock-photo-5871670-foot-steps.php. Accessed on April 7, 2012.
29. Foot Steps. Christopher Ong. Available at: http://2020chrisong.blogspot.com/2010_09_01_archive.html. Accessed on April 7, 2012.
30. Walk Faster as You Age to Increase Your Longevity. Immortal Humans. Available at: http://www.immortalhumans.com/walk-faster-as-you-age-to-increase-your-longevity/. Accessed on April 7, 2012.
31. Science News. Available at: http://www.sciencedaily.com/releases/2008/04/080416110114.htm. Accessed on April 7, 2012.
32. The Need to Know about Stretching. Fit Chick Tricks. Available at: http://fitchicktricks.com/fitness/the-need-to-know-about-stretching/. Accessed on April 7, 2012.

References

33. Question Mark. Free Images Archive. Available at: http://freeimagesarchive.com/img1320.search.htm. Accessed on April 7, 2012.
34. Walker. Medical Supplies and Equipment Co. Available at: http://mobility-products.medical-supplies-equipment-company.com/medical-rolling-wheeled-walker-144.htm. Accessed on April 7, 2012.
35. Proform Performance 400. TreadmillReview.net. Avilable at: http://www.treadmillreview.net/besttreadmillbuys.html. Accessed on April 7, 2012.
36. Fitness for the Older Adult. Milwaukee Jewish Community Center. Available at: http://www.jccmilwaukee.org/flex-66-specialty-fitness.html. Accessed on April 7, 2012.
37. Al Walking. Open Clip Art Library. Available at: http://openclipart.org/detail/91549/paro_AL_walking. Accessed on April 7, 2012.