Allied Health Media SpeechPathology.com

Treatment to Improve Timing & Synchronization of Critical Neural Networks for Speech, Language, and Cognitive–Communicative Abilities

Presenter: Amy Vega, M.S., CCC-SLP

Moderated by:

Amy Hansen, M.A., CCC-SLP, Managing Editor, SpeechPathology.com

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3+ years SLP Professional Experience Required

Contact Amy Natho at anatho@speechpathology.com

interactive metronome

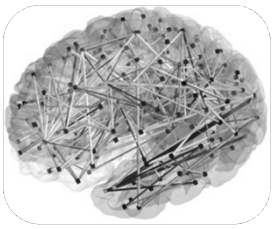
Accelerate Outcomes.
Exceed Expectations.

•Slide 5

Treatment to Improve Timing & Synchronization of Critical Neural Networks for Speech, Language, and Cognitive–Communicative Abilities

Amy Vega, MS, CCC-SLP
Interactive Metronome
Clinical Education Director

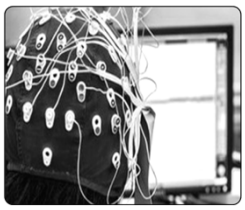
Interactive Metronome®

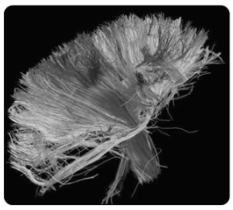


- Industry leading biometric technology
- Measures & improves human timing & synchronization of neural networks
- Bottom-up approach to SLP service delivery
- Evidence-based, objective, flexible, engaging & effective

•Slide 7

Neural Synchronization





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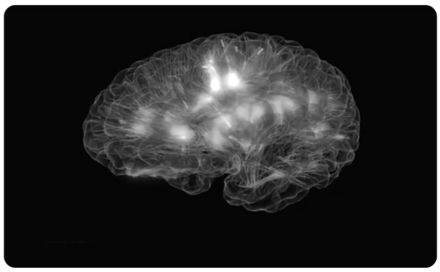
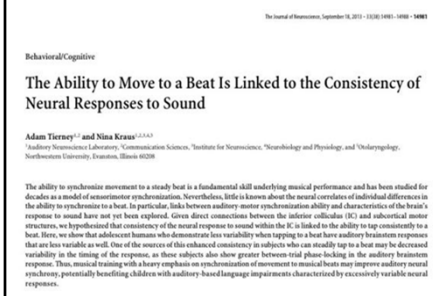
Glass Brain Paints Image of Activity in Real Time



http://www.youtube.com/watch?v=dAIQeTeMJ-I

Auditory-Motor Timing & Rhythm: Impact on SLP Service Delivery

Effect of timing on auditory processing *(Hornickel & Kraus, 2013; Tierney & Kraus, 2013)*


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

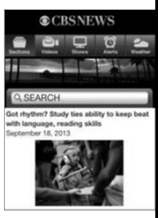
Behavioral/Cognitive

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.



•Slide 10

The Missing Piece in SLP Clinical Practice

- More efficient treatment
- More effective outcomes
- Prepares patient to benefit more from other SLP interventions
- Recovery versus compensation

•Slide 11

Hardware

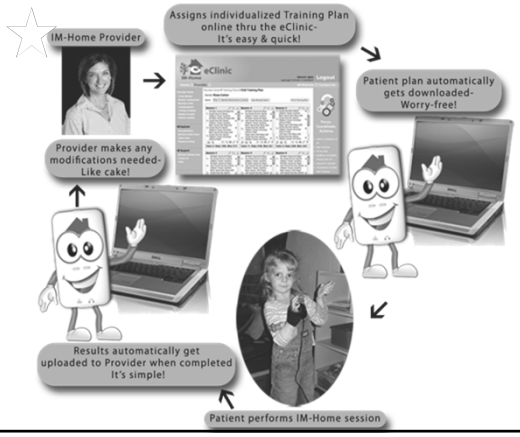
- **Master Control Unit** *with USB cord*
- **Headphones**
- **Button Switch**
- **Tap Mat**
- **In-Motion Insole Triggers** *(IM Pro only)*

•Slide 12

Software

- Biometric assessment & treatment tool
- Auditory-motor exercises to facilitate SLP treatment & outcomes
- Visual training tools
- Adjustable settings
- Engaging therapeutic games for children & adults
- Avatar builder

IM-Home & eClinic

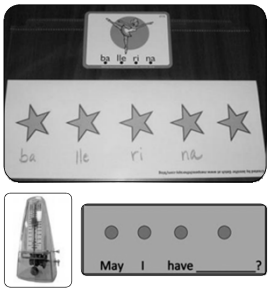


Demonstration

- Movie: Interactive Metronome Demo

Interactive Metronome

Different from a Metronome, Music, & Pacing



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

•Slide 16

AUTISM
Speech & Language

Wan, C.Y. & Schlaug, G. (2010). Neural pathways for language in autism: the potential for music-based treatments. Future Neurol. 2010 November; 5(6): 797–805

- **White matter tracts (arcuate fasciculus, extreme capsule and the uncinate fasciculus) 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.**

•Slide 17

AUTISM
Speech & Language

Nelson et al., 2013

- **Preliminary analysis of electrocortical data following 15 sessions of IM training in a randomized, controlled study showed that IM produced re-myelination & re-establishment of critical white matter tracts, including the arcuate fasiculus, in subjects who experienced significant demyelination from TBI.**

AUTISM
Auditory-Visual Synchronization

Stevenson, R.A., Siemann, J.K., Schneider, B.C., Eberly, H.E., Woynaroski, T.G., Camarata, S.M., & Wallace, M.T. (2014). Multisensory Temporal Integration in Autism Spectrum Disorders. The Journal of Neuroscience, 34(3), 691-697.

- **Trouble integrating simultaneous auditory & visual sensory information**
- **ASD brain has difficulty associating visual and auditory events that happen within a temporal window, including paired audiovisual speech stimuli**
- **Confusion between senses – hands over ears may be strategy to block out one sense to help process one sense at a time.**
- **This timing deficit hampers development of social, communication & language skills**

AUTISM
Clinical Observations

- **Decreased perseverative behaviors, tics, fidgets & compulsive behaviors**
- **Improved classroom behaviors and academic achievement – more in sync with activities and environment around them**
- **Parents describe their child as being 'more comfortable in their own skin'**
- **Increased timing and coordination of motor control (decreased clumsiness, improved posture and symmetry)**
- **Increased volitional eye-contact & social engagement**
- **Increased perception of social cues**
- **Increased attention & ability to follow directions**
- **Decreased anxiety & improved ability to self-regulate**
- **Decreased startle response**
- **Improved sensory processing, including ability to give and receive hugs, decreased oral hypersensitivity**
- **Increased ability to tolerate unexpected changes in environment and routine**
- **Increased fluency and content of speech**

•Slide 20

Oral Motor
Oral Hypersensitivity

- **Movie: Sawyer Before IM**

•Slide 21

Oral Motor
Feeding

- Movie: Sawyer After IM

•Slide 22

Facilitating Developmental Milestones

Emma, 18 months

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

•Slide 23

Facilitating Developmental Milestones

- Movie: Emma

•Slide 24

Reading Skills

- **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

McGrew, KS, Taub, G & Keith, TZ (2007)

•Slide 25

Reading Skills

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)

•Slide 26

Reading Skills

- **Controlled study n = 49** *(7 – 11 yrs)*
  - Concurrent oral & written language impairments
  - Reading disability
  - Lower to middle class SES
- **Control -** 16 IM sessions over 4 weeks, 15 min duration per session
- **Experimental -** IM training in addition to reading instruction
- **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."

Ritter, M., Colson, K.A., & Park, J. (2012).

•Slide 27

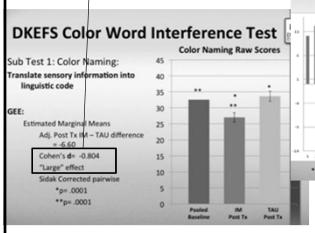
Traumatic Brain Injury

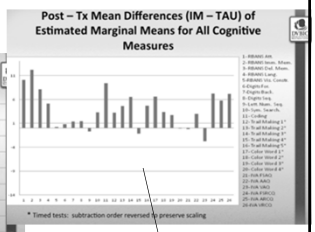
- Blind randomized, controlled study
- N=46 active duty soldiers with mild-moderate blast-related TBI
- Control: Treatment as Usual (OT, PT, ST)
- Experimental: Treatment as Usual (OT, PT, ST) plus 15 sessions of Interactive Metronome treatment @ frequency of 3 sessions per week.

•Slide 28

Nelson, et al.(2013)

Cohen's d= .804
"Large" effect



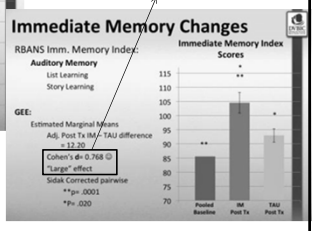


21/26 tests favor IM over TAU in direction of change at post treatment

•Slide 29

Nelson, et al. (2013)

Cohen's d= 0.768
☺
"Large" effect

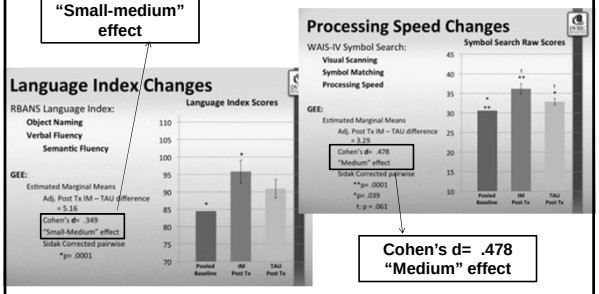


Cohen's d= .511
"medium" effect

•Slide 30

Nelson, et al. (2013)

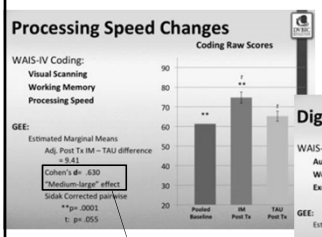
Cohen's d= .349
"Small-medium" effect



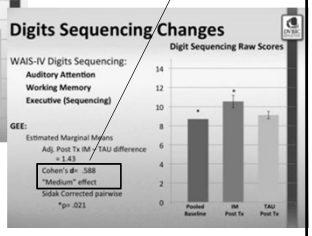
Cohen's d= .478
"Medium" effect

•Slide 31

Nelson, et al. (2013)



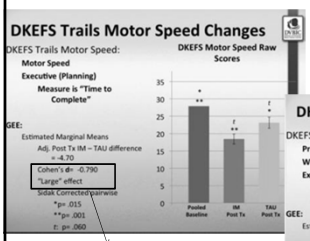
Cohen's d= .588
"Medium" effect



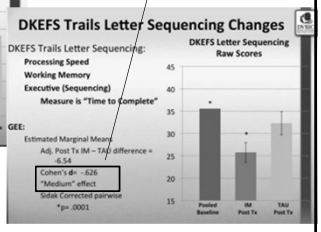
Cohen's d= .630
"Medium-large" effect

•Slide 32

Nelson, et al. (2013)



Cohen's d= .626
"Medium" effect



Cohen's d= .790
"Large" effect

•Slide 33

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

Temporal Processing Impaired in Aphasia

- **Sidiropoulos, K, Ackermann, H, Wannke, M, & Hertrich, I. (2010). Temporal processing capabilities in repetition conduction aphasia. Brain & Cognition, Aug (73)3, 194-202.**
- **Stefanatos, GA, Braitman, LE, & Madigan, S. (2007). Fine grain temporal analysis in aphasia: evidence from auditory gap detection. Neuropsychologia, 45(5), 1127-1133.**
- **Szelag, E, von Steinbuchel, N, & Poppel, E. (1997). Temporal processing disorders in patients with Broca's aphasia. Neuroscience Letters, 235(1-2), 33-36.**
- **von Steinbuchel, N, Wittman, M, Strasburger, H, and Szelag, E. (1999). Auditory temporal-order judgement is impaired in patients with cortical lesions in posterior regions of the left hemisphere. Neuroscience Letters, 264(1-3), 168-171.**
- **Robson, H, Grube, M, Lambon Ralph, MA, Griffiths, TD, and Sage, K. (2013). Fundamental deficits of auditory perception in Wernicke's aphasia. Cortex, 49(7), 1808-1822.**
- **Robson, H, Keidel, JL, Lambon Ralph, MA, and Sage, K. (2012). Revealing and quantifying the impaired phonological analysis underpinning impaired comprehension in Wernicke's aphasia. Neuropsychologia, 50(2), 276-288.**

•**Slide 35**

APHASIA

Stefanatos, GA, Braitman, LE, & Madigan, S. (2007). **Fine grain temporal analysis in aphasia: evidence from auditory gap detection.** Neuropsychologia, 45(5), 1127-1133.

- Examined auditory temporal processing in individuals with acquired aphasia
- Individuals with aphasia produced fewer correct responses than age-matched neurologically intact controls
- They did even worse in the presence of background noise
- The difficulties with gap detection observed in the aphasic group suggest the existence of **fundamental problems in processing the temporal form or microstructure of sounds characterized by rapidly changing onset dynamics.**

•Slide 36

APHASIA

Sidiropoulos, K, Ackermann, H, Wannke, M, & Hertrich, I. (2010). **Temporal processing capabilities in repetition conduction aphasia.** Brain & Cognition, Aug (73) 3, 194-202.

- Looked at temporal resolution capacities of the central-auditory system in a case of conduction aphasia
- Concluded that **auditory timing deficits may account at least partially for impairments in speech processing.**

•Slide 37

APHASIA

Robson, H, Grube, M, Lambon Ralph, MA, Griffiths, TD, and Sage, K. (2013). **Fundamental deficits of auditory perception in Wernicke's aphasia.** Cortex, 49(7), 1808-1822.

- Investigated the nature of the comprehension impairment in Wernicke's aphasia by examining the relationship between deficits in auditory processing of fundamental, non-verbal acoustic stimuli and auditory comprehension.
- Results showed there is **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.**

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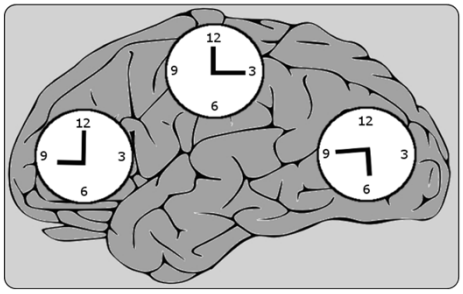
Out of Sync Brain



•Slide 39

Kelly (age 18) - High School Senior

Kelly

- **Movie: Kelly Speaking**

•Slide 41

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

•Slide 42

Attention Deficit Hyperactivity Disorder

Effect of Interactive Metronome® Training on Children with ADHD. Shaffer et al. (2001)

- **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

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Attention Deficit Hyperactivity Disorder

Effect of Interactive Metronome® Training on Children with ADHD. Shaffer et al. (2001)

- **58 tests/subtests**
  - Attention & concentration
  - Clinical functioning
  - Sensory & motor functioning
  - Academic & cognitive skills
- **Interactive Metronome group**
  - Statistically significant improvements on 53 of 58 tests ($p \leq 0.0001\%$)
- **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

•Slide 44

Brian

27 IM Sessions (3 months)

- **7 year old male**
- **Short attention span, hyperactive behavior and repetitive habits such as chewing**
- **Unable to attend in class, disruptive, slow to follow directions**
- **School is focusing more on behavior management than academics**
- **Difficulty with language processing**
- **Frequent meltdowns!!**

•Slide 45

Test of Auditory Processing Skills (TAPS)

SUBTEST	PRE-IM (percentile)	POST-IM (percentile)
Word Discrimination	37th	**84th**
Phonological Segmentation	16th	**50th**
Word Memory	37th	**84th**
Auditory Comprehension	25th	**75th**
OVERALL SCORES		
Phonological Skills	55th	**86th**
Memory	50th	**63rd**
Cohesion	47th	**70th**

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Test of Everyday Attention in Children

SUBTEST	PRE-IM (percentile)	POST-IM (percentile)
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**

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Social Emotional Evaluation (SEE)

SUBTEST	PRE-IM	POST-IM
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**

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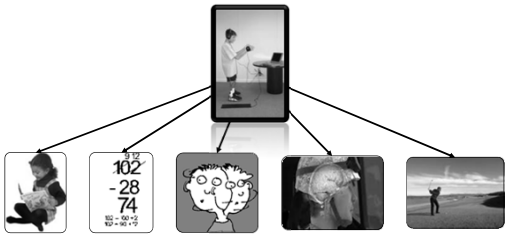
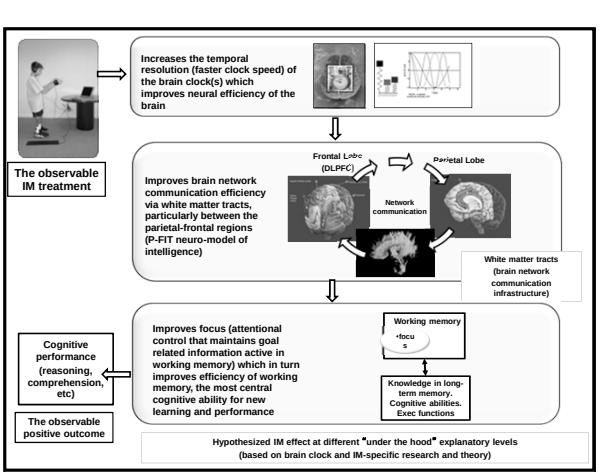
Parent/Teacher Observations

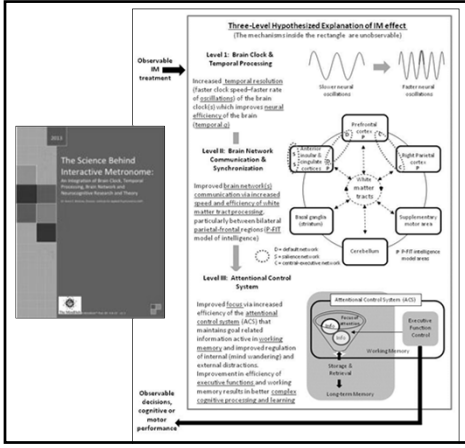
- **Teachers**
  - Improved behavior, interaction, attention, and work completion
  - More interested in writing, better sustained attention to writing tasks, improved legibility
  - Improved reading comprehension
- **Parents**
  - More cooperative with siblings/peers
  - Easier to calm and better able to self-regulate before his emotions escalate out of control
  - Improved eye/hand coordination

•Slide 49

Impacting Domain-General Learning Mechanisms







Report available at:

The MindHub

Who May Benefit?

- **Attention Deficit/Hyperactivity Disorder**
- **Autism Spectrum Disorders**
- **Traumatic Brain Injury**
- **Concussion/mTBI**
- **Brain Tumor (following surgery or chemotherapy)**
- **Auditory Processing Disorder**
- **Dyslexia and Other Reading Disorders**
- **Language-Learning Disorders**
- **Aphasia**
- **Cognitive Impairments associated with Parkinson's, MS**

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Candidates for IM Training

IMPAIRED COGNITIVE ABILITIES

- Executive functions
  (*attentional control, initiation, behavioral self-regulation, self-monitoring, self-correction, problem solving*)
- Attention
  (*focused, shifting, selective, divided*)
- Working memory
- Processing speed
- Cognitive stamina
- Planning, organizing & sequencing
- Time-management

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Candidates for IM Training

IMPAIRED SPEECH & LANGUAGE

- Auditory processing
- Receptive language
- Expressive language (*oral & written*)
- Thought organization
- Reading comprehension & fluency
- Articulation & speech intelligibility
- Phonological processing
- Motor speech *(apraxia)*
- Fluency/stuttering/cluttering

•Slide 55

Candidates for IM Training

IMPAIRED SOCIAL-BEHAVIORAL SKILLS

- Conversational skills
- Eye-contact
- Reciprocal social interactions (*timing, turn-taking, humor*)
- Impulse control
- Aggression
- Hyperactivity
- Disinhibition
- Affect & vocal inflection

•Slide 56

Candidates for IM Training

IMPAIRED SENSORY PROCESSING & INTEGRATION

- Sensory over-responsivity
- Sensory under-responsivity
- Sensory-seeking behavior
- Sensory discrimination
- Sensory-based motor skills
  - Praxis
  - Posture

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Candidates for IM Training

IMPAIRED MOTOR SKILLS

- Motor planning & sequencing
- Coordination
- Balance
- Gait
- Posture
- Functional mobility
- ADLs & IADLs
- Handwriting
- Functional use of hemiplegic limbs
- Functional use of prosthetic limbs

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INPATIENT

- **FREQUENCY:** Daily IM treatment
- **DOSAGE:** 15-20 minutes of IM treatment per day
- **DURATION:** Varies, but typically 2-4 weeks

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OUTPATIENT

- **FREQUENCY:** 2-3 IM treatment sessions per week
- **DOSAGE:** 30 minutes of IM treatment per session
- **DURATION:** Varies, but typically 8-12 weeks

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Insurance Reimbursement

- **IM is a treatment modality & does not have its own CPT code**
- **Prescription & insurance authorization for SLP evaluation and treatment**
- **Bill customary charges:**
  - Speech and language therapy
  - Cognitive development

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Interactive Metronome® Today

Over 25,000 Medical Rehabilitation, Mental Health and Education Professionals are Interactive Metronome Certified (IMC) in over 30 countries.

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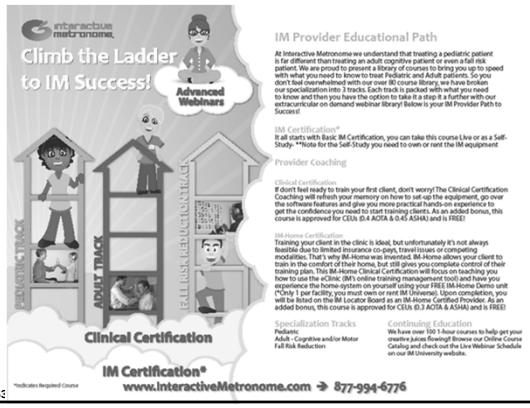
IM Certification & Continuing Education



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