

Interactive Metronome®-Why Is Timing So Important?

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Objectives

- ▶ Discuss the research related to Interactive Metronome®.
- ▶ Provide the goals of Interactive Metronome®.
- ▶ Describe how Interactive Metronome® is a valuable therapy tool for assessment & treatment of patients suffering with a brain injury or other diagnoses.

What is Interactive Metronome®?

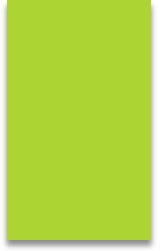
An assessment and treatment tool that helps to re-set the brain's internal timing, rhythm, and synchronization for improved cognitive and motor functioning.



"Our brains measure time continuously. We are aware of how long we have been doing a particular thing, how long it has been since we last slept, and how long it will be until lunch or dinner. We are ready, at any moment, to make complex movements requiring muscle coordination with microsecond accuracy, or to decode temporally complex auditory signals in the form of speech or music. Our timing abilities are impressive, diverse, and worthy of investigation."

(Lewis & Walsh, 2005)



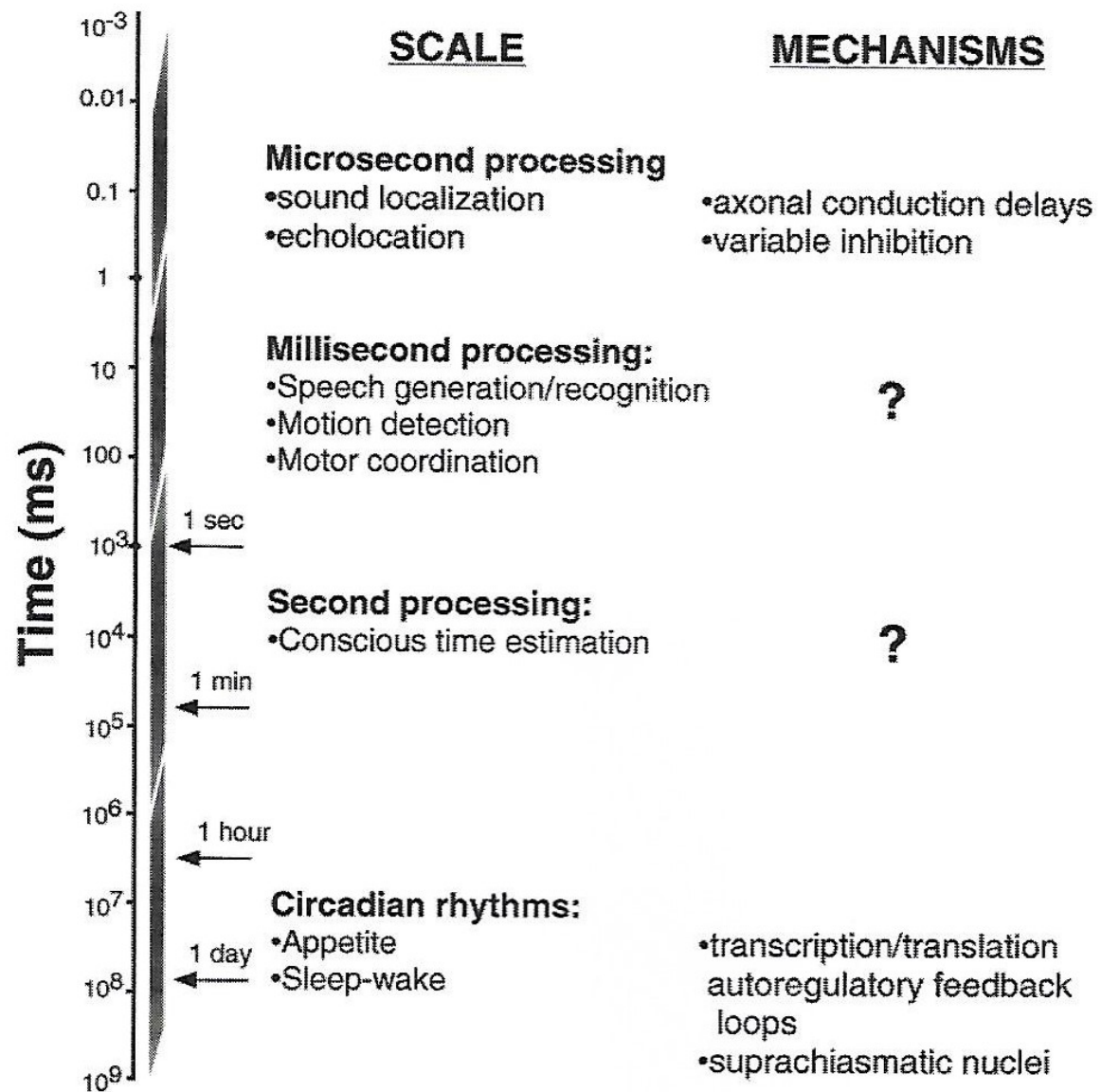


Spatial processing: “processing of stimuli defined by which sensory neurons are activated”
For example, what we see or feel.

Temporal processing: “...the decoding of temporal information or the generation of timed motor responses. In its simplest form, temporal processing may consist of neurons that respond selectively to the interval between two events”
For example, the duration/interval between two sounds.

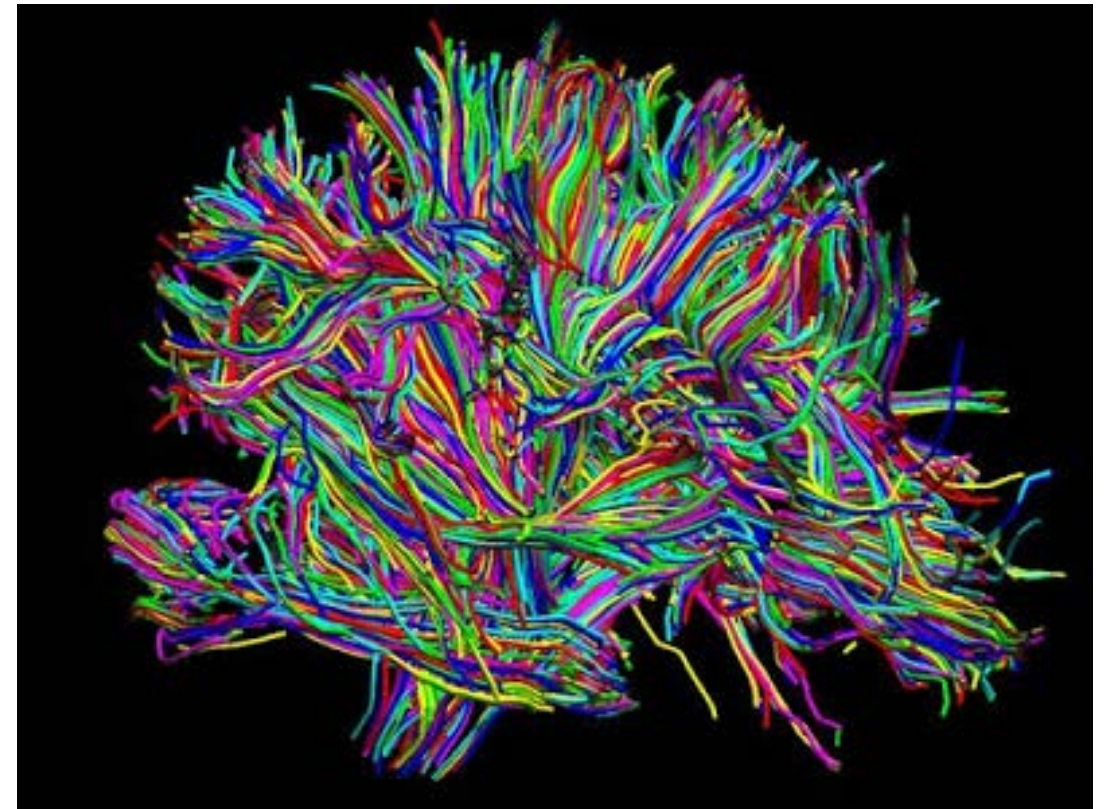
Most everything we do involves spatial-temporal processing and it is critical to sensory & motor timing.

Timescales of Temporal Processing



How does all of this processing happen?

- ▶ Initially, specific areas of the brain were thought to work independently to complete cognitive & motor tasks.
- ▶ “Contemporary neuroscience now recognizes that the human brain processes information via different brain circuits or loops, which at a higher level are studied as large-scale brain networks...Large-scale brain network research suggests that cognitive, sensory and motor functioning is the result of communication between different brain systems distributed throughout the brain.” (McGrew, 2013)



(Image: David Shattuck, Arthur Toga, Paul Thompson/UCLA Lab of Neuro Imaging)

Neurons

Cells within the nervous system that communicate electrical and chemical signals.

Synapse is the point where two neurons meet for transmission of these signals.

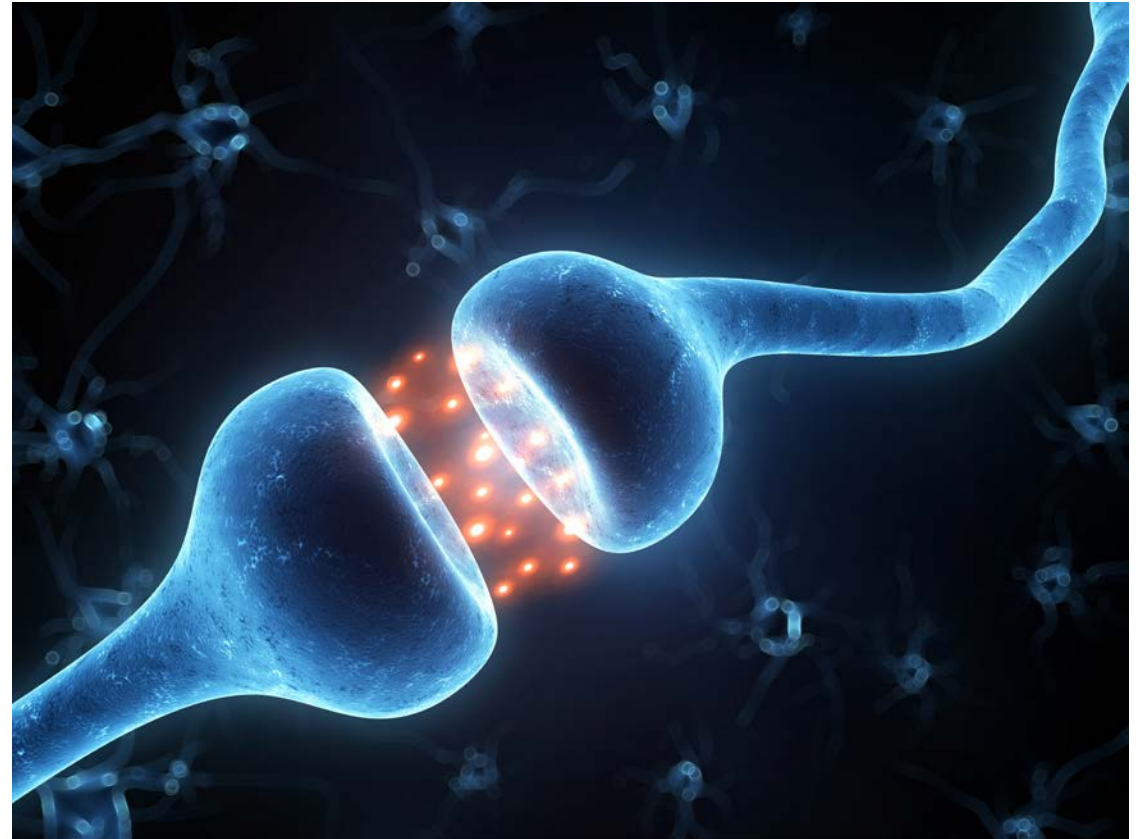


Neuroplasticity

"...the brain's ability to change and reorganize in response to some change in input from internal or external sources." (Clifford, 1999)

Hebbian plasticity: When neuron synapses fire together, connections are strengthened and when they don't, the connections are weakened.

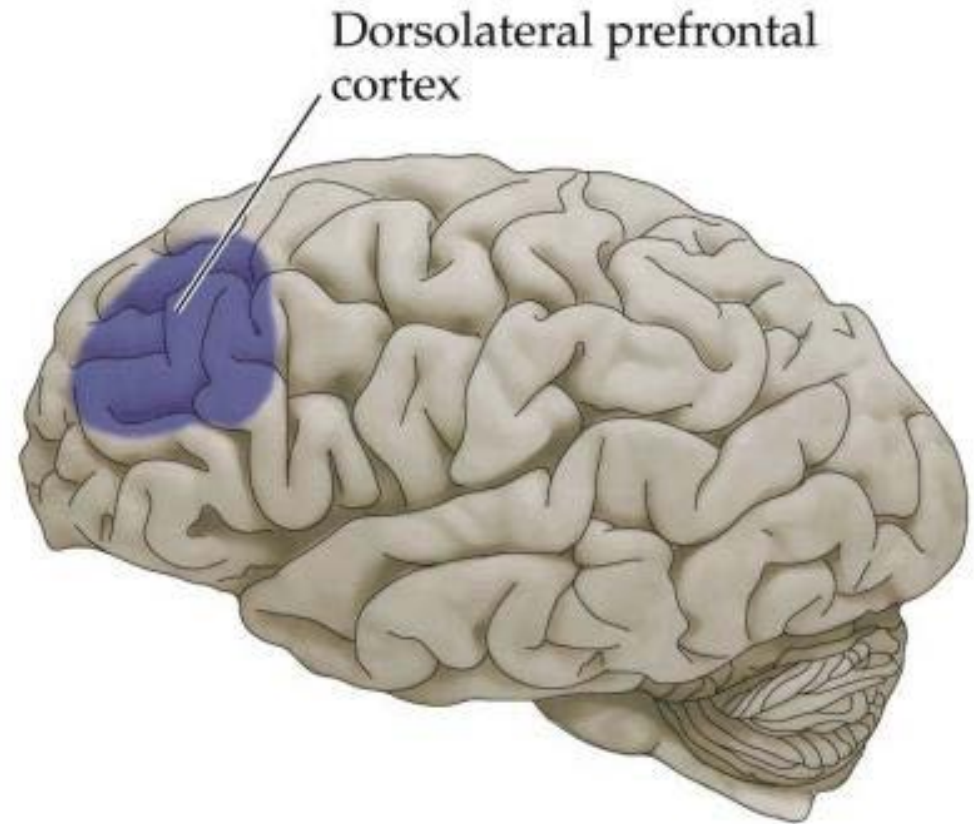
"What fires together, is wired together."



Dorso-Lateral Pre-Frontal Cortex

- Executive Functions-
planning, organizing
- Working memory
- Attention
- Inhibition
- Timing

(Buhusi & Meck 2005, Rao, Mayer, & Harrington, 2001, Rubia & Smith 2004)



(Image:<https://www.quora.com/Neuroanatomy-What-are-the-primary-functions-of-the-dorsolateral-prefrontal-cortex>)

Basal Ganglia

- Motor planning & movement
- Working memory
- Procedural learning
- Initiative
- Timing

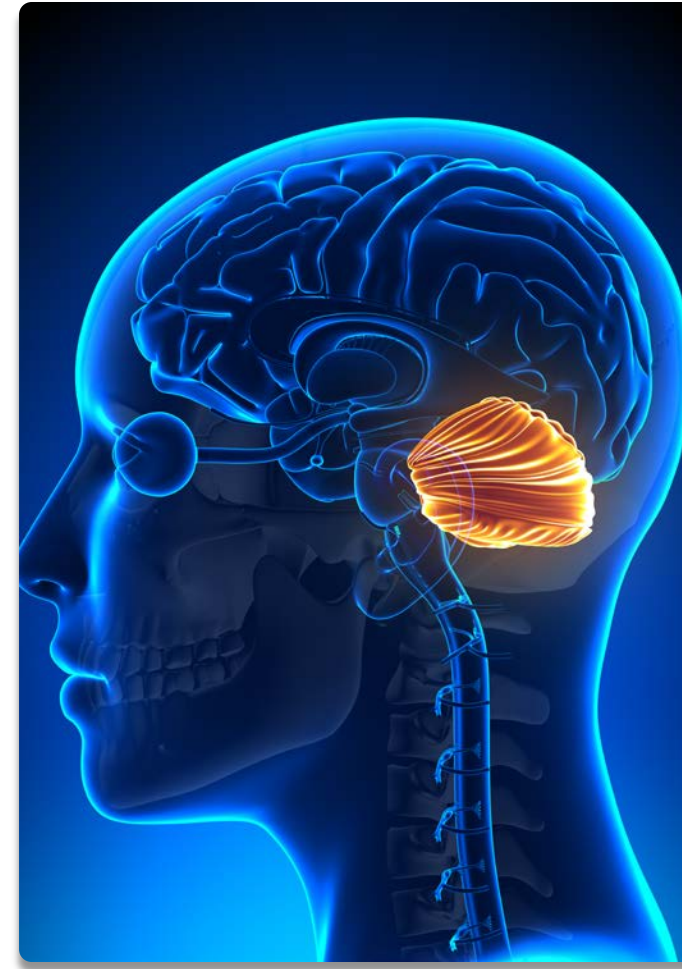
(Alpinar 2004, Buhusi & Meck 2005, Ferrandez, Hugueville, Lehericy, Poline, Marsault, & Pouthas, 2003, Mauk & Buonomano 2004, McGrew 2013, Rubia & Smith 2004)



Cerebellum

- Balance, posture
- Speech Production
- Timing

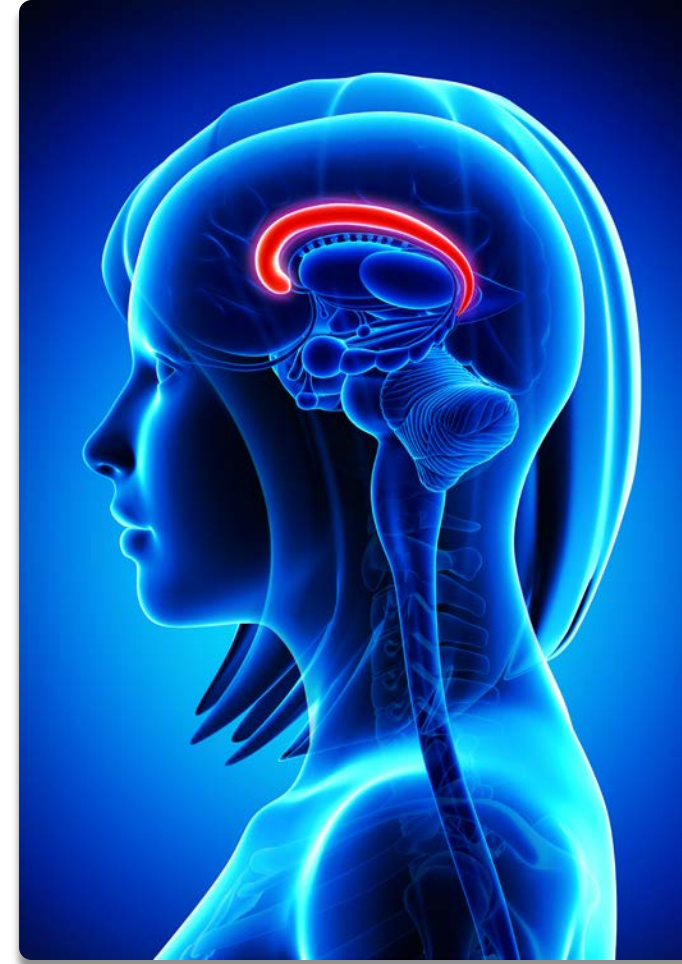
(Bengtsson, Ullen, Ehrsson, Hashimoto, Kito, Naito, Forssberg, & Sadato, 2009, Buhusi & Meck 2005, Mauk & Buonomano 2004, McGrew 2013, Rao, et al 2001, Rubia & Smith 2004)



Anterior Cingulate Cortex

- Error detection
- Attention
- Motivation
- Emotion
- Timing

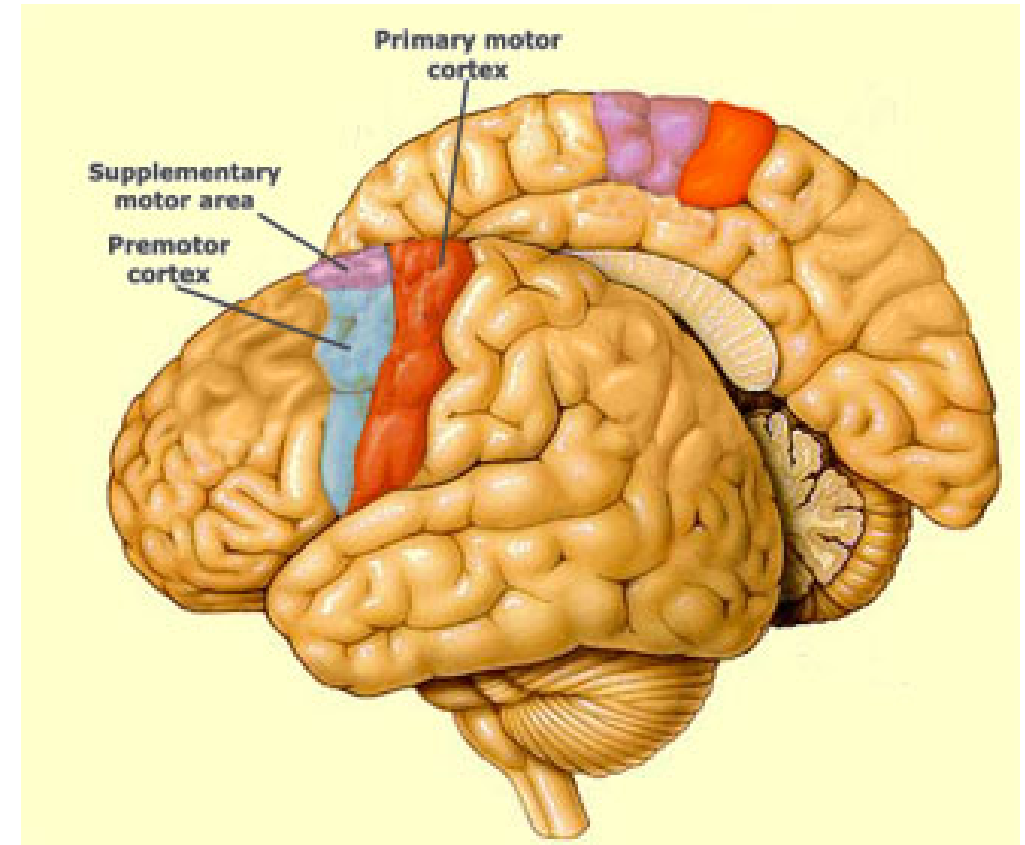
(Alpiner 2004, Macar, Lejeune, Bonnet, Ferrara, Pouthas, Vidal, & Maquet, 2002, Rubia, Overmeyer, Taylor, Brammer, Williams, Simmons, Andrew, & Bullmore, 1998, Rubia & Smith 2004)



Supplementary Motor Area

- Control of postural stability
- Self-initiated actions
- Coordinating movement with both hands
- Timing

(Bengtsson, et al 2009, Buhusi & Meck 2005, Ferrandez et al, 2003, Macar, et al 2002, Rubia, et al 1998, Rubia & Smith 2004)



(Image:http://thebrain.mcgill.ca/flash/i/i_06/i_06_cr/i_06_cr_mou/i_06_cr_mou.html)

The Role of fMRI in Defining Auditory-Motor Processing Networks

Dr. Neal Alpin, 2004

Those with IM training showed increased activity in the following areas:

- 5/7 right calcarine sulcus
- 3/7 bilateral cingulate gyrus
- 5/7 left posterior temporal gyrus
- 2/7 bilateral temporal activity
- 3/7 right superior frontal gyrus
- 4/7 left superior frontal gyrus; 1 having bilateral activation
- 3/7 left posterior central gyrus

The one patient without IM training, had absent activity.



Ability to Move to a Beat Linked to the Consistency of Neural Response to Sound

- ▶ Inferior colliculus, the channel for nearly all sound, appeared to play a role in timing
- ▶ Variability in synchronized tapping and cABR (complex auditory brainstem response) were linked
- ▶ Poor synchronized tapping related to more neural jitter
- ▶ Good synchronized tapping related to less neural jitter
- ▶ Shared neural pathways for auditory processing and motor planning
- ▶ "...it is possible that training in rhythmic abilities including beat synchronization practice could lead to a more stable neural representation of sound, in addition to improving linguistic skills, such as phonological awareness and reading."

IM Training in Children with ADHD

- ▶ 56 boys, age 6-12.5 years, with a diagnosis of ADHD
- ▶ Divided into 3 groups
- ▶ IM group received 15 one hour IM sessions over 3-5 weeks
- ▶ Video group received 15 one hour sessions over 3-5 weeks
- ▶ Control group participated in recess
- ▶ They were pre- and post-tested at the same time of day to control for med schedules and circadian rhythms
- ▶ Control group showed improvement on 28/58 and declined on 30/58 suggesting no significant combined directional pattern
- ▶ IM group showed improvement on 53/58 tests –video group improvement on 40/58 tests
- ▶ Only the parents of the IM group rated their children as significantly less aggressive

(Shaffer, Jacokes, Cassily, Greenspan, Tuchman, & Stemmer, 2001)

Reading Intervention in Children with Language & Reading Impairments-Baylor University

- ▶ 49 school-age children, grades 2-5, diagnosed with co-occurring language & reading impairments
- ▶ Looked at the difference in reading fluency & reading comprehension for those who did and did not receive IM training along with standard intervention
- ▶ IM group received 15 minutes of IM each day for a total of 4 hours over 4 weeks
- ▶ All received 48 hours of standard language & reading intervention
- ▶ Both groups made gains, but the IM group outperformed the control group

(Ritter, Colson, & Park 2012)

Effects of IM on Mathematical Achievement

- ▶ 86 school-age children, grades 1-4
- ▶ IM group received 18 daily sessions approximately 50 minutes in length, over 4 weeks
- ▶ Control group participated in recess
- ▶ Using the WJ III Calculation and Math Fluency tests, those in the IM group, "completed, on average, more mathematic problems, were more accurate in their math problem solving, and completed the mathematic problems faster than the control group."
- ▶ Both groups made statistically significant gains; however, IM group had 12% growth compared with standard growth

(Taub, McGrew, & Keith 2015)

Effects on Upper Extremity Function, ADL, and Quality of Life

- ▶ 30 stroke patients; greater than 6 months post
- ▶ IM group received 12 thirty minute sessions, 3x a week for 4 weeks
- ▶ Control group trained with Bilateral arm Self-Exercise (BSE) program
- ▶ More statistically significant differences in the total score of Manual Function Test and finger control time in the IM Group
- ▶ More statistically significant differences in total score of Modified Barthel Index and dressing item for IM group
- ▶ More statistically significant difference in the domain of self-help activities in Stroke Specific Quality of Life Scales in the IM group

(Yu, Lee, Kim, & Cha, 2017)

IM Training in Severe, Stroke-Induced Arm Hemiparesis

- ▶ 2 participants with severe arm hemiparesis
- ▶ 68 year old male with ischemic stroke 23 years prior
- ▶ 75 year old male with ischemic stroke 2 year 2 month prior
- ▶ Received therapy 3 x week for 4 weeks which included 30 minutes of IM use and then “a combination of purposeful and occupation-based activities for the final 25 min.” Activities were determined by the Canadian Occupational Performance Measure
- ▶ Reduced arm impairment and increases in average functional ability, perceived quality of life, and perception of overall recovery
- ▶ Both had clinically significant COPM score improvement

(Beckelhimer, Dalton, Richter, Hermann, & Page, 2011)

Effects of IM Therapy on Cognitive Functioning After Blast-Related Brain Injury: A Randomized Controlled Pilot Trial

Nelson, MacDonald, Stall, & Pazdan, 2013

- 46 active duty soldiers demonstrating cognitive difficulties after mild-to-moderate blast-related TBI
- IM group received 15 one hour sessions along with the standard treatment
- Control group received standard treatment

Assessment	Skills Measured	Outcome
DKEFS: Color Word Interference	Attention, response inhibition	Cohen's d= .804 LARGE
RBANS Attention Index	Auditory attention, auditory memory & processing speed	Cohen's d= .511 MED-LARGE
RBANS Immediate Memory Index	Auditory attention, auditory memory & processing speed	Cohen's d= .768 LARGE
RBANS Language Index	Confrontation naming, verbal fluency & processing speed	Cohen's d= .349 SMALL-MED
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= .478 MED
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 MED-LARGE
WAIS-IV Digits Sequencing	Auditory attention, working memory, cognitive flexibility, rote memory & learning	Cohen's d= .588 MED
DKEFS Trails: Motor Speed	Motor speed, executive functions	Cohen's d= .790 LARGE
DKEFS Trails: Letter Sequencing	Processing speed, working memory & executive functions	Cohen's d= .626 MED-LARGE
Group that received IM + TAU outperformed the control group that received only TAU on 21 of 26 assessments (p=.0001) (Nelson, MacDonald, et. al., 2013, https://www.slideshare.net/InteractiveMetronome/intro-im-proapp)		

Electrocortical Functioning Results

- ▶ EEG (Electroencephalogram), which shows neural activity by detecting simultaneous firing of neurons, was completed on participants
- ▶ Good with decision/inhibition processes
- ▶ Go/No-Go matching task was used
- ▶ Synchronized brain responses in the fronto-parietal areas changed more in IM group



Overall Outcomes

- ▶ EEG results “indicate enhanced functional connectivity of cortical operators following IM”
- ▶ “Clear evidence of brain plasticity and effect of building millisecond timing awareness and response-ability”
- ▶ “IM Therapy appears to improve cognition in these patients”

“May indicate:

- ▶ improved multi-sensory readiness
- ▶ more robust inhibitory networks
- ▶ better coordinated response production
- ▶ increased cortical endurance
- ▶ very possibly reflect re-establishment of white matter connections for these networks”

(Nelson, 2012)

“You don’t have to just teach compensatory strategies. You can actually try to get back what was lost. You can actually try to recover function.”

(Nelson, 2012)





And now the real
fun....How do we use IM?

Goals of IM

- Improve Neural timing/decrease timing variability
- Synchronize neural networks
- Improve the benefit of other interventions

(Interactive Metronome, Inc, 2016)



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