MODULE 1

THE IMPORTANCE OF TIMING & RHYTHM: AN OVERVIEW OF THE EVIDENCE

MODULE 1

THE IMPORTANCE OF TIMING & RHYTHM: AN OVERVIEW OF THE EVIDENCE

70 MINUTES

LEARNING OBJECTIVES:

- Overview of Interactive Metronome® technology
- Importance of Timing & Rhythm
- Review of IM & Supporting Research Studies

LOG YOUR ACTIVITY TIME HERE!
In each Module evaluation, you will be asked to log the amount of time it takes you to complete each course activity. This information will be used to ensure that the course CEUs have been calculated accurately. Please use this space provided to log your start time.

VIDEO START TIME

________ AM/PM

ESTIMATED TOTAL TIME FOR THIS ACTIVITY IS 56 MINUTES

START

GATHER NEEDED EQUIPMENT & MATERIALS

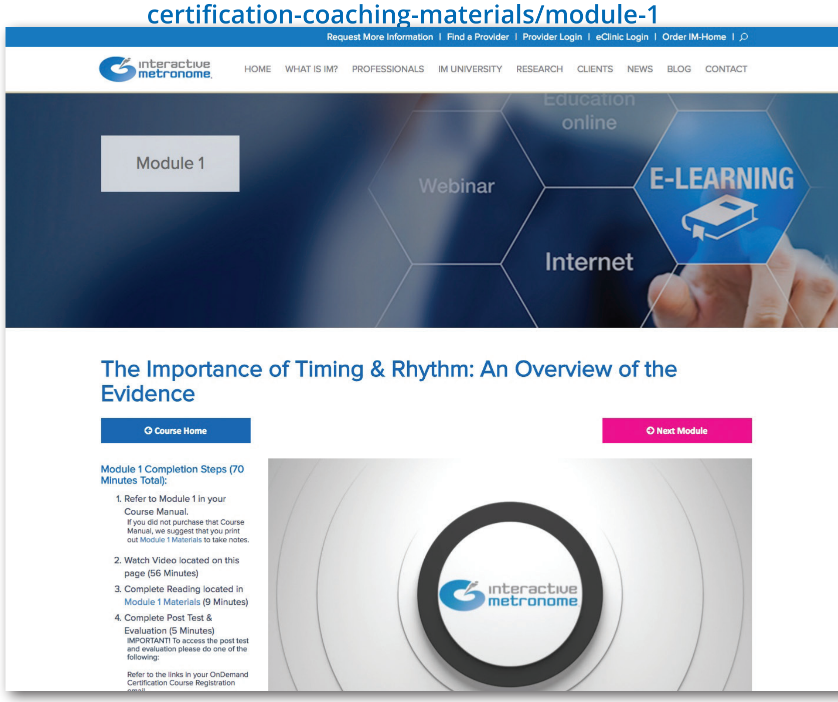
You will need the following to complete Module 1:

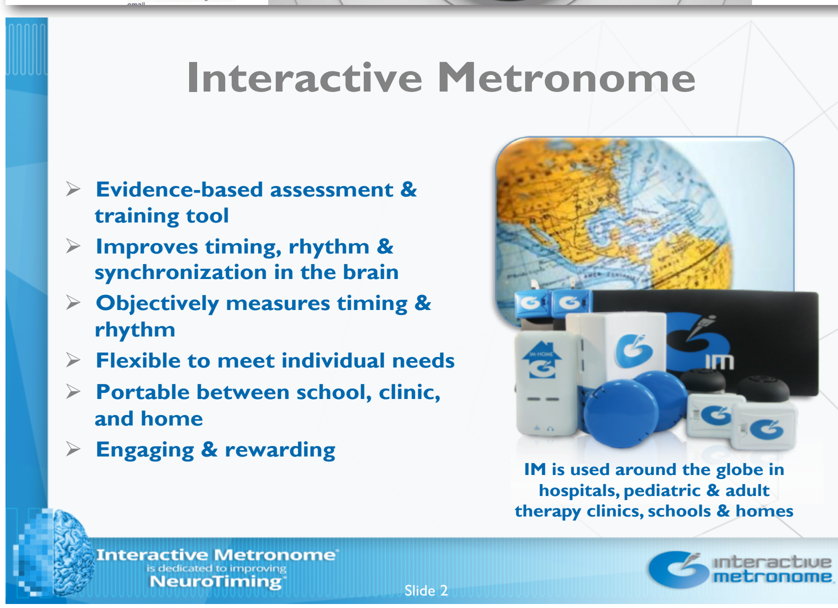
- Computer with Internet connection
- Pencil to take notes

WATCH THE VIDEO

56 minutes

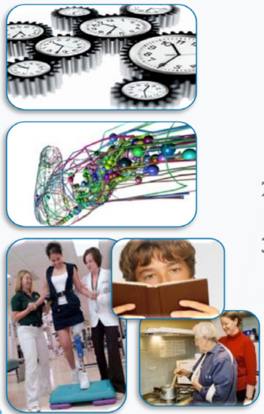
Access the Module video here:
https://www.interactivemetronome.com/im-ondemand-certification-coaching-materials/module-1





NOTES

IM Has Three Goals



1. **Improve neural timing & decrease neural timing variability (jitter) that impacts speech, language, cognitive, motor, & academic performance**
2. **Build more efficient & synchronized connections between neural networks**
3. **Increase the brain's efficiency, performance & ability to benefit more from other rehabilitation & academic interventions**

Interactive Metronome is dedicated to improving NeuroTiming

Slide 3

interactive metronome

Who Benefits from IM?

- **Attention Deficit/Hyperactivity Disorder**
- **Autism Spectrum Disorders**
- **Auditory Processing Disorder**
- **Sensory Processing Disorder**
- **Language-Learning Disorders**
- **Dyslexia and Other Reading Disorders**
- **Executive Function Disorder**
- **Cerebral Palsy**
- **Stroke**
- **Traumatic Brain Injury/Concussion**
- **Brain Tumor**
- **Parkinson's**
- **Multiple Sclerosis**
- **Sports & Performance Enhancement**

Interactive Metronome is dedicated to improving NeuroTiming

Slide 4

interactive metronome

PRECAUTIONS

SEIZURE

- Stress, fatigue, & stimuli that are auditory, visual, vestibular, &/or rhythmical can elicit seizures in individuals with epilepsy.
- Avoid known triggers if using IM with an individual who has epilepsy, & proceed only with physician's approval.
- There are no documented cases of IM contributing to seizures in epileptics, but it is possible if seizures are not medically controlled.

IMPLANTED PACEMAKER & DEFIBRILLATOR

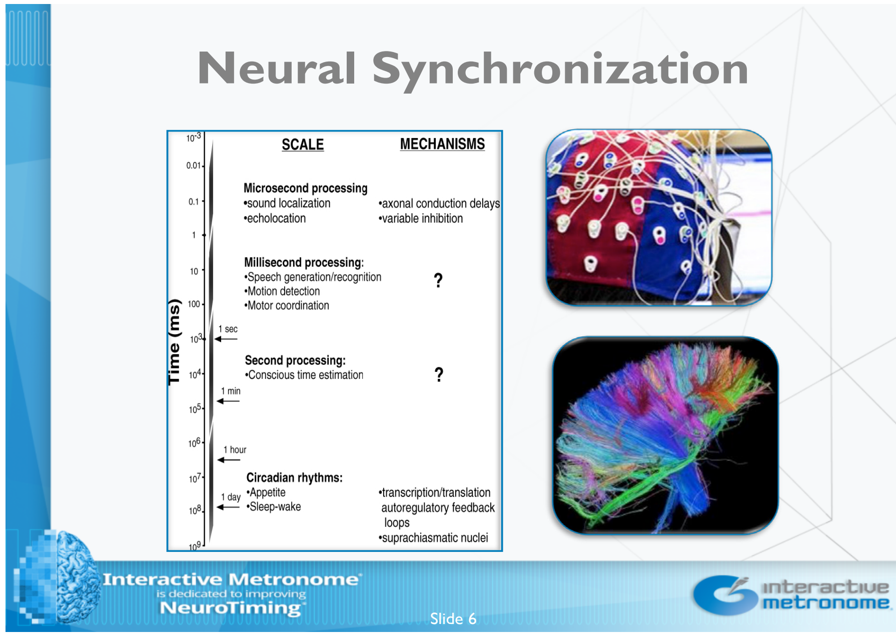
- When worn on the head, headphones **do not pose a health risk** to individuals with implanted pacemakers & defibrillators. All headphones (wired and wireless) contain a magnetic substance called neodymium for the purpose of sound reproduction which may cause electromagnetic interference with these implanted devices **if the headphones are placed within 3 centimeters of the surface of the chest.** Keeping the headphones at least 3 centimeters away from the surface of chest is considered safe, at which point experts say there is *no longer any electromagnetic interference*. Individuals with implanted pacemakers & defibrillators should avoid draping headphones around the neck to avoid direct contact with the chest.

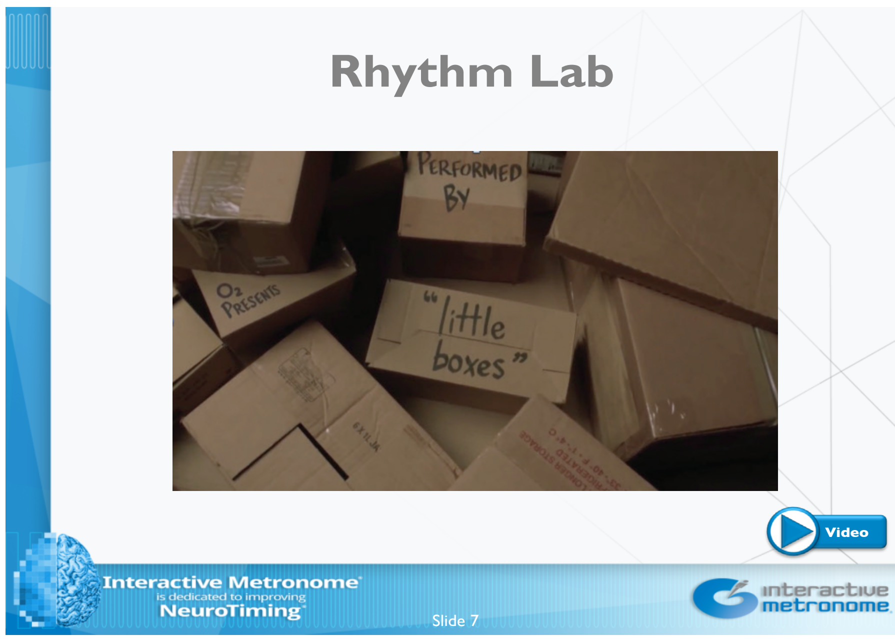
Interactive Metronome is dedicated to improving NeuroTiming

Slide 5

interactive metronome

NOTES


Neural Synchronization
SCALE
MECHANISMS
Time (ms)
Microsecond processing
•sound localization
•echolocation
•axonal conduction delays
•variable inhibition
Millisecond processing:
•Speech generation/recognition
•Motion detection
•Motor coordination
?
1 sec
Second processing:
•Conscious time estimation
?
1 min
1 hour
Circadian rhythms:
1 day
•Appetite
•Sleep-wake
•transcription/translation autoregulatory feedback loops
•suprachiasmatic nuclei
Interactive Metronome
is dedicated to improving
NeuroTiming
Slide 6
interactive metronome


Rhythm Lab
PERFORMED BY
O2 PRESENTS
"little boxes"
Video
Interactive Metronome
is dedicated to improving
NeuroTiming
Slide 7
interactive metronome


Rhythm Lab
Metronome Beat – regulated tempo
Base Beat – "Home Beat" of the music
Polyrhythms
Interactive Metronome
is dedicated to improving
NeuroTiming
Slide 8
interactive metronome

NOTES

Why Is This Important?

SCIENTIFIC AMERICAN

Interactive Metronome® is dedicated to improving NeuroTiming®

Slide 9

"Elements of music have been used effectively….for various therapeutic needs. These elements include melody, harmony, tempo, dynamics, timbre, form, and rhythm. The organizing factor in all music is rhythm; therefore, rhythm serves as a timekeeper in the therapeutic application of music for motor rehabilitation goals and is foundational to auditory-motor synchronization. Auditory rhythmic cueing refers to an auditory sound stimulus with a fixed inter stimulus interval (such as the output from a metronome)."

-Hardy and LaGasse

From, "Rhythm, movement, and autism: using rhythmic rehabilitation research as a model for autism.

Interactive Metronome® is dedicated to improving NeuroTiming®

Slide 10

Auditory-Motor Synchronization Impacts Auditory Processing, Language & Motor Skills (Tierney & Kraus, 2013)

- Ability to tap in sync (*to the millisecond*) with an auditory beat is directly correlated to consistency of auditory brainstem response to sound, ability to read, & phonological awareness
- Ability to tap in sync with an auditory beat directly correlated with degree of neural jitter (noise in the system)
  - more trouble synchronizing = greater neural jitter
  - less trouble synchronizing = less neural jitter
- Children with speech-language-reading disorders have co-occurring fine & gross motor impairments & much more difficulty with timed, rhythmic mvmt compared to those that develop speech-language-reading normally (*trouble tapping in sync with the auditory beat*)
- Shared neural pathways for motor and auditory processing

www.brainvolts.northwestern.edu

Interactive Metronome® is dedicated to improving NeuroTiming®

Slide 11

NOTES

Rhythmicity and Brain Function

- **Brain areas engaged in music perception and production overlap with non-musical networks**
  (Thaut, 2005; Patel 2011)
- **Auditory rhythm activates motor areas of the brain including the pre-motor cortex, supplementary motor areas, pre-supplementary motor areas, and the lateral cortex**
  (Bengtsson, et al 2009)
- **Rhythmicity plays a critical part in learning, development, and performance.**
  (Thaut et al, 1999a, 2009; Molinari et al 2005)
- **Rhythmic synchronization is an effective tool for rehabilitation for patients with Parkinson's disease** (Miller et al., 1996; McIntosh et al., 1997; Rochester et al., 2009), **TBI** (Hurt et al., 1998; Kenyon and Thaut, 2000), **stroke** (Roerdink et al., 2007, 2009; Hayden et al, 2009), **and Huntington's disease** (Thaut et al., 1999b)

Interactive Metronome is dedicated to improving NeuroTiming

Slide 12

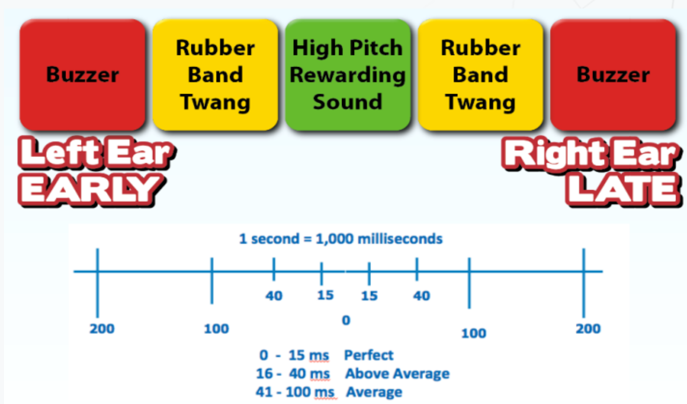
interactive metronome

IM DEMO

Interactive Metronome is dedicated to improving NeuroTiming

Slide 13

interactive metronome



Interactive Metronome is dedicated to improving NeuroTiming

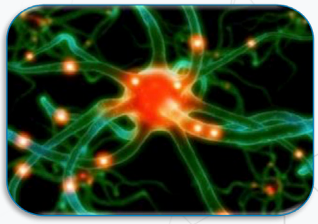
Slide 14

interactive metronome

NOTES

What just happened?

- **Five neurological functions exercised at once:**
  1. Controlled Attention & Concentration
  2. Working Memory
  3. Sensory Integration
  4. Motor Planning/Sequencing for Coordination & Functional Motor Control
  5. Synchronization of timing in multiple brain regions for increased neural efficiency & performance



- **Neuroplasticity…"What is fired together, is wired together"**

IM vs Gaming/Music/ Brain Fitness

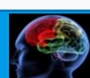
IM

- **Research supports the use of IM to improve timing**
- **Measurable**
- **Objective**
- **Real Time Feedback**
- **High Repetitions**

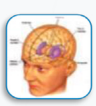
Gaming/Music/ Brain Fitness

- **Video games don't measure timing**
- **Feedback is not given to the ms timing range**
- **Improvements are game specific only**
- **Little to no bilateral or lower extremity work**
- **Low repetitions**

IM Training Synchronizes Neural Networks



Timing Network



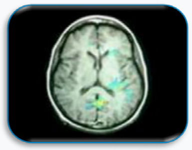
Dorso Lateral Pre-Frontal Cortex	Basal Ganglia	Cingulate Gyrus	Cerebellum
Timing	Timing	Timing	Timing
Motor Planning	Voluntary Motor Coordination	Executive Functioning	Sense of Body Position
Speech		Modulate Emotions	Production of Speech

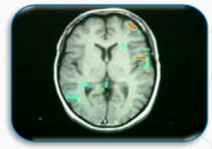
NOTES

IM Neuro-Imaging Study

Presented at 65th Annual American PM&R Conference

Alpiner (2004). Results from this pilot fMRI study show IM directly promotes neural efficiency, with bilateral activitation of multiple parts of the neuro-network. *Repetitive auditory-motor training, specifically IM, holds promise for neuroplasticity of higher and lower brain centers.*



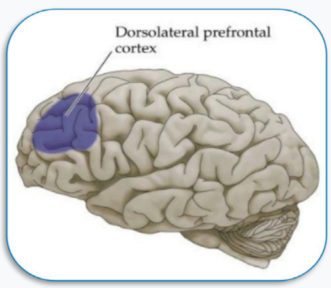


CINGULATE GYRUS	BASAL GANGLIA	MEDIAL BRAINSTEM
Allows Shifting of Attention Cognitive Flexibility	Integrates Thought and Movement	Neuro-Motor Pipeline

Interactive Metronome is dedicated to improving NeuroTiming

Slide 18

Dorso-Lateral Pre-Frontal Cortex



- **Motor planning**
- **Rich connections to basal ganglia**
  (Hale & Fiorello, 2004; McNab & Klingberg, 2008)
- **Temporal aspects of speech, such as rapidly changing acoustic information**
  (Schirmer, 2004)
- **Controlled executive attention and working memory**
  (Lewis & Miall, 2006; McNab & Klingberg, 2008)
- **Uniquely oriented to time**
  (Buhusi & Meck, 2005; Huey et al., 2006)

Interactive Metronome is dedicated to improving NeuroTiming

Slide 19

Basal Ganglia

- **Goal-directed voluntary movement**
  (Buhusi & Meck, 2005)
- **Motor planning, sensory performance, and sensorimotor integration**
  (Mauk & Buonomano, 2004)
- **Working memory**
  (McNab & Klingberg, 2008)
- **Controlled executive attention**
  (McNab & Klingberg, 2008)
- **Posture, tone, motor activity, response coordination, sequencing, control of ongoing movement**
  (Hale & Fiorello, 2004; McNab & Klingberg, 2008; Mauk & Buonomano, 2004; Middleton & Strick, 2000)
- **Temporal aspects of speech**
  (Schirmer, 2004)
- **Rich connections to the cerebellum**

Evidence is implicating the role of the basal ganglia in mental-timing functions.
(Buonoman & Karmarkar, 2002; Buhusi & Meck, 2005; Janata & Grafton, 2003; Lewis & Miall, 2006; Mauk & Buonomano, 2004; Nobre & O'Reilly, 2004; Peretz & Zatorre, 2005)

Interactive Metronome is dedicated to improving NeuroTiming

Slide 20

NOTES

Cingulate Gyrus

- **Responsible for executive, evaluative, cognitive, & emotional functioning**
  (Bush et al, 2000)
- **Error detection, anticipation of tasks, motivation, and modulation of emotional responses**
  (Bush *et al.*, 2000; Nieuwenhuis *et al.*, 2001; Posner & DiGirolamo, 1998)
- **Processing top-down and bottom-up stimuli and assigning appropriate control to other areas of the brain**
  (Posner & DiGirolamo, 1998)
- **Especially involved when effort is needed to carry out a task, such as in early learning and problem solving**
  (Allman *et al.*, 2001)
- **Connections to prefrontal, parietal, and motor cortex, as well as frontal eye fields**
  (Posner & DiGirolamo, 1998)

Interactive Metronome® is dedicated to improving NeuroTiming®
Slide 21

Cerebellum

- **Sense of body position (balance, posture, eye movement)**
  (Hale & Fiorello, 2004)
- **Coordinated motor acquisition & temporal aspects of speech**
  (Debaere et al., 2001; Mauk & Buonomano, 2004; Schirmer, 2004)
- **Involved in timing**
  (Buonoman & Karmarkar, 2002; Bushi & Meck, 2005; Lewis & Miall, 2006; Mauk & Buonomano, 2004; Ivry, 1993; Janata & Grafton, 2003; Nobre & O'Reilly, 2004; Peretz & Zatorre, 2005; Rapoport et al., 2000)

Interactive Metronome® is dedicated to improving NeuroTiming®
Slide 22

Timing In Child Development

Kuhlman, K. & Schweinhart, L.J. (1999)

- **n = 585** (ages 4-11)
- **Significant correlation between IM timing and academic performance**
  - Reading, Mathematics
  - Oral/written language
  - Attention
  - Motor coordination and performance

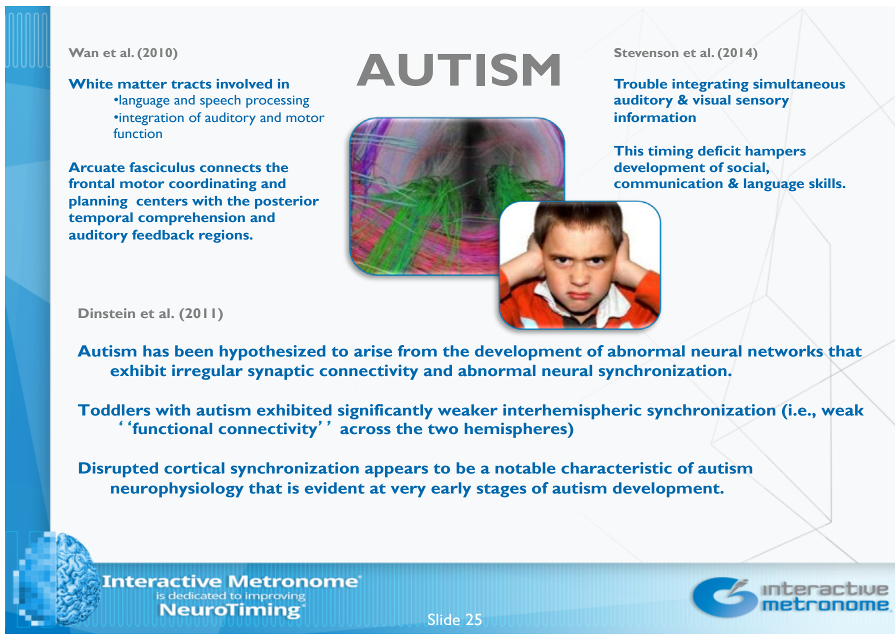
- **Timing was better:**
  - As children age
  - If achieving academically (**California Achievement Test**)
  - If taking dance & musical instrument training
  - If attentive in class
- **Timing was deficient:**
  - If required special education
  - If not attentive in class

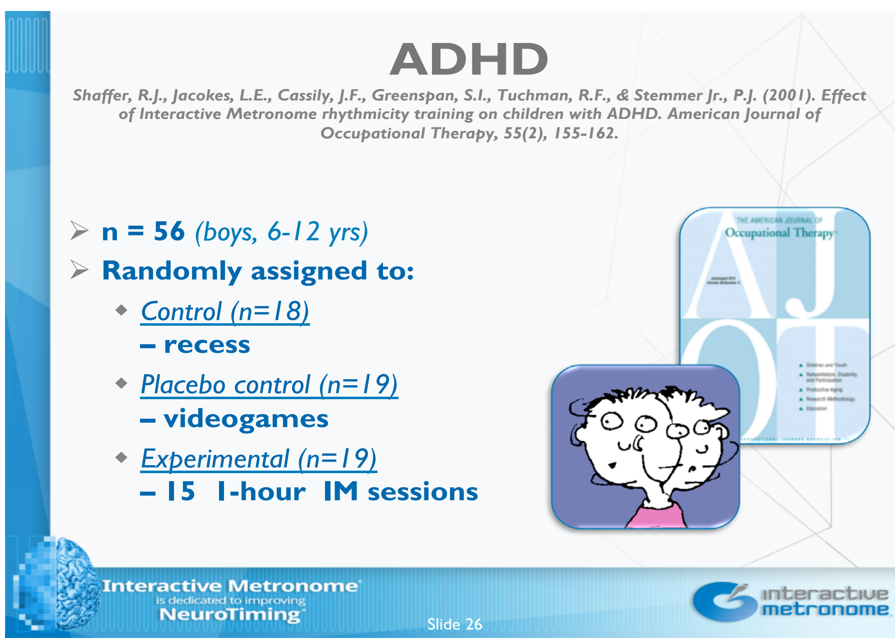
HIGHSCOPE®

Interactive Metronome® is dedicated to improving NeuroTiming®
Slide 23

NOTES


SPEECH & LANGUAGE
Video
Interactive Metronome
is dedicated to improving
NeuroTiming
Slide 24
interactive metronome


AUTISM
Wan et al. (2010)
White matter tracts involved in
•language and speech processing
•integration of auditory and motor function
Arcuate fasciculus connects the frontal motor coordinating and planning centers with the posterior temporal comprehension and auditory feedback regions.
Stevenson et al. (2014)
Trouble integrating simultaneous auditory & visual sensory information
This timing deficit hampers development of social, communication & language skills.
Dinstein et al. (2011)
Autism has been hypothesized to arise from the development of abnormal neural networks that exhibit irregular synaptic connectivity and abnormal neural synchronization.
Toddlers with autism exhibited significantly weaker interhemispheric synchronization (i.e., weak ''functional connectivity'' across the two hemispheres)
Disrupted cortical synchronization appears to be a notable characteristic of autism neurophysiology that is evident at very early stages of autism development.
Interactive Metronome
is dedicated to improving
NeuroTiming
Slide 25
interactive metronome


ADHD
Shaffer, R.J., Jacokes, L.E., Cassily, J.F., Greenspan, S.I., Tuchman, R.F., & Stemmer Jr., P.J. (2001). Effect of Interactive Metronome rhythmicity training on children with ADHD. American Journal of Occupational Therapy, 55(2), 155-162.
n = 56 (boys, 6-12 yrs)
Randomly assigned to:
Control (n=18)
– recess
Placebo control (n=19)
– videogames
Experimental (n=19)
– 15 1-hour IM sessions
Occupational Therapy
AJOT
Interactive Metronome
is dedicated to improving
NeuroTiming
Slide 26
interactive metronome

ADHD

- **Improvements**
  - Attention to task
  - Processing speed & response time
  - Attaching meaning to language
  - Decoding for reading comprehension
  - Sensory processing (auditory, tactile, social, emotional)
  - Reduced impulsive & aggressive behavior
- **58 tests/subtests**
  - Attention & concentration
  - Clinical functioning
  - Sensory & motor functioning
  - Academic & cognitive skills
- **Interactive Metronome group**
  - Statistically significant improvements on 53 of 58 tests ($p \leq 0.0001\%$)

Interactive Metronome® is dedicated to improving NeuroTiming® Slide 27 interactive metronome

SENSORY PROCESSING DISORDER

Video

Interactive Metronome® is dedicated to improving NeuroTiming® Slide 28 interactive metronome

Auditory Processing Pilot Study

Etra (2006)

- **n = 8**
- **IM training x 15 hrs**
- **Statistically significant gains** *(SCAN-C):*
  1. Filtered Words
  2. Auditory Figure-Ground
  3. Dichotic Listening: Competing Words
  4. Dichotic Listening: Competing Sentences
- **Greatest improvement in dichotic listening.**
  - "Strongly suggests IM affects auditory processing disorders by influencing neurological organization."

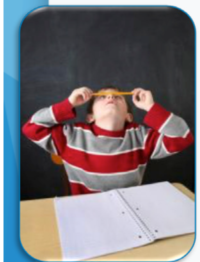
Interactive Metronome® is dedicated to improving NeuroTiming® Slide 29 interactive metronome

NOTES

MODULE 1

NOTES

Brian



TEST OF AUDITORY PROCESSING SKILLS	PRE	POST
OVERALL SCORES		
Phonological Skills	55th	**86th**
Memory	50th	**63rd**
Cohesion	47th	**70th**

TEST OF EVERYDAY ATTENTION IN CHILDREN	PRE	POST
Sustained-Divided Attention	> 0.2nd	**96.7 – 98.5th**
Selective-Focused Attention	12.2 – 20.2nd	**56.6 – 69.2nd**
Sustained Attention	0.2 – 0.6th	**30.9 – 43.4th**

SOCIAL EMOTIONAL EVALUATION	PRE	POST
RECEPTIVE SCORES		
Identifying Emotional Reactions	20	**26**
Understanding Social Gaffes	2	**20**
Understanding Conflicting Messages	6	**10**
RECEPTIVE PERCENTILE CHANGE	5th	**90th**
EXPRESSIVE SCORES		
Identifying Emotional Reactions	20	**28**
Understanding Social Gaffes	2	**20**
Understanding Conflicting Messages	6	**10**
EXPRESSIVE PERCENTILE CHANGE	10th	**95th**

Interactive Metronome is dedicated to improving NeuroTiming

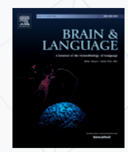
interactive metronome

Slide 30

READING

Incorporation of feedback during beat synchronization is an index of neural maturation and reading skills.

Kraus et al., 2016



- **74 adolescents clapped in sync with an auditory beat (using IM) with and without visual feedback for timing.**
- **They underwent tests of cognitive and literacy skills.**
  - **Verbal intelligence via Wechsler Abbreviated Scale of Intelligence (WASI)**
  - **Working memory via Woodcock Johnson III Test of Cognitive Abilities (WJ – III)**
  - **Phonological Awareness & Phonological Memory via Comprehensive Test of Phonological Processing (CTOPP)**
  - **Reading via Woodcock Johnson Test of Achievement (WJ – III)**
  - **Reading Fluency via Test of Word Reading Efficiency – 2nd Edition (TOWRE-2)**
- **The brain's electric activity was measured at rest and in response to sound, with scalp electrodes.**
  - **Cortical Speech Processing via amplitude & latency of cortical auditory evoked potential (CAEP) components elicited by speech sounds**
  - **Spectral power of intrinsic neural oscillatory power in the gamma frequency band (31-50 Hz) at rest via continuous EEG.**

Interactive Metronome is dedicated to improving NeuroTiming

interactive metronome

Slide 31

READING

- **Adolescents who could clap more in sync with the beat (to the millisecond) with & without visual feedback had more advanced language skills in the areas of**
  - **Working memory**
  - **Phonological processing**
  - **Reading**
- **Adolescents who did a superior job at clapping in sync with the beat when receiving visual feedback for timing demonstrated a more mature neural profile on EEG (for resting neural activity and for neural activity in response to speech sounds)**
- **"These findings show that the ability to incorporate visual feedback while keeping a beat systematically aligns with brain maturity. It stands to reason, then, that training the brain to exploit multisensory rhythm processing could speed up brain maturation and bolster cognitive health."**

Interactive Metronome is dedicated to improving NeuroTiming

interactive metronome

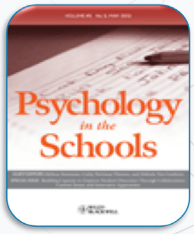
Slide 32

NOTES

READING

McGrew, KS, Taub, G & Keith, TZ (2007). Improvements in interval time tracking and effects on reading achievement. Psychology in the Schools, 44(8), 849-863.

- **Controlled studies**
  - Elementary **n = 86**
  - High School **n = 283**
- **18 Interactive Metronome training sessions (4 weeks)**
- **Elementary:**
  - ~ 2SD ↑ in timing
  - Most gains seen in those who had very poor timing to begin with
  - 18-20% growth in critical pre-reading skills (phonics, phonological awareness, & fluency)
- **High School:**
  - 7-10% growth in reading (rate, fluency, comprehension)
  - Achievement growth beyond typical for age group



Interactive Metronome® is dedicated to improving NeuroTiming® Slide 33

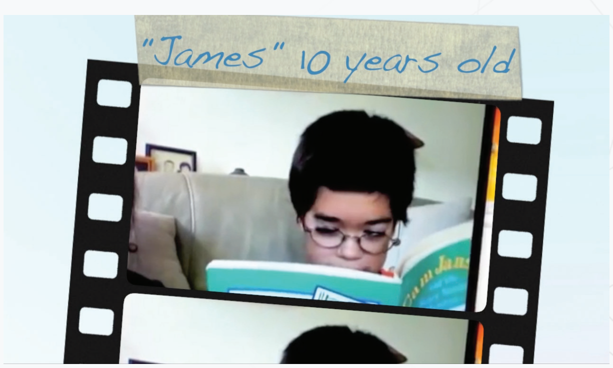
READING

Based upon numerous peer reviewed studies examining the role of timing & rhythm and cognitive performance, the authors concluded Interactive Metronome must be increasing:

- Efficiency of working memory
- Cognitive processing speed & efficiency
- Executive functions, especially executive-controlled attention (FOCUS) & ability to tune-out distractions
- Self-monitoring & self-regulation (META-COGNITION)

Interactive Metronome® is dedicated to improving NeuroTiming® Slide 34

READING



Video

Interactive Metronome® is dedicated to improving NeuroTiming® Slide 35

NOTES

READING

Ritter, M., Colson, K.A., & Park, J. (2012). Reading Intervention Using Interactive Metronome in Children With Language and Reading Impairment: A Preliminary Investigation. *Communication Disorders Quarterly*, Published online September 28, 2012.

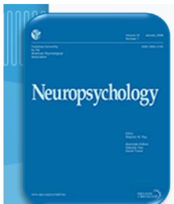
- **Controlled study, n = 49** *(7 – 11 yrs)*
  - Concurrent oral & written language impairments
  - Reading disability
  - Lower to middle class SES
- **Control -** Reading Intervention 4 hours per day, 4 times per week for 4 weeks.
- **Experimental -** 15 min of IM training per session prior to reading intervention
- **While both groups demonstrated improvement, gains in the IM group were more substantial (to a level of statistical significance).**
- **Overall IM group improved 2-4 times over the Control Group.**

Measure	Improvement over Control Group
Reading Naturally	3.67 times
DIBELS-6 (literacy skills)	3.29 times
GORT 4 – rate	4.31 times
GORT 4 – fluency	1.8 times
GORT 4 – comprehension	2.6 times

"The findings of this study are relevant to others who are working to improve the oral and written language skills and academic achievement of children, regardless of their clinical diagnosis."

BAYLOR UNIVERSITY

Interactive Metronome is dedicated to improving NeuroTiming Slide 36 interactive metronome



TRAUMATIC BRAIN INJURY

- **Blind randomized, controlled study**
- **n=46 active duty soldiers with mild-moderate blast-related TBI**
- **Control: Treatment as Usual (OT, PT, ST)**
- **Experimental: Treatment as Usual (OT, PT, ST) plus 15 sessions of Interactive Metronome treatment @ frequency of 3 sessions per week.**

Interactive Metronome is dedicated to improving NeuroTiming Slide 37 interactive metronome

DVBIC Defense and Veterans Brain Injury Center

TRAUMATIC BRAIN INJURY PUBLISHED RESULTS

ASSESSMENT	SKILLS MEASURED	OUTCOME
DKEFS: Color Word Interference	Attention, response inhibition	Cohen's d= .804 LARGE p=.0001
RBANS Attention Index	Auditory attention, auditory memory & processing speed	Cohen's d= .511 LARGE p=.004
RBANS Immediate Memory Index	Auditory attention, auditory memory & processing speed	Cohen's d= .768 LARGE p=.0001
RBANS Language Index	Confrontation naming, verbal fluency, & processing speed	Cohen's d= .349 MED p=.0001
WAIS-IV Symbol Search	Processing speed, short-term visual memory, visual-motor coordination, cognitive flexibility, visual discrimination, speed of mental operations, & psychomotor speed	Cohen's d= 0.478 MED p=.0001
WAIS-IV Coding	Visual attention, processing speed, short-term visual memory, visual perception, visual scanning, visual – motor coordination, working memory, & encoding	Cohen's d= ..630 LARGE p=.0001
WAIS-IV Digits Sequencing	Auditory attention, working memory, cognitive flexibility, rote memory & learning,	Cohen's d= .588 LARGE p=.021
DKEFS Trails: Motor Speed	Motor speed, executive functions	Cohen's d= .790 LARGE p=.015
DKEFS Trails: Letter Sequencing	Processing speed, working memory, and executive functions	Cohen's d= .626 LARGE p=.0001

Group that received IM + TAU outperformed the control group that received only TAU on 21 of 26 assessments (p=.0001)

Interactive Metronome is dedicated to improving NeuroTiming Slide 38 interactive metronome

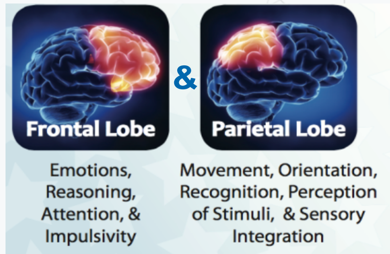
Electrocortical Assessment

- 64 channels of EEG
- Capturing resting state and event- related activity
- Event-related potentials only captured when the brain is firing synchronously

Special thanks to Mark Sebes, Physical Therapy Assistant

IM physiologically changed the brain

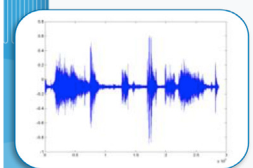
Pre and post EEG scans showed IM increased activation and coordination in both the



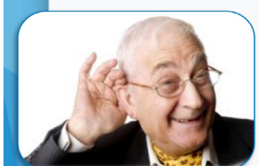
Interactive Metronome is dedicated to improving NeuroTiming

Slide 39

APHASIA

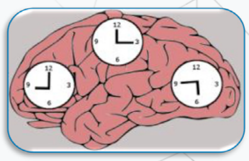


"…fundamental problems in processing the temporal form or microstructure of sounds characterized by rapidly changing onset dynamics."
Stefanatos et al (2007)



"…auditory timing deficits may account, at least partially, for impairments in speech processing."
Sidiropoulos et al (2010)

"…co-occurrence of a deficit in fundamental auditory processing of temporal and spectro-temporal non-verbal stimuli in Wernicke's Aphasia that may contribute to the auditory language comprehension impairment."
Robson et al (2012)



Interactive Metronome is dedicated to improving NeuroTiming

Slide 40

Interactive Metronome & Motor Learning

- **Four factors of motor learning addressed by Interactive Metronome are:**
  1. Early cognitive engagement
  2. Repetitive practice
  3. Practice of specific functional motor skills
  4. Feedback for millisecond timing to facilitate motor learning

Interactive Metronome is dedicated to improving NeuroTiming

Slide 41

NOTES

NOTES

HEMIPLEGIA

Beckelhimer, S.C., Dalton, A.E., Richter, C.A., Hermann, V., & Page, S.J. (2011) Computer-based rhythm and timing training in severe, stroke-induced arm hemiparesis. *American Journal of Occupational Therapy, 65,* 96-100.

UNIVERSITY OF Cincinnati

- **Pilot study: n=2**
  - Ischemic stroke with R hemiplegia x 23 yrs prior
  - Ischemic stroke with L hemiplegia x 2 yrs prior
- **Substantial results:**
  - ↑ ability to grasp, pronate, and supinate arm & hand
  - ↑ ability to perform ADLs
  - ↑ self-efficacy
  - ↑ self-report of quality of life

Interactive Metronome is dedicated to improving NeuroTiming

Slide 42

interactive metronome

The Effectiveness of the IM with Healthy Aging Adults

Dr. Leonard Trujillo, OTR/L, Eastern Carolina University
Presented at 2016 AOTA Conference

- **N= 15, Healthy Aging adults (60 – 80 yrs.)**
- **Training: 18 sessions**
- **30 – 45 minutes per session**
  - **Never exceeding 275 reps per task**
- **All participants only performed upper extremity exercises and were seated during training for safety precautions**

Interactive Metronome is dedicated to improving NeuroTiming

Slide 43

interactive metronome

Results

Assessment	Overall Improvement
Modified IM Long Form (seated, all upper extremity exercises)	77%
Short Form	31%
Math Fluency (WJII)	23%
Reading Fluency (WJII)	12%
Decision Speed (WJII)	5%
Visual Matching (WJII)	4%
The d2 Test of Attention • Implicates improvements in the ability to stay focused and attend to more difficult tasks and task over time.	16%
Four Step Square Test • Implicates improvements in balance, sped, and confidence in independent ambulation and other daily tasks. This includes ability to dress and bath with confidence.	88% *
The 9 Hole Peg Test • Implicates improvements in fine motor, dexterity, sense of accuracy and confidence in independence in other daily tasks. This includes ability to dress, eat and perform fine motor tasks with confidence.	3%

Interactive Metronome is dedicated to improving NeuroTiming

Slide 44

interactive metronome

Significance of this study

- **<u>Most notable gain</u>: Four Step Square Test improved 88%**
- **Implicates improvement in:**
  - **Balance**
  - **Speed**
  - **Confidence with Independent Ambulation**
- **This has significant meaning for adults who are at risk of falling and is a substantial outcome considering all participants only performed upper extremity tasks during training and were seated**

These participants did not perform lower extremity IM exercises nor did they work on standing balance or ambulation, yet a HUGE effect size was seen!

Interactive Metronome® is dedicated to improving NeuroTiming®

Slide 45

interactive metronome

NOTES

PARKINSON'S

Daniel Togasaki, MD, PhD

- **n=36 individuals with mild-moderate Parkinson's**
  - **Control Group:** rhythmic movement and clapping to music, metronome, or playing videogames
  - **Experimental:** Interactive Metronome training x 20 hours (rhythmic movement + feedback for timing)
  - "In this controlled study computer directed rhythmic movement training was found to improve the motor signs of parkinsonism."

cause care cure

The Parkinson's Institute and Clinical Center

Interactive Metronome® is dedicated to improving NeuroTiming®

Slide 46

interactive metronome

Ongoing IM Research

- **University of New Mexico & University of Washington:** $2M NIH grant to study effects of IM training on cognitive & motor skills in Native Americans with cerebrovascular disease
- **Northwestern University:** Biological underpinnings of IM & link between neural synchronization & language-based literacy skills
- **Department of Defense (DVBIC):** Larger scale replication study on soldiers with mild-moderate blast-related TBI
- **Pittsburgh VA:** Cognitive & language function in schizophrenia

Interactive Metronome® is dedicated to improving NeuroTiming®

Slide 47

interactive metronome

NOTES

At the end of each Module, you will be asked to log the amount of time it takes you to complete each course activity. This information will be used to calculate the number of CEUs that will be awarded by ASHA & AOTA.

VIDEO END TIME ________ AM/PM

TOTAL ACTIVITY TIME (IN MINUTES) ________ MIN.

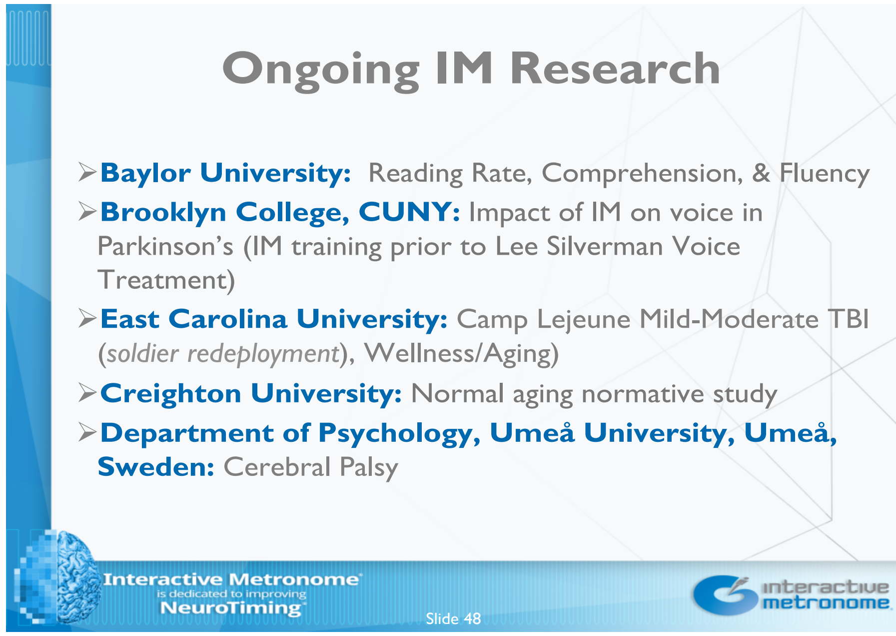
ESTIMATED TOTAL TIME FOR THIS ACTIVITY IS 56 MINUTES

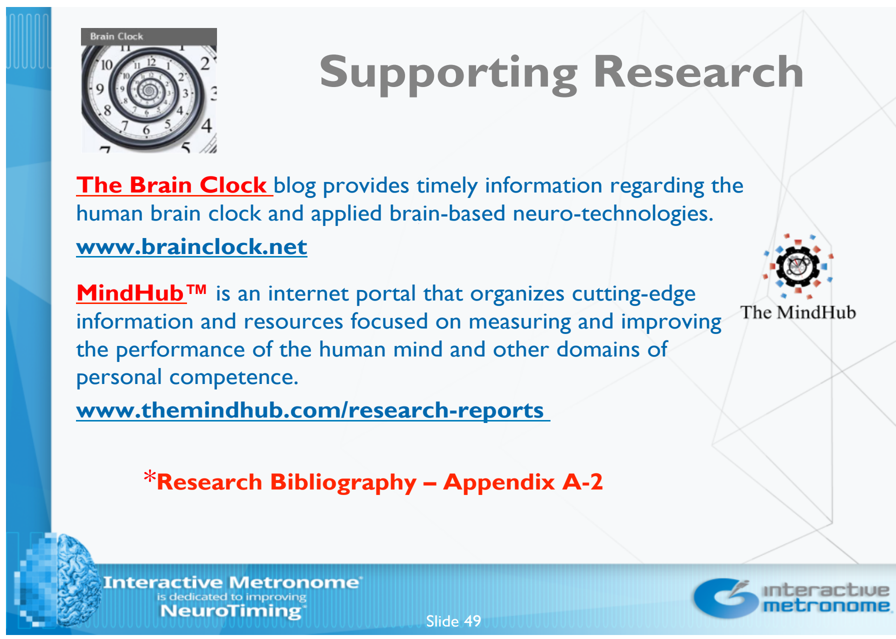
LOG YOUR ACTIVITY TIME HERE!

READING START TIME

________ AM/PM

ESTIMATED TOTAL TIME FOR THIS ACTIVITY IS 9 MINUTES

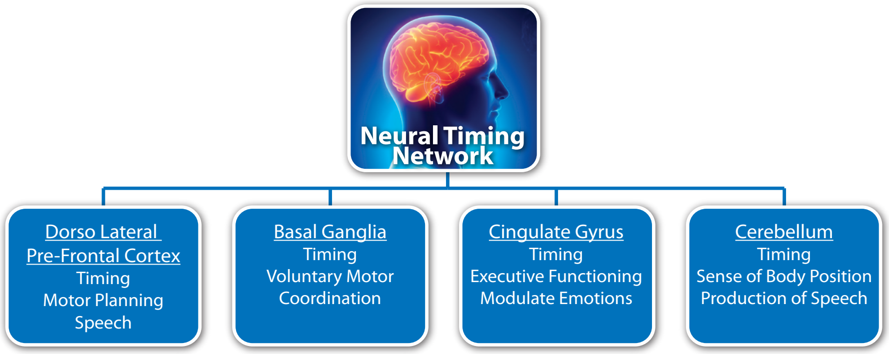




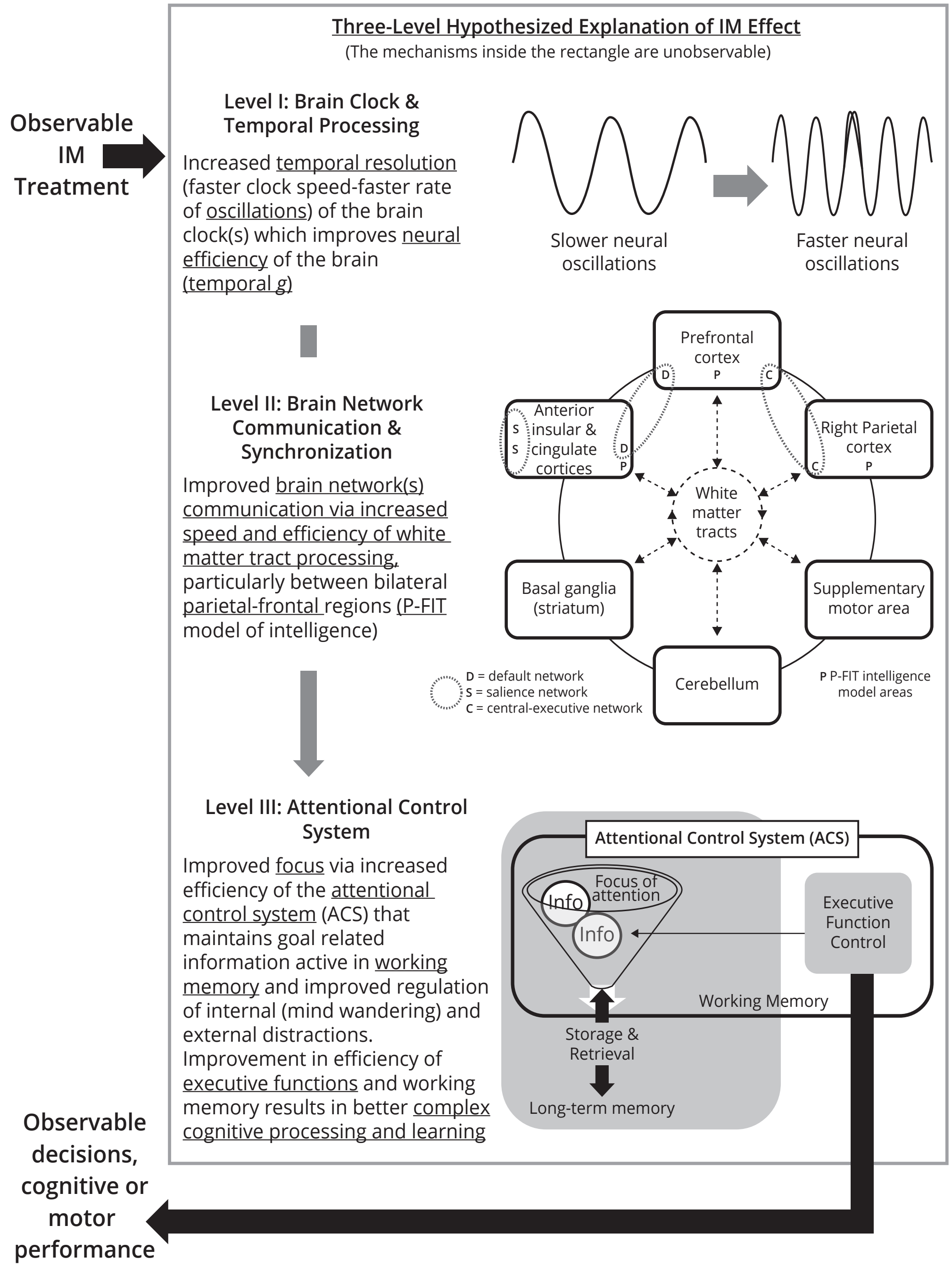
COMPLETE THE ADDITIONAL READING

9 minutes

In scientific literature, timing and rhythm training is referred to as *Synchronized Metronome Tapping*. There is much evidence to support the efficacy of Synchronized Metronome Tapping for enhancing skills like reading, mathematics, speech/articulation, language, social skills, attention, cognitive processing speed, working memory, auditory processing, motor coordination, balance, and gait. Areas of the brain responsible for these skills are part of the **neural timing network**, or what is referred to as our internal clock.



While there is documented benefit associated with incorporating music and rhythm in therapies and academic interventions (i.e., for focus or reading), **no other program or technology measures or provides feedback for millisecond timing.** The patented feedback system of IM is what sets it apart, accelerates outcomes, and helps you exceed expectations! Now, let's explore more of the science behind IM and what is referred to as the "IM Effect."



NOTES

IM TRAINING IMPROVES COGNITIVE PROCESSING & FOCUS

Cognitive focus plays a crucial role in success or failure at school, work, and in almost all aspects of human performance. Yet, few of us receive formal training on how to improve our focus *(or to control our attention).* Contemporary brain research has shed light on the nature of cognitive focus and has provided technology to train and maintain a "focused brain."

The human mind has a limited capacity to engage in laser-beam like focus or controlled attention—up to 20 to 30 minutes maximum. Current research defines focus (or controlled attention) as the ability to direct your attentional spotlight on only the information that is relevant to the task at hand and to information about this task contained in your mental workspace (working memory). Maintaining appropriate focus and keeping the key bits of information in working memory that pertain to successful completion of the task, while tuning out irrelevant distractions, requires constant monitoring and timely feedback to the attentional control center of the brain. When you are focused, cognitive control mechanisms work behind the scenes to constantly monitor performance and immediately detect interference. It is the job of the cognitive control mechanisms to deflect any outside distractions and internally self-generated mind wandering so that you can successfully maintain focus. Focus training can result in the "quieting of the busy mind."

It is believed that IM improves focus by improving the resolution and efficiency of your internal brain clock(s) and temporal processing (i.e., the rate of processing). In turn, this increased neural efficiency, which is hypothesized to result in more efficient brain connectivity, communication, and synchronization via increased integrity of the brains white matter tract communication system, produces more efficient communication between critical brain networks. In particular, research and theory suggests that IM training increases the efficacy of the parietal-frontal brain network, the brain network most associated with general intellectual functioning, working memory, controlled attention and executive functions.

IM training incrementally teaches you to focus exclusively on a target tone and deploy cognitive tools to deflect distractions, most likely through improvements in the efficiency of communication within the parietal-frontal brain regions. It is hypothesized that IM training results in enhanced ability to invoke on-demand-focus or controlled attention. The real-time millisecond feedback received during IM training requires you to develop the ability to block out external distractions and mind wandering—and thus, stay focused. Over time, and with sustained motivated practice, it is possible to train the brain to engage in increased on-demand focus (McGrew, 2012).

One of the most observable outcomes of IM training is better focus or controlled attention (affecting working memory and cognitive performance). Research suggests that this outcome likely occurs due to underlying changes in complex, critical brain and domain-general neurocognitive mechanisms produced by IM training. The effect on domain-general cognitive mechanisms produces results across a variety of performance domains, like reading, auditory processing, organizational skills, and motor coordination/control. This is referred to as the "IM Effect."

THE "IM EFFECT": IM TRAINING IMPACTS DIVERSE AREAS OF ABILITY AND PERFORMANCE

Interactive Metronome® (IM) research has reported positive IM effects for ADHD behavior, speech and language disorders, sports performance (golf and tennis), improvement of gait, reading achievement, stroke, and traumatic brain injury rehabilitation (Beckelhimer, Dalton, Richter and Harmann, 2011; Libkuman and Otani, 2002; McGrew and Vega, 2009; Nelson, 2012; Ritter, Colson and Park, 2013; Shaffer, Jacokes, Cassily, Greenspan, Tuchman and Stemmer, 2001; Sommer and Rönnqvist, 2009; Taub, McGrew and Keith, 2007). The diversity of domains positively impacted by IM technology begs the question—"how can a single neurotechnology produce positive outcomes across such a diverse range of human performance domains?" The only plausible scientific answer is that IM must be impacting a domain-general ("jack-of-all-trades") brain-based mechanism or set of mechanisms.

DOMAIN-SPECIFIC VERSUS DOMAIN-GENERAL BRAIN AND LEARNING MECHANISMS

NOTES

Most all children and adults have learned to ride a bike for recreational purposes. We have over-learned the act of cycling so we can bike with little in the way of deliberate thinking. We do not need to consciously tell each leg to move in a certain pattern, monitor how accurately our legs moved, tell our arms to turn the handle bars, etc. The resources of our immediate memory are free to observe others walking nearby, look at the interesting decorations of a house, talk to our riding partner, think about work, etc.

If a person practiced recreational biking one hour a day for four weeks straight the person may improve his recreational biking behavior. However, one would not expect this recreational cycling practice to transfer to improvement in speaking, reading comprehension, work performance, or golf. This is an example of a circumscribed or compartmentalized set of skills or behaviors that have been over-learned (i.e., automatized) and that are under the control of a set of narrow *domain-specific* (i.e., recreational biking) *brain mechanisms.* Domain-specific mechanisms are specialized brain mechanisms that process only specific kinds of information dedicated to learning about a *particular area of knowledge* (Rakison and Yermolayeva, 2011). Domain-specific mechanisms are important for automatic, efficient human performance in many day-to-day environments but, in general, *improvement via training is typically restricted to improvement within the specific limited set of skills and behaviors.*

On the other hand, a **domain-general** mechanism is one that, if affected, results in changes in performance across multiple and diverse areas of human functioning. According to Rakison and Yermolayeva (2011), **domain-general mechanisms** are "processes that are both knowledge-universal and modality-universal in that the same mechanisms function across a wide range of knowledge areas and inputs" (p.135). Such an underlying brain-based mechanism is a "jack-of-all-trades" that can be applied to a wide range of novel problems and performance (Chiappe and McDonald, 2005). **The only viable explanation for the diversity of the IM effect is the hypothesis that IM is impacting a fundamental domain-general brain-based cognitive mechanism, network, or set of mechanisms and networks.**

More support for the concept of a **domain-general brain mechanism** is the finding that a variety of clinical disorders have been associated with poor brain clock timing and temporal processing. These include ADHD, dyslexia, age-related deficits and declines (e.g., Alzheimer's), motor coordination and production disorders (e.g., apraxia, cerebral palsy, gait disorders), Parkinson's disease, schizophrenia, speech and language disorders (e.g., dysfluency, aphasia, apraxia), traumatic brain injury (TBI), and autism (McGrew and Vega, 2009).

The convergence of research by mental timing scholars studying normal cognitive processes and research implicating the inefficiency of temporal processing in a variety of clinical disorders is consistent with the notion of a domain-general master internal brain clock (or systems of clocks). There is strong support for the hypothesis that IM training improves the resolution and efficiency of our internal brain clock(s), and therefore improves temporal processing (or the rate of processing). In turn, this increases neural efficiency. It is thought that greater neural efficiency results in more efficient brain connectivity, communication, and synchronization via increased integrity of the brains white matter tract communication system, producing more efficient communication between critical brain networks. In particular, research and theory suggests that IM training may be increasing the efficacy of the parietal-frontal brain network, the brain network most associated with general intellectual functioning, working memory, controlled attention and executive functions.

NOTE: *More comprehensive information can be found at www.interactivemetronome.com. Click on RESEARCH, then under The Science, click on Three-Level Hypothesized Explanation of the IM Effect, McGrew 2012). The proposed model draws from a broad and diverse set of contemporary research from multiple disciplines, such as cognitive psychology, neuropsychology, neuroscience, neurology, molecular psychology, biological psychology, the psychology of music, and the study of human intelligence. Additional research is needed to verify the current explanatory model, evaluate its utility to explain positive IM effect research in multiple domains, and to suggest necessary revisions and extensions.*

NOTES

IM IMPROVES MOTOR CONTROL AND COORDINATION

The neurological process of motor acquisition and the mastering of movement has been studied extensively. Understanding this process and how IM may affect this process builds the foundation of our practice and knowledge of the **IM Effect**. Recent studies have shown that multiple areas of the brain are involved in the acquisition and mastery of movement. "One important component of human motor learning is the assembly of different movements into sequential action.

Sequences of movements can be learned at multiple levels of representation. Functional imaging studies and transcortical magnetic stimulation (TMS) have begun to distinguish the separate neural systems that are involved in the cognitive, perceptual, motoric, and temporal aspects of learning" (Grafton et al., 1998). "In the past, motor areas of the brain were thought to be distinct from areas that control cognitive functions. However, over the last few years, those lines have blurred significantly and it is now recognized that areas such as the cerebellum and the basal ganglia influence both motor function and non-motor function" (Leisman and Melillo, 2010). It has also become apparent that it's not enough for different areas of the brain to be involved in motor learning but that the timing and quality of signals within the neural network of these areas are essential for effective motor control. "Because movements involve changes in muscle length over time, motor control and timing are inextricably related. Most movements involve the coordinated activation of agonist muscles to initiate motion and antagonist muscles as a brake. These activations require accurate timing on the order of tens of milliseconds. Indeed, pathologies that disrupt the timing between agonist and antagonist actions lead to dysmetric or inaccurate movements". "All sensory and motor processing ultimately relies on spatial-temporal patterns of action potentials" (Mauk and Buonomano, 2004).

Regions of the brain recruited during skill acquisition vary depending on the exact timing relative to performance of the training movements (Censor and Cohen, 2011). IM uniquely ties these inherent motor-involved areas of the brain together, and with timing and sequence training improve the process of motor performance and mastery. Willingham describes four processes that support motor-skill learning. He states that motor-skill learning should be differentiated from motor control. Motor control refers to the processes that support the planning and execution of movements. Motor skill learning refers to the increasing spatial and temporal accuracy of movements with practice. He goes on to say that recently, a number of researchers have proposed that motor-skill processes may grow directly out of motor-control processes; in other words, motor skill may be nothing more or less than the increasingly efficient operation of motor-control processes (Willingham, 1999).

Timing is essential for effective motor control. "There is a striking neuroanatomical overlap between the areas consistently recruited by timing tasks and those traditionally implicated in the processes of motor selection and preparation. These two processes also overlap from a neurochemical point of view, with the dopaminergic D2 receptor system being implicated in both timing and motor function" (Coull et al., 2011). The inherent nature of the Interactive Metronome® system with a "timing" based motor response and temporal processing of sensory information with movement has the potential to develop motor control and then through repetition and organization, develop motor skills.

Motor control refers to the mechanisms underlying skilled behavior, including neural, physical, and behavioral mechanisms (Sage, 1984). Motor control is the study of the nature and causes of movement and involves the human's ability to fixate the body (postural control) and to move the body (balance) (Berg-McCormack and Riske-Perrin, 1997). It involves organization of the central nervous system (CNS) so that individual muscles and joints become coordinated and sensory information from the environment and/or the body used to control movement, allow people to select a movement for a specific goal (Heuer & Schmidt,1988). Motor control arises from interactions among cognitive, perceptual, and motor systems within a person and from interactions of the person with the task and the environment (Shumway-Cook and Woollacott, 1995).

The motor control system is dependent on feedback and timing to improve its efficiency. There are two types of feedback: intrinsic and extrinsic (Schmidt, 1991). Intrinsic feedback is the sensory information provided internally to a person as a result of movement. This includes somatosensory information from joints, as well as visual and auditory information. Extrinsic feedback is from an external source, such as a therapist or equipment (i.e., biofeedback). Extrinsic feedback can be given concurrently with the task or at the end of the task (terminal feedback) (Schmidt, 1988). Feedback increases the rate of improvement of a new task, enhances performance on tasks that are over-learned, and increases the frequency of reports that tasks seem less fatiguing and are more interesting with feedback than without feedback (Sage, 1984). Practice and feedback are considered to be the two most important factors in skill acquisition (Schmidt, 1988; Schmidt, 1991; Sage, 1984; Shumway-Cook and Woollacott, 1995).

Repetition and improved efficiency of the motor control pathways "free up" the active working memory and cognitive resources for planning and more complex motor tasks such as writing, playground activities, driving and sports performance. Practice can be purposefully repetitive when the intent is to try to repeat a movement directed at improving one's skill in order to increase efficiency and effectiveness and decrease the likelihood of undesirable outcomes (Ezekiel, et al., 2000). Following their initial acquisition through training, motor skills are consolidated into a more stable state, resistant to interference (Brashers-Krug et al. 1996).

Interactive Metronome® has all the key ingredients to facilitate motor control and learning, by activating the areas of the brain involved in motor performance and engaging the timing centers of the brain. Through repetition and feedback, the efficiency and effectiveness of the communication between these areas of the brain are improved. Long-term potentiation and the myelination of the white matter tracts between these areas of the brain is therefore elicited, and the process of motor control and learning automated.

CANDIDATES FOR IM TRAINING

Individuals of all ages, from infants to the elderly, benefit from improving timing and rhythm to facilitate development and rehabilitate cognitive, communicative, sensory, and motor skills. Scientists have studied the brains of individuals with several common conditions and have determined that impaired temporal processing (or poor synchronization of neural networks in the brain) underlies many of the observable symptoms of these conditions: ADHD, Autism, Dyslexia and other reading disorders, Auditory Processing Disorder, Tourette, and Parkinson's.

Timing & rhythm degrades as we age affecting sensory, motor, and cognitive abilities. In particular, impairment in temporal resolution results in reduced ability to process rapid events impacting safety, driving, decision-making speed, processing speech (especially in noise), memory, and other abilities. With training to improve timing and synchronization, measurable gains are observed in cognitive and perceptual skills compared to individuals who do not undergo such training (Anderson et al, 2012).

ABILITIES IMPACTED BY NEURAL TIMING & SYNCHRONIZATION

COGNITIVE ABILITIES

- executive functions
- attentional control
- initiation
- behavioral self-regulation
- self-monitoring
- self-correction
- problem-solving
- attention
- focused
- shifting
- selective
- divided
- working memory
- cognitive processing speed
- cognitive stamina
- planning, organizing and sequencing
- time-management

NOTES

SPEECH & LANGUAGE SKILLS

- auditory processing
- receptive language
- expressive oral and written language
- reading comprehension and fluency
- articulation and speech intelligibility
- phonological processing
- motor speech (apraxia)
- thought organization

BEHAVIORAL SKILLS

- conversational skills
- eye-contact
- reciprocal social interactions (timing, turn-taking, humor)
- impulse control
- aggression
- hyperactivity
- disinhibition
- affect and vocal inflection

SENSORY PROCESSING

- sensory over-responsivity
- sensory under-responsivity
- sensory-seeking behavior
- sensory discrimination
- sensory-based motor skills
    - *praxis*
    - *posture*

MOTOR SKILLS

- motor planning and sequencing (praxis)
- coordination
- balance
- gait
- posture
- functional mobility
- ADLs and IADLs
- handwriting
- functional use of hemiplegic limb(s)
- functional use of prosthetic limb(s)

ACADEMIC PERFORMANCE

- reading rate, fluency and comprehension
- mathematics
- attention to relevant information, to class work, and to teacher during instruction
- comprehension of verbal instructions and class lectures
- thought organization and attention to spelling and punctuation for writing
- thought organization for oral presentations
- timely completion of assignments and tests
- sequencing and organizational skills

ATHLETIC PERFORMANCE

- coordination
- mental processing speed and decision-making
- real-time monitoring of cognitive and physical actions
- ability to apply intense focus for extended periods of time
- ability to filter out internal and external distractions
- mental and physical endurance

LOG YOUR ACTIVITY TIME HERE!

READING END TIME

_________ AM/PM

TOTAL VIDEO ACTIVITY TIME (IN MINUTES)

_________ MIN.

ESTIMATED TOTAL TIME FOR THIS ACTIVITY IS 9 MINUTES

TAKE THE ONLINE POST-TEST & EVALUATION FOR MODULE 1

5 minutes

To view the course materials for this Module visit:
https://www.interactivemetronome.com/im-ondemand-certification-coaching-materials/module-1

CONTACT US WITH ANY QUESTIONS

Interactive Metronome, Inc.
13798 NW 4th St., Suite 300
Sunrise, FL 33325

Toll Free: 877-994-6776, Phone: 954-385-4660

Clinical Support:
clinicaled@interactivemetronome.com

Education Support:
education@interactivemetronome.com

Technical Support:
support@interactivemetronone.com

NOTES

DON'T FORGET TO REFERENCE YOUR NOTES FOR THE TIME LOGGED ACTIVITIES IN THIS MODULE, WHICH WILL BE ASKED IN THE EVALUATION.