interactive metronome®

Accelerate Outcomes.
Exceed Expectations.

Introduction to Interactive Metronome: Professional Application in Hospitals, Clinics, and Schools

Amy Vega, MS, CCC-SLP

Interactive Metronome

Clinical Education Director

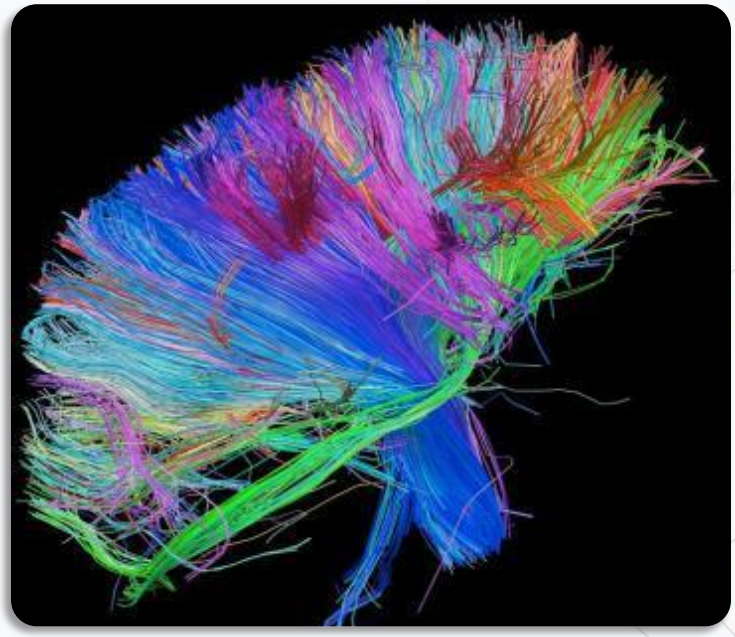
Demonstration of the Interactive Metronome

Video

Who Benefits from IM?

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

Neural Synchronization



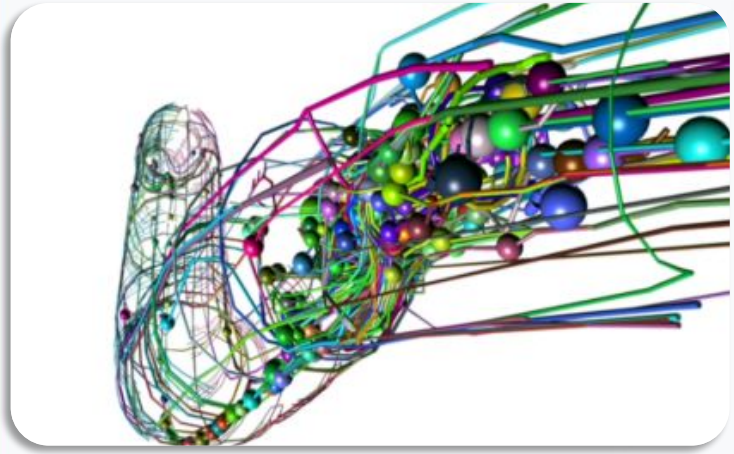
Poor timing & synchronization… at the center of it all

- Attention
- Information processing
- Working memory
- Speech & language
- Reading & learning
- Self-regulation & other executive functions
- Sensory processing
- Handwriting
- Motor coordination
- Balance

Interactive Metronome Training Goals

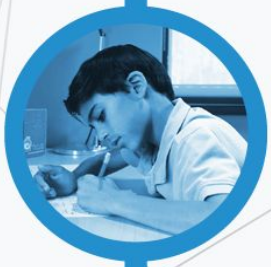
1. **Improve neural timing & decrease neural timing variability (jitter) that impacts speech, language, cognitive, motor, & academic performance**

Interactive Metronome Training Goals



2. **Build more efficient & synchronized connections between neural networks**






Interactive Metronome Training Goals

3. **Increase the brain's efficiency & performance & ability to benefit more from other rehabilitation & academic interventions**

Interactive Metronome Hardware

- Master Control Unit with USB cord
- Headphones
- Button Switch
- Tap Mat
- In-Motion Insole Triggers (IM Pro only)

IM Universe Software

- Objective assessment & training tool
- Engaging & fun
- Reports & graphs
- Adjustable settings

Video

IM Exercises

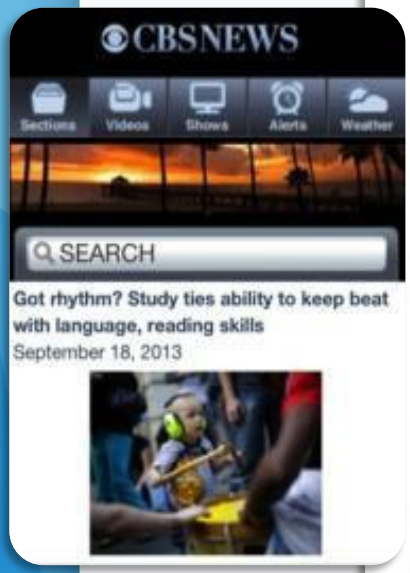
Video

Interactive Metronome

Different from a Metronome, Music, & Pacing

- **FEEDBACK to improve "internal" timing & rhythm**
- **Adjustable settings (tempo, feedback parameters, volume, visual displays/cues…)**
- **Steady, rhythmical beat**
- **Intensity of training & repetition**
- **Cognitively engaging & rewarding experience**

Auditory-Motor Synchronization Impacts Auditory Processing, Language & Motor Skills



The Journal of Neuroscience, September 18, 2013 • 33(38):14981–14988 • 14981

Behavioral/Cognitive

The Ability to Move to a Beat Is Linked to the Consistency of Neural Responses to Sound

Adam Tierney[1,2] **and Nina Kraus**[1,2,3,4,5]

[1]Auditory Neuroscience Laboratory, [2]Communication Sciences, [3]Institute for Neuroscience, [4]Neurobiology and Physiology, and [5]Otolaryngology, Northwestern University, Evanston, Illinois 60208

The ability to synchronize movement to a steady beat is a fundamental skill underlying musical performance and has been studied for decades as a model of sensorimotor synchronization. Nevertheless, little is known about the neural correlates of individual differences in the ability to synchronize to a beat. In particular, links between auditory-motor synchronization ability and characteristics of the brain's response to sound have not yet been explored. Given direct connections between the inferior colliculus (IC) and subcortical motor structures, we hypothesized that consistency of the neural response to sound within the IC is linked to the ability to tap consistently to a beat. Here, we show that adolescent humans who demonstrate less variability when tapping to a beat have auditory brainstem responses that are less variable as well. One of the sources of this enhanced consistency in subjects who can steadily tap to a beat may be decreased variability in the timing of the response, as these subjects also show greater between-trial phase-locking in the auditory brainstem response. Thus, musical training with a heavy emphasis on synchronization of movement to musical beats may improve auditory neural synchrony, potentially benefiting children with auditory-based language impairments characterized by excessively variable neural responses.

www.brainvolts.northwestern.edu

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

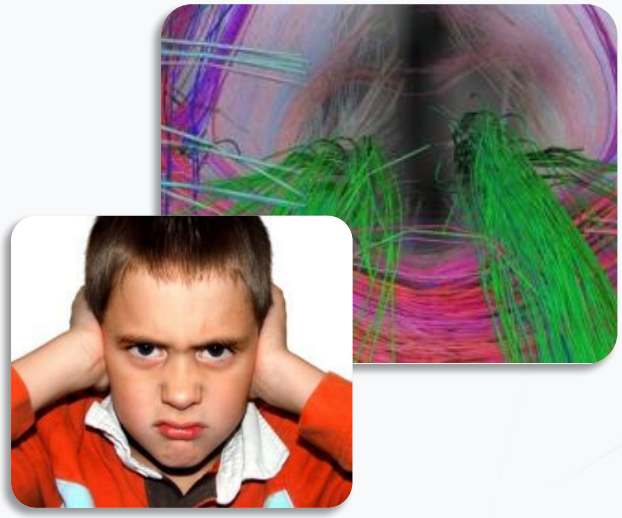
AUTISM

Wan & Schlaug (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.

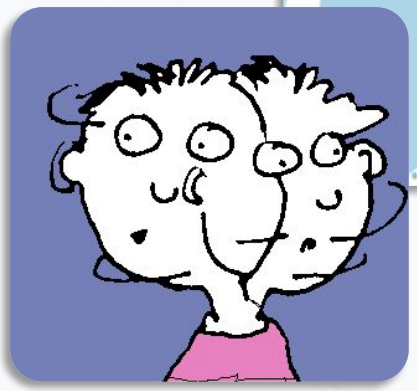
Toddlers with autism exhibited significantly weaker interhemispheric synchronization (i.e., weak "functional connectivity" across the two hemispheres)

Disrupted cortical synchronization appears to be a notable characteristic of autism neurophysiology that is evident at very early stages of autism development.

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. Americal 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



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

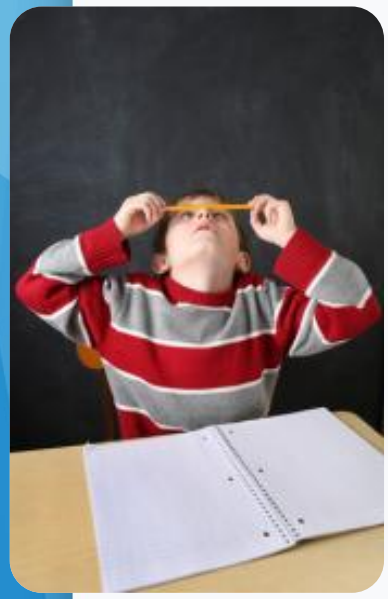
58 tests/subtests

- Attention & concentration
- Clinical functioning
- Sensory & motor functioning
- Academic & cognitive skills

Interactive Metronome group

- Statistically significant improvements on 53 of 58 tests ($p \leq 0.0001\%$)

Brian



TEST OF AUDITORY PROCESSING SKILLS	PRE	POST
OVERALL SCORES		
Phonological Skills	55th	86th

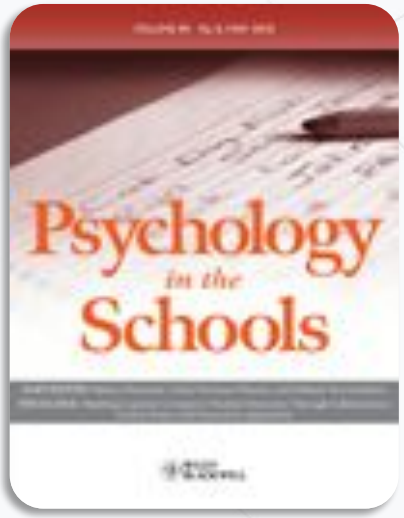
TEST OF EVERYDAY ATTENTION IN CHILDREN	PRE	POST
Sustained-Divided Attention	> 0.2nd	96.7 – 98.5th
Selective-Focused Attention	12.2 – 20.2nd	56.6 – 69.2nd
Sustained Attention	0.2 – 0.6th	30.9 – 43.4th

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

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



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)

Video

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 (as mentioned above).

- **While both groups demonstrated improvement, gains in the IM group were more substantial (to a level of statistical significance).**
  - "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

SENSORY PROCESSING DISORDER

Video

CONGENITAL & DEVELOPMENTAL DISORDERS

- Emma, 18 months
- Aicardi Syndrome
- Agenesis of the Corpus Callosum (complete)
- Seizure Disorder
- Cerebral Palsy
- Failure to Thrive
- Global Developmental Delays

CONGENITAL & DEVELOPMENTAL DISORDERS

Video

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.

TRAUMATIC BRAIN INJURY PUBLISHED RESULTS

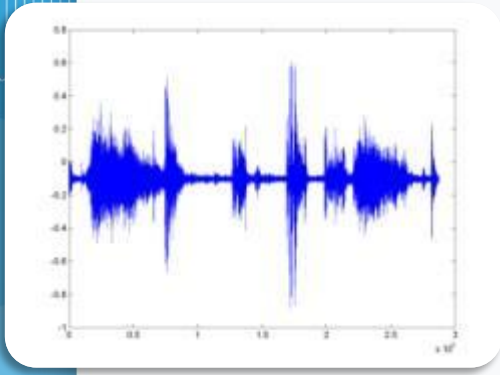
ASSESSMENT	SKILLS MEASURED	OUTCOME
DKEFS: Color Word Interference	Attention, response inhibition	Cohen's d= .804 LARGE p=.0001
RBANS Attention Index	Auditory attention, auditory memory & processing speed	Cohen's d= .511 LARGE p=.004
RBANS Immediate Memory Index	Auditory attention, auditory memory & processing 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)

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



APHASIA

"…fundamental problems in processing the temporal form or microstructure of sounds characterized by rapidly changing onset dynamics."

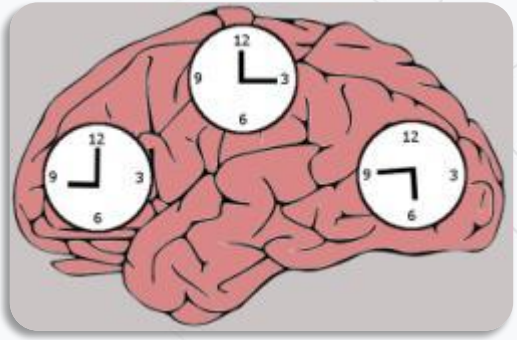
Stefanatos et al (2007)

"…auditory timing deficits may account, at least partially, for impairments in speech processing."

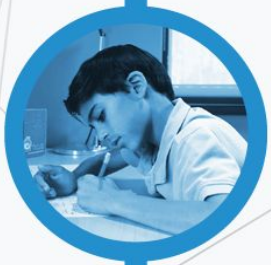
Sidiropoulos et al (2010)

"…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 (2013)



Kelly



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

BALANCE & GAIT

IM In-Motion

- **The smooth transition between phases of the gait cycle is an integrated activity that is difficult to learn through practice of individual parts.**
- The only true way to practice walking is to walk.
- **Goals for gait training with IM in-motion trigger:**
  - improve biomechanics
  - alter gait speed
  - increase stride length…

Video

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."

Video

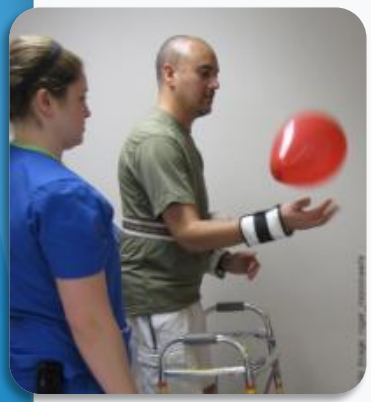
Interactive Metronome & Motor Learning

- **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

Cognitive Engagement

Early stages of motor learning during Interactive Metronome training are mainly cognitive.

Motor learning at this stage involves the conscious thought process of figuring out how, when, and what movements are needed to facilitate action.



functional Repetitive ^ Practice

Motor Learning…

- Cannot be achieved without repetitive practice
- As learning occurs, the motor skill becomes more automated and the cognitive demand is decreased

- **The individual will perform 10's of 1,000's more repetitions during Interactive Metronome than he would during traditional OT or PT therapies.**
- **Interactive Metronome exercises can be tailored to address specific, functional movement patterns.**

Feedback

Knowledge of Results

- **Specific scores are provided at the end of each exercise & can be compared to previous scores**
  - Millisecond average
  - Millisecond variability
  - Bursts (perfect consecutive hits)
  - IAR (highest number of perfect consecutive hits)
- **Scores enable the person to monitor progress toward movement goals over time**

Feedback

- **Feedback provided in real-time (for each trigger hit) about the timing, rhythm & quality of movement**
  - Auditory and/or visual guides provide immediate feedback so that the person can make online corrections for attention and motor planning & sequencing
  - The challenge with providing KNOWLEDGE OF PERFORMANCE feedback is speed! Typically, by the time a therapist has said something, *the motor plan has passed.*

Knowledge of Performance

FALL RISK REDUCTION COACHING & CERTIFICATION

Musculoskeletal

Proprioceptive

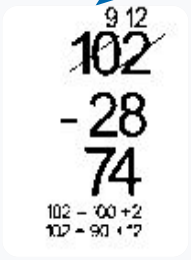
Occulomotor

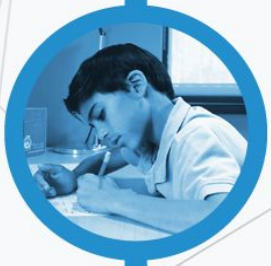
Vestibular

Cognitive

Communication

Interactive Metronome & Domain-General Learning Mechanisms





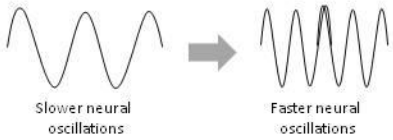
Three-Level Hypothesized Explanation of IM effect

(The mechanisms inside the rectangle are unobservable)

Observable IM treatment

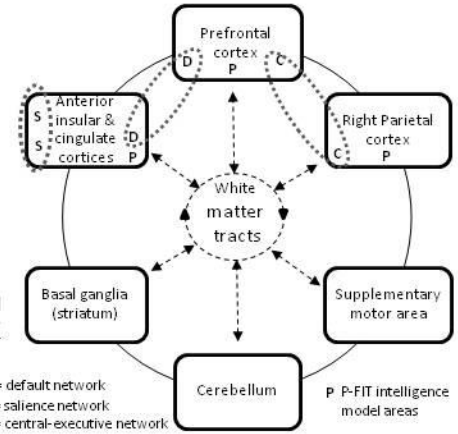
Level 1: Brain Clock & Temporal Processing

Increased temporal resolution (faster clock speed–faster rate of oscillations) of the brain clock(s) which improves neural efficiency of the brain (temporal *g*)



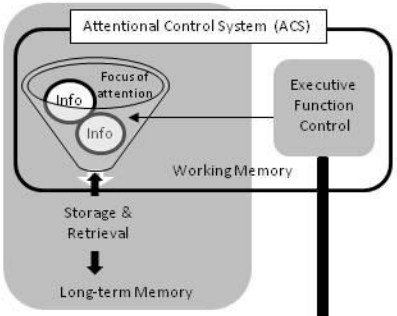
Level II: Brain Network Communication & Synchronization

Improved brain network(s) communication via increased speed and efficiency of white matter tract processing, particularly between bilateral parietal-frontal regions (P-FIT model of intelligence)



Level III: Attentional Control System

Improved focus via increased efficiency of the attentional control system (ACS) that maintains goal related information active in working memory and improved regulation of internal (mind wandering) and external distractions. Improvement in efficiency of executive functions and working memory results in better complex cognitive processing and learning



Observable decisions, cognitive or motor performance

Full report available at:

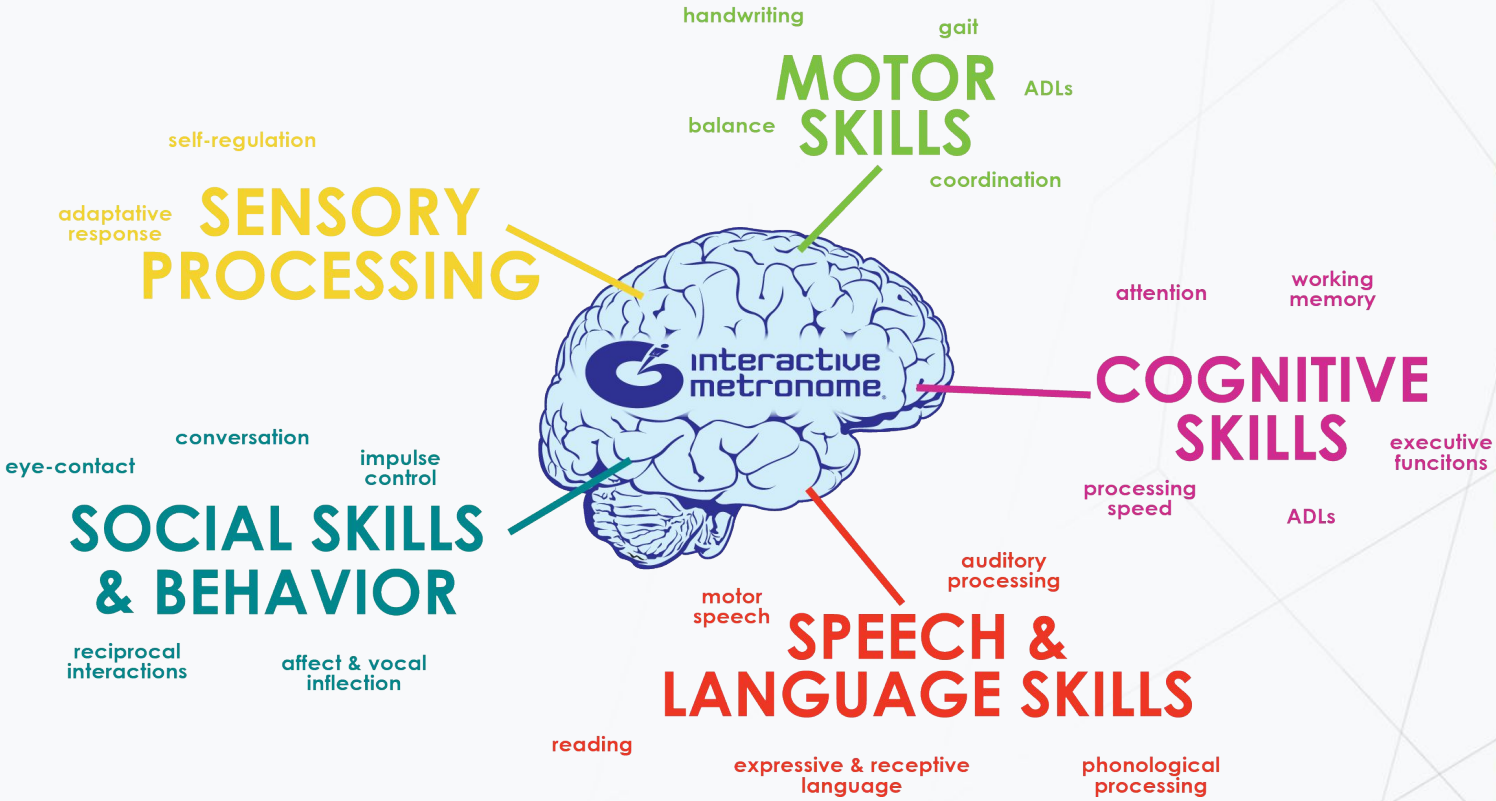
The MindHub

www.interactivemetronome.com

Click on SCIENCE

Interactive Metronome® is dedicated to improving NeuroTiming®

interactive metronome


handwriting
gait
MOTOR SKILLS
ADLs
balance
coordination
self-regulation
adaptative response
SENSORY PROCESSING
interactive metronome
attention
working memory
COGNITIVE SKILLS
executive funcitons
processing speed
ADLs
conversation
eye-contact
impulse control
SOCIAL SKILLS & BEHAVIOR
reciprocal interactions
affect & vocal inflection
auditory processing
motor speech
SPEECH & LANGUAGE SKILLS
reading
expressive & receptive language
phonological processing

FREQUENCY & DOSAGE

- **FREQUENCY:**
  - Inpatient rehab: daily
  - Outpatient rehab, clinics & schools: 3x/week
- **DOSAGE:**
  - Inpatient rehab: 15-20 min/day
  - Outpatient rehab, clinics & schools: 15-60 min/day
- **DURATION:**
  - Inpatient rehab: 2-4 wks, continued as outpatient
  - Outpatient rehab, clinics & schools: 8 – 12 wks (15+ training sessions)

Insurance Reimbursement for Allied Health Professionals

- **IM is a treatment modality & does not have its own CPT code**
- **Prescription & insurance authorization for evaluation and treatment**
- **Bill customary charges:**
  - Speech and language therapy
  - Cognitive development
  - Therapeutic activities
  - Therapeutic exercise
  - Gait training
  - Neuromuscular re-education
  - Individual psychotherapy…

Kelly

Video

IM Education

- Certification
- Specialization Tracks
- Coaching Programs
- 100+ OnDemand Course Library
- Badges to promote & market your education accomplishments

Contact Information

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