

## IM Academic/Ped, Sports & General Research

### Academic/Ped

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#	Summary Page	Improvement Areas	Title	Author/ Brand Association	Publication	Notes
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17	14	DCD	Timing abilities among children with developmental coordination disorders (DCD) in comparison to children with typical development	Sara Rosenblum & Noga Regeve	<i>Published in Research in Developmental Disabilities</i>	
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#	Summary Page	Improvement Areas	Title	Author/ Brand Association	Publication	Notes
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#	Summary Page	Improvement Areas	Title	Author/ Brand Association	Publication	Notes
23	18	Brain	Interactive Metronome- Underlying neurocognitive correlates of effectiveness	Dr. Patrick Gorman	<i>White Paper</i>	
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## All IM Research

<https://www.interactivemetronome.com/im-specific-research-white-papers#1535547780314-cfd71411-b082>

- Download our [Research Flashcards](#) that include a summary of each study or select the individual papers to download below.
- Download a full list of [IM Research References](#).

## IM Academic/Ped Research

1.

### Reading Intervention Using Interactive Metronome® in Children with Language and Reading Impairment: A Preliminary Investigation



In this study, it was shown that the technology used in BrainBeat (Interactive Metronome) impacted all the vital rhythms that are so important to the development of language and literacy. It was found that common language deficits were associated with brain timing deficits, which is exactly what BrainBeat addresses.

Michaela Ritter, Karen A. Colson & Jungjun Park

*Published in Communication Disorders Quarterly*

This study shows that after only 4 hours of IM training, larger gains were made in most areas of reading achievement over the control group. In a 4 week time period, the IM group did 15 minutes of training before a traditional reading intervention while the control group just did the traditional reading intervention. The improvements over the control group are listed below.

- Reading Naturally +5.48
- DIBELS-6 +5.77
- GORT4-rate +0.96
- GORT4-fluency +0.32
- GORT4-comprehension +0.77

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2.



In this study, it was shown that children who could consistently synchronize movements in time with a beat, demonstrated a tighter brain-body connection which is linked with more advanced language skills, better literacy, faster processing speeds, improvements in speech-language processing, word reading, spelling, language, and syntax.

[VIEW INFOGRAPHIC](#)

### Clapping in time parallels literacy and calls upon overlapping neural mechanisms in early readers

Silvia Bonacina, Jennifer Krizman, Travis White-Schwoch, and Nina Kraus

*Published in ANNALS OF THE NEW YORK ACADEMY OF SCIENCES*

The ability to synchronize motor movements with a steady auditory beat is dependent upon a shared network between sensory and motor systems that also engages auditory and cognitive processes involved in reading. The purpose of this study was to investigate whether links, that have been previously demonstrated in older children, exist between synchronization ability and literacy skills in 64 typically developing children. Results indicated that children who can synchronize most consistently with the least variability in timing & rhythm demonstrate more advanced neurophysiological responses linked with language skills. Significantly, performing the auditory-motor synchronization with visual feedback for millisecond timing (Interactive Metronome) was linked with several literacy skills, including

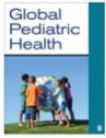
processing speed, phonological processing, word reading, spelling, morphology, and syntax. "These results suggest that rhythm skills and literacy call on overlapping neural mechanisms, supporting the idea that rhythm training may boost literacy in part by engaging sensory-motor systems."

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## 3.

### How Rhythmic Skills Relate and Develop in School-Age



Northwestern  
University

In this study, it was shown that the technology used in BrainBeat (Interactive Metronome) impacted all the vital rhythms that are so important to the development of language and literacy. It was found that common language deficits were associated with brain timing deficits, which is exactly what BrainBeat addresses.

**Silvia Bonacina, Jennifer Krizman, Travis White-Schwoch, Trent Nicol, and Nina Kraus**

***Published in GLOBAL PEDIATRIC HEALTH***

#### RESULTS:

Simply drumming to an isochronous beat had no impact on recall of rhythmic patterns. Children who performed better at drumming to the beat of music were better at both drumming to a beat and remembering rhythmic patterns. However, children who were able to clap in time with a steady beat with the least amount of variability in their synchronization (due to real time millisecond feedback from Interactive Metronome) demonstrated better ability to drum to a beat, recall rhythmic patterns & drum to the beat of music. According to Dr Nina Kraus, rhythm is complicated, there are several rhythm intelligences, & Interactive Metronome, by itself, impacts all of these vital rhythms that are so

important to the development of language and literacy. "Several clinical populations exhibit timing deficits that co-occur with language deficits; for example, individuals with reading impairment often struggle to tap along to an isochronous beat. It is conceivable that clapping in time to feedback could be a viable intervention for populations with distinct rhythmic deficits (such as one group who struggles to synchronize to a beat and another who struggles to remember rhythmic patterns)." The authors hypothesize that the perception & production of rhythm begins as a global skill early and becomes more specialized later in life. This is in line with previous IM research and the IM Indicator Table data.

#### DETAILS:

- n=68 typically developing children between 5 – 8 years of age
- n=46 children were re-assessed 1 year after conclusion of the study to monitor development of rhythmic skills
- first study of its kind to provide evidence of the interconnections among rhythmic skills in school-age children
- assessed via 4 different rhythmic tasks:
  - **3 tasks used a conga drum, with a trigger to register drum hits:**
    1. Drumming to an Isochronous Beat: listen and drum to an isochronous pacing beat presented through in-ear headphones
    2. Remembering and Repeating Rhythmic Patterns: listen to 3 repetitions of a rhythmic sequence without drumming and then drum out the sequence during a pause, producing the sequence exactly when it would have occurred had it repeated a fourth time
    3. Drumming to the Beat of Music: listen to a musical excerpt through speakers and tap to the perceived beat
  - 1 task involved clapping in time and was completed using Interactive Metronome (IM)

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**Incorporation of Feedback during Beat Synchronization is an Index of Neural Maturation and Reading Skills**

4.

Kali Woodruff Carr, Ahren B. Fitzroy, Adam Tierney, Travis White-Schwoch, Nina Kraus



This study concluded that precise timing skills and coordination of sensory perceptions are vital skills associated with speech, language and literacy and training interventions (like BrainBeat) that improve timing, synchronization and offer sensory feedback are useful as remedial strategies for individuals who struggle with language learning impairments.

### ***Published in Brain & Language***

Speech communication involves integration and coordination of sensory perception and motor production, requiring precise temporal coupling. Beat synchronization, the coordination of movement with a pacing sound, can be used as an index of this sensorimotor timing. We assessed adolescents' synchronization and capacity to correct asynchronies when given online visual feedback. Variability of synchronization while receiving feedback predicted phonological memory and reading sub-skills, as well as maturation of cortical auditory processing; less variable synchronization during the presence of feedback tracked with maturation of cortical processing of sound onsets and resting gamma activity. We suggest the ability to incorporate feedback during synchronization is an index of intentional, multimodal timing based integration in the maturing adolescent brain. Precision of temporal coding across modalities is important for speech processing and literacy skills that rely on dynamic interactions with sound.

Synchronization employing feedback may prove useful as a remedial strategy for individuals who struggle with timing-based language learning impairments.

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5.

## **Psychology** *in the* **Schools**

A published study showed that children completing a training program with Interactive Metronome technology achieved accelerated reading outcomes with a gain of 7 – 20% in reading achievement.

### **Improvements in interval time tracking and effects on reading achievement**

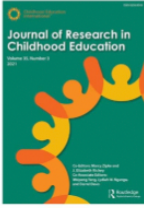
Gordon E. Taub, Kevin McGrew & Timothy Z. Keith

### ***Published in Psychology in the Schools***

A study published in the journal Psychology in Schools showed that children completing a training program with Interactive Metronome achieved accelerated reading outcomes. A gain of 7 – 20% in reading achievement was shown in the 49 children whose reading and pre-reading skills were pre and post-tested.

6.

## Effects of Improvements in Interval Timing on the Mathematics Achievement of Elementary School Students



Training with the technology of Interactive Metronome offers significant gains in cognitive, motor and academic skills. Students that completed 18 once-daily sessions demonstrated significantly higher scores for mathematics achievement when compared to the control group, who participated in recess.

**Gordon E. Taub, Kevin S. McGrew & Timothy Z. Keith**

*Published in Journal of Research in Childhood Education*

A total of 86 students ranging in age from 7-10 years of age from 1st through 5th grade classrooms at an inner-city charter school participated in a randomized, controlled study to examine the effect of IM training on mathematics achievement. Students in the experimental group participated in 18 daily sessions of IM training (50 minutes each) over a period of 4 weeks. Students in the control group participated in recess. All study participants participated in pre & post testing with The Woodcock-Johnson III Tests of Achievement to evaluate mathematics achievement. As shown in several other IM studies, there was again an observed cross domain effect from sensorimotor synchronization training with IM (i.e., previous studies have shown IM training for timing/rhythmicity generalizes to

significant gains in cognitive, motor and academic skills). Students that received 18 daily sessions of IM training demonstrated significantly higher scores for mathematics achievement when compared to students who participated in recess. The authors provide an in-depth analysis for these findings, including “an integration of psychometric theory and contemporary information processing theory to provide a context from which to develop preliminary hypotheses to explain how a nonacademic intervention designed to improve timing/rhythmicity can demonstrate a statistically significant effect on students’ mathematics achievement scores.”

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7.

Training with BrainBeat May Improve Brain Function



This paper summarizes the scientific findings that explain why a movement based repetition program, made with feedback in millisecond precision, might be influential in improving brain efficiency and cognitive skills.

**Processing speed and motor planning: the scientific background to the skills trained by Interactive Metronome® technology**

**Susan J. Diamond**

*White Paper*

A study of 585 children found significant correlations between the students’ mental timing as measured by IM and their academic performance in reading, math, language, science, social studies and personal study skills. This study shows that brain timing plays a foundational role in a child’s academic performance.

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## 8. Learning Problems and the Left Behind

Preventing Children from Falling Behind in School.



This study of (40) "at risk" 4th and 5th grade students showed dramatic gains in reading and math fluency in only 4 weeks of training.

**Dr. Cindy Cason**

***White paper presented at the annual meeting of the National Association of Elementary School Principals***

This study of 40 4th and 5th grade "at risk" children showed dramatic gains in reading and math fluency in only 4 weeks. 40 similar students in the control group showed no improvement at all.

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## 9. The Effect of Interactive Metronome® Training on Children's SCAN-C Scores

Central Auditory Processing Disorder Improvements



Children diagnosed with Central Auditory Processing Disorder showed a statistically significant improvement in 4 areas of auditory processing.

**Joel L. Etra**

***White Paper***

This pilot study by Joel Etra, PhD, SLP measured the effects of IM on children diagnosed with Central Auditory Processing Disorder. It showed that IM statistically significantly improved 4 areas of auditory processing in all the children tested. The largest increases occurred in dichotic listening, a measure of selective attention.

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## 10.

Gains from Training Remain 6 Months Later!



A study of 13 patients measured across a broad spectrum of function showed that gains made with Interactive Metronome technology were still present 6 months after therapy was completed.

**Pathways Center Final Statistical Analysis**

**Lee E. Jacokes**

***White Paper***

A study of 13 patients measured across a broad spectrum of function shows that gains made with IM are still present 6 months after therapy was completed.

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11.

Brain Timing's Foundational Role in Academics



A study of 585 children found significant correlations between the students' mental timing and their academic performance in reading, math, language, science, social studies and personal study skills.

**Timing in child development**

**Kristyn Kuhlman & Lawrence Schweinhart**

*Published in High/Scope Press*

A study of 585 children found significant correlations between the students' mental timing as measured by IM and their academic performance in reading, math, language, science, social studies and personal study skills. This study shows that brain timing plays a foundational role in a child's academic performance.

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12.

Positive Effects for Children with ADHD!



A study of 56 preteen boys diagnosed with ADHD found statistically significant improvements in attention and concentration, motor coordination, language processing, reading and math fluency and the ability to control impulsivity.

**Effect of Interactive Metronome® Training on Children with ADHD**

**Robert J. Shaffer, Lee E. Jacokes, James F. Cassily, Stanley I. Greenspan, Robert F. Tuchman & Paul J. Stemmer, Jr.**

*Published in American Journal of Occupational Therapy*

A study of 56 pre-teen boys diagnosed with ADHD found that those using IM showed statistically significant improvement in attention and concentration, motor coordination, language processing, reading and math fluency and the ability to control impulsivity.

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## Academic Research with other modalities in addition to IM

13.



Research Program at McClean Hospital, Harvard Medical School.

### Evaluation of the Hardy Brain Camp

Hannah Grossman & Mary E. Brenner

#### *White Paper*

This was an evaluation of the Hardy Brain Camp, designed for the Boys and Girls Club of America. The theoretical underpinnings of Hardy Brain Training are that learning improves when processing speed, perceptual-motor, sensory, and cognitive skills improve. The Hardy Training is a two-part training system: 1) a movement to a beat-millisecond timing training (MTT) and 2) a movement to a beat plus a cognitive component-ball bounce activity (Ball Training). Interactive Metronome® is the central component of Hardy Brain Training. 62 elementary students between 2nd and 5th grade were randomly assigned to one of three groups: Control, Interactive Metronome®, or Interactive Metronome® plus Ball Training. Before and after a 20 session training period, all participants were given standardized measures of processing speed, reading fluency, and math fluency. The

group that received Interactive Metronome plus Ball Training outperformed both of the other groups on measures of processing speed and reading & math fluency.

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14.



### Academic and Behavioral Improvements in 2nd-8th Grade Students in the Hardy Brain Camp Program: Report on the Hardy Brain Camp Pilot Study of the Boys & Girls Clubs of Greater Oxnard and Port Hueneme and the United Boys & Girls Clubs of Santa Barbara County

Jamshid Damooei

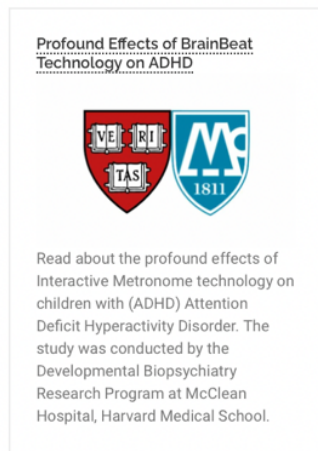
#### *White Paper*

The academic and behavioral performance of 54 students (grades 2-8) was measured before and after participation in the Hardy Brain Camp program, the centerpiece of which is Interactive Metronome training. Students were identified for participation in the Hardy Brain Camp because they demonstrated difficulties with learning, attention, organization, behavior, poor grades, listening, following directions, completing schoolwork, reading

and/or math weaknesses that significantly interfered with academic performance. The theoretical underpinnings of Hardy Brain Training are that learning improves when processing speed, perceptual-motor, sensory, and cognitive skills improve. The Hardy Brain Training is a two-part training system: 1) a movement to a beat-millisecond timing training (MTT) via Interactive Metronome and 2) a movement to a beat plus a cognitive component- ball bounce activity plus Interactive Metronome (Ball Training).

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15.



## Profound Effects of Interactive Metronome and Brain Balance Exercises on a Subset of Children with Attention Deficit Hyperactivity Disorder

Martin H Teicher, PhD, MD

*White paper: Developmental Biopsychiatry Research Program, McClean Hospital, Harvard Medical School*

### RESULTS:

Preliminary results from this ongoing study showed that 5 of 14 children (36%) diagnosed with ADHD demonstrated 40% or greater improvement on standardized neuropsychological measures of hyperactivity and spatial working memory (the executive function most notably impaired in ADHD) following completion of a combined Interactive

Metronome (IM) and Brain Balance (BB) training protocol. According to Dr Teicher, “this is a degree of improvement that we have not previously observed in children with ADHD unless they were receiving medications, and then only if they were receiving the correct medication at optimal dose.”

Neuroimaging of brain regions strongly implicated in the neurobiology of ADHD helped to parse out the influence of each training program and the effect of combining them. Specifically, scans showed that BB training was associated with increased connectivity between prefrontal cortex and the frontal pole, temporal pole, cerebellum, precentral gyrus and supramarginal gyrus with extensive effects on connectivity of the amygdala and hippocampus, which are involved in implicit and explicit memory as well as stress response.

Increased connectivity of the amygdala with supramarginal gyrus, cingulate gyrus, anterior cingulate, angular gyrus, frontal pole and precuneus were associated with combined IM and BB training. Greater connectivity between the amygdala and cingulate allows for better emotional self-regulation and impulse-control.

IM training was associated with increased connectivity between the hippocampus and the angular gyrus, precuneus, middle temporal gyrus, lateral occipital cortex, supramarginal gyrus, cingulate gyrus and frontal pole, areas responsible for language processing, memory retrieval, handwriting, mathematical calculations, and L/R discrimination. A closer examination of the impact on the cerebellum revealed that IM training was associated with increased resting state functional connectivity between: cerebellum I and middle frontal gyrus; cerebellum II and inferior temporal gyrus/fusiform gyrus; cerebellum IV-V and parahippocampal gyrus and inferior temporal gyrus/fusiform gyrus; cerebellum VII and lateral occipital cortex; cerebellum VIII and superior frontal gyrus and cerebellum IX and lingual gyrus and postcentral gyrus. IM training was also associated with decreased resting state functional connectivity between cerebellum III and anterior cingulate gyrus and cerebellum VI and lateral occipital gyrus.

“These appear to be potent changes. Our findings of symptomatic improvement and enhanced connectivity of the supramarginal gyri with the amygdala, hippocampus, and prefrontal cortex is consistent with a recent report showing that reduced connectivity of the left and right supramarginal gyri was associated with increased symptom severity in ADHD<sup>24</sup>. Given the role these regions appear to play in timing makes these observations particularly compelling.”

Research is ongoing and will continue to investigate and further define the host of neurobiological changes associated with IM and BB training as well as their relationship to clinical outcome for individuals with ADHD.

### DETAILS:

- n=14 (8-14 years of age) confirmed to have ADHD through structured diagnostic interview (K-SADS-PL)
- intervention: 15 weeks of combined Interactive Metronome and Brain Balance training (up to 75 sessions) were completed remotely via online access
  - standardized exercises with no individualization
  - not directly supervised by an experienced administrator (carried out by families at home)

- clinical outcome measures:
  - ADHD Quotient System. “This test is highly responsive to the effects of medication, correlates with blood levels of methylphenidate but is not responsive to placebo. Indeed, we reported in N=30 children receiving placebo that only 7% showed a greater than 25% improvement and none had a 40% or greater improvement in Quotient scaled scores.”
  - Cambridge Neuropsychological Test Automated Battery (CANTAB) to evaluate spatial working memory
  - Neuroimaging with diffusion MRI optimized to evaluate the brain’s structural connections (part of the Human Connectome Project)

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## Motor Research

16.

Measurement Technology used in BrainBeat Validated



This study showed the validity of the assessment and measurement tools employed by Interactive Metronome's technology, in order to measure and improve a child's [praxis](#).

### **Validity of Long Form Assessment in Interactive Metronome® As a Measure of Children's Praxis**

**Kyeong-Mi Kim, Ph.D., O.T., Seo-Yoon Heo, M.P.H., O.T., Mi-Su Kim, D.S., O.T., Soo-Min Lee, D.S., O.T.**

*Published in The Journal Korean Academy of Sensory Integration*

The aim of this study is to verify validity of Long Form Assessment, which is an Interactive Metronome measure (LFA-IM), as a measurement of praxis of children. The study was implemented from March 2015 to July 2015. Twenty-five children with Attention Deficit Hyperactivity Disorder (ADHD) and those without ADHD (age of 6~11) were selected from a local university hospital and community in Gyeong-Nam province and Busan for this study. In order to examine discriminative validity of LFA-IM, Bruininks-Oseretsky Test of Motor

Proficiency, second edition (BOT-2) was used to compare the difference of results with LFA-IM for both children with and without ADHD. For concurrent validity, correlation between LFA-IM and BOT-2 was investigated using Spearman correlation coefficients. For the comparison between children with ADHD and children without ADHD, there were significant differences in the total scores of LFA-IM ( $p < .05$ ). Regarding the concurrent validity, there was a strong negative correlation between the total scores of LFA-IM and BOT-2 ( $p < .05$ ). In addition, there was high correlation between LFA-IM and BOT-2 for the area of hand control ( $r_s = -.532$ ), and high negative correlation for the area of fine-motor accuracy ( $r_s = -.447$ ), hand dexterity ( $r_s = -.532$ ), and balance control ( $r_s = -.623$ ) ( $p < .05$ ). This study identified validities of LFA-IM as an assessment of praxis of children. The results showed that it is appropriate to evaluate praxis of children with the total score of LFA-IM and, thus, it is believed that LFA-IM has a potential clinical utility. However, there should be more researches with large number of subjects.

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17.

### Help with Developmental Coordination Disorders (DCD)



The study strongly recommends consideration for Interactive Metronome technology as an evaluation and intervention tool for children with Developmental Coordination Disorders.

### Timing abilities among children with developmental coordination disorders (DCD) in comparison to children with typical development

Sara Rosenblum & Noga Regeve

*Published in Research in Developmental Disabilities*

The aim of the study was to compare timing abilities and temporal aspects of handwriting performance and relationships between these two components among children with Developmental Coordination Disorders (DCD) and a control group. Forty two children, 21 diagnosed as DCD and 21 with typical development, aged 7–12, were matched for age, gender and school performed 14 tasks of the interactive metronome (IM) and three functional handwriting tasks on an electronic tablet that was part of a computerized system (ComPET – computerized penmanship evaluation tool). The IM supplies response time, while on- paper and in-air time per written stroke is received from the ComPET. Results indicated significant differences between the groups for both IM and handwriting tasks (ComPET). Linear regression indicated that the mean IM response time explained 37% of variance of the in-air time per stroke during a paragraph-copying task. Furthermore, based on one discriminate function including two measures reflected timing ability, 81% of all participants were correctly classified into groups. Study results strongly recommend consideration of the IM as an evaluation and intervention tool for children with DCD who are faced with timing deficits in their everyday functioning.

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18.

### Significant Clinical Effects with ADHD Children



Rhythm feedback training 'trains the brain' to plan, sequence, and process information more effectively which leads to improvements in behavior in attention-deficit/hyperactivity disorder.

### Effects of motor sequence training on attentional performance in ADHD children

Gerry Leisman & Robert Melillo

*Published in International Journal on Disability and Human Development*

This study addresses the lack of motor coordination in ADHD children and suggests that going through IM training would have a significant effect on improving focus in ADHD children.

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19.

Elite Athletes Achieve Even Better  
Performance



Training using Interactive Metronome technology positively impacted executive-controlled attention and working memory leading to improved performance in motor coordination, precision and speed.

## Influences of Synchronized Metronome Training on Soccer Players' Timing Ability, Performance Accuracy, and Lower-Limb Kinematics

Louise Rönnqvist, Rachel McDonald and Marius Sommer

*Published in FRONTIERS IN PSYCHOLOGY*

The purpose of this study was to evaluate the effect of Interactive Metronome (IM) training on athlete's sensorimotor timing ability and whether timing and rhythm training is a valuable adjunct to soccer training for performance enhancement. Twenty-four female sub-elite and elite outfield soccer players ages 16.2 to 25.8 were randomly assigned to an experimental group that received 45-50 min sessions of Interactive Metronome (IM) training 3x/week in addition to regular pre-season

soccer practices (for a total of 12 IM sessions over 4 weeks) or a control group that just participated in the same pre-season soccer practices. Millisecond timing and rhythm were measured via Interactive Metronome. Both groups also participated in pre and post examination of performance on a complex, high cognitive-load stepping task, recorded in 2D and 3D for each participant via an optoelectronic motion capture system, for kinematic analysis.

### RESULTS:

The experimental (IM) group demonstrated significant improvement in millisecond timing, compared to the control group, as a result of IM training. Additionally, the group that received IM training demonstrated greater speed and accuracy on the high cognitive-load, complex stepping task. IM training appeared to positively impact executive-controlled attention and working memory in the experimental group leading to improved performance in motor coordination, precision and speed when compared to the control group. Of interest, those athletes who demonstrated the MOST improvement in timing scores on Interactive Metronome also demonstrated the GREATEST gains in speed and accuracy on the complex stepping task. Correlations were found between the participants' performance on the stepping task and kinematic parameters, likely associated with inter-individual variations in higher-order cognitive processing ability. Recent studies have confirmed that executive functions are imperative for high performance in soccer and hockey. The more elite the player, the higher they tend to perform on tests of executive functioning. "...the findings from the present study provide support for the explanation that SMT [Interactive Metronome training] may strengthen the neural pathways within the spatiotemporal network, and thereby improve motor planning ability."

"To conclude, even if physical strength and mental ability are of high importance in all sport performance, sensorimotor timing ability may be the key factor. The present study emphasizes the importance of improving the cognitive-motor planning ability and sensorimotor timing skills, especially in team sport such as soccer where the players have to rely on accurately timed actions on milliseconds level. It is clear from the results that synchronized sensorimotor timing abilities should be acknowledged as a critical factor for soccer player's performance. Additionally, that SMT [Interactive Metronome training] also may be beneficial for both general motor planning and in other sports performance and situations of complex, high cognitive-motor demanded tasks, and dynamic contexts."

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20.

Big Athletic Performance Gains!



Both golfers and elite soccer players experienced significant gains in golf shot accuracy and soccer kick accuracy along with more consistent play.

## Effect of timing training in golf and soccer players: skill, movement organisation, and brain activity

Marius Sommer

### *Doctoral Thesis*

This paper is an in-depth analysis of the effect of IM training for sensorimotor synchronization on peak athletic performance based upon 3 studies conducted at Umeå University, Umeå, Sweden. The following studies are discussed: Sommer, M. & Rönqvist, L. (2009). *Journal of Sports Science and Medicine*, 8, 648-656. This study investigated the impact of IM training on golf shot accuracy and variability. Sommer, M., Häger, C. & Rönqvist, L. (2014). *Sports Biomechanics*, 13, 1-16. This study further investigated the impact of sensorimotor synchronization training (via IM training) on the kinematic properties of the golf swing, specifically spatiotemporal movement organization and dynamics. Sommer, M., Häger, C., Olsson, C. J., & Rönqvist, L. (2014). Manuscript in progress. This study investigated the effect of IM training on cross-pass soccer kick accuracy in elite and sub-elite female soccer players. Underlying brain activity was studied via fMRI. In summary, these randomized, controlled studies revealed that sensorimotor synchronization training with IM significantly improved several aspects of athlete performance, including:

1. Improved motor timing ability
2. Improve golf shot and soccer kick accuracy
3. Decreased variability in performance outcome [more consistent]
4. Decreased activation within bilateral cerebellum, fusiform gyrus and superior temporal gyrus on fMRI, demonstrating a more efficient pattern of neural recruitment after IM training [automaticity]

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21.

Brain Training Improves Athletic Performance!

SCIENCE & MEDICINE  
JOURNAL of SPORTS

Brain training and improvements in brain timing was shown to have a strong influence on the performance of a golfer's swing, which like most sports, requires fine motor-coordination.

## Improved motor-timing: effects of synchronized metronome training on golf shot accuracy

Marius Sommer & Louise Rönqvist

### *Published in Journal of Sports Science and Medicine*

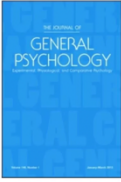
This European study is an independent recreation of earlier IM research studying golfers. This new study showed the same results: working with IM's timing exercises improves golfers' control of their swing and improves shot accuracy.

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22.

Training Improves Precision & Accuracy of Golfers



If training in timing dramatically improves motor movement, as shown with golfers, then training may also be used to improve performance in other sports such as basketball, baseball, tennis as well as other activities requiring precise timing.

## **Training in timing improves accuracy in golf**

**Terry M. Libkuman & Hajime Otani**

***Published in The Journal of General Psychology***

This published study demonstrates a connection between IM's timing exercises and improvements in complex movements as seen in dramatic improvements in golf shot accuracy.

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## General Brain Research

23.

Greater Attention, Mental Processing & Cognitive Abilities



This treatment can facilitate greater attention, mental processing, and cognitive abilities. This treatment can be applied to a diverse group of people, as well as to individuals who wish to improve their concentration, mental processing, attention and performance.

### Interactive Metronome- Underlying neurocognitive correlates of effectiveness

**Dr. Patrick Gorman**

#### *White Paper*

A white paper by psychologist Dr Patrick Gorman explaining the underlying neuro-cognitive mechanisms of IM training.

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24.

Improved Accuracy & Transmission Speed in the Brain



fMRI studies confirm that Interactive Metronome technology strengthens neural networks to make the transmission of information between areas faster and with greater accuracy. Repetitive auditory-motor training, holds promise for neuroplasticity of higher and lower brain centers.

### The role of functional MRI in defining auditory-motor processing networks

**Dr. Neal Alpiner**

#### *White paper presented at national PM&R conference 2004*

A study of 13 patients measured across a broad spectrum of function shows that gains made with IM are still present 6 months after therapy was completed.

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