Fall 2015

Reading Intervention Using Interactive Metronome Treatment

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READING INTERVENTION USING INTERACTIVE METRONOME TREATMENT

A Thesis
Presented to
The Faculty of the School of Teacher Education
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Master of Arts in Education

By
Denise J. Lewis

December 2015
READING INTERVENTION USING INTERACTIVE METRONOME TREATMENT

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ACKNOWLEDGEMENTS

I dedicate this thesis to my husband, Michael Lewis and my children, Samuel, Andrea and Sophia, who have supported me in fulfilling my dreams. My best friend, Rachel Leer, whose words of encouragement and push for tenacity ring in my ears. I also dedicate this thesis to my extended family and friends who have supported me throughout the process. I will always appreciate all they have done. To my participants, your willingness to try something new and contribute to this study provided insight and growth for me as a researcher that I am eternally grateful for.

I wish to thank my committee members who were more than generous with their expertise and precious time. A special thanks to Dr. Nancy Hulan for her countless hours of reading, encouraging, and most of all patience throughout the entire process. Thank you to Dr. Christina Noel, Dr. Lucy Maples, and Dr. Susan Keesey for agreeing to serve on my committee. I would like to acknowledge and thank Kimberly Hudson and The Reading Room for allowing me to conduct my research and providing support. These individuals made the completion of this research an enjoyable experience.
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The purpose of this research study was to examine the effects of Interactive Metronome (IM), a non-academic treatment, when integrated with reading intervention. The intention was to analyze the degree to which IM affected fluency when introduced alongside reading intervention. The research questions that guided this study focused on how internal timekeeping affects reading fluency.

This study used a multiple baseline across participant’s single-subject design. Three participants were monitored to determine a baseline using Curriculum Based Measures and Correct Word Per Minute data, and then each received a total of 15 hours of Interactive Metronome treatment. Progress was documented with progress monitoring of fluency using Curriculum Based Measures over a period of 17-22 weeks. Results suggest that students did not benefit from the Interactive Metronome treatment. Data derived from the study does not indicate a causal relationship between Interactive Metronome and improved fluency. Future research should investigate a possible connection between Interactive Metronome and comprehension.
Introduction

Fluency is often defined as having three key elements: rate (words per minute), accuracy (number of words correctly identified), and prosody (or rhythms and tones of spoken language), with which a reader performs a reading task (Diamond, 2008; Hudson, Lane, & Pullen, 2005). The intonation of a text read aloud can impact the meaning of the text dramatically (Dowhower, 1991; Glavach, 2011; Rasinski, 2000; Stanovich, 1980). Fluency is well studied and there are many implications for instruction. Even with the abundance of literature available, students still struggle with fluency and consequently, with comprehension. According to Rasinski et al. (2005), a lack of reading fluency may be one cause for low reading comprehension among high school students showing how the effects of poor reading follow students through elementary and middle school. This disconnect impacts a student’s academic achievement (Rasinski et al., 2005).

Historically, discussions on this topic have indicated that lack of fluency can be the result of slow decoding and word recognition abilities. Prior research suggests that the nature and importance of facilitating fluency in the initial stages of literacy acquisition will ensure steady progress in the development of reading and the creation of independent readers (Stayter & Allington, 1991).

Statement of the Problem

Reading fluency is paramount to student academic achievement. Some students may be able to read the words of a passage accurately or they may be able to read words quickly, but combining the two — rate and accuracy poses a challenge. In this situation, the student may be able to partially read a passage but is unable to understand the passage because so much of the student’s mental energy is diverted to the task of decoding rather
than comprehending. When readers can read a passage quickly and accurately with automaticity they can spend the mental energy on comprehending. When traditional reading interventions do not produce results, there may be instances in which additional and distinct intervention may benefit a reader. The lack of fluency in reading is the focus of the intervention under question here. This study was designed to examine one potential intervention with the intent to improve fluency.

Purpose of the Study

The purpose of this study was to determine if the Interactive Metronome treatment positively impacts a student’s ability to read fluently.

The central question that this research project examined is what effect does an intervention involving the Interactive Metronome have on an individual’s reading fluency?
Definition of Terms

*Cognition*- The term cognition is used in several loosely related ways to refer to the facility for the human like processing of information (Interactive Metronome, 2013)

*Comprehension*- The ability to understand what is read and measured by retelling elements of the story (Leslie & Caldwell, 2009; Stein & Glenn, 1979).

*Fluency*- The ability to read with speed and accuracy as well as with appropriate expression as measured by subtracting the number of errors from the total number of words read in one minute for speed, or rate, and by counting the number of errors prior to the 100th word and subtracting this number from 100 for accuracy (Diamond, 2008; Howell, 1982; Hudson et al., 2005)

*Interactive Metronome (IM)*- Interactive Metronome is an intensive computer based program used to improve a student's processing abilities that affect attention, motor planning, sensory processing and sequencing (Interactive Metronome, 2007).

*Mental Interval Timekeeping*- the way the brain represents and tells the time (Buhusi & Meck, 2005). This can be visualized as the second hand on a clock. The baseline would be the regular tick on the second hand. The brain however may have a “clock” that is too fast or too slow. This abnormality can create disfluency and affect reading comprehension. Also, the timekeeping the brain does is much more refined down to milliseconds, which can affect a person’s ability to maintain a rhythm or speed (McGrew, 2007).
*Rapid Temporal Auditory Processing* - The processing of oral language that is impaired due to the inability to process the rapid spectro-temporal, or the function of both time and frequency, characteristics of phonemes or sounds. This in turn is posited to disrupt essential components of language learning, beginning with the acquisition of phonological representations (Gaab, Gabrieli, Deutsch, G.K, Tallal, & Temple, 2007).
Review of the Literature

Introduction

Fluency is an essential function for students to achieve academic success. Previous research characterizes fluency as a complicated and multifaceted process (National Institute of Child Health and Human Development [NICHHD], 2000). When an educator is faced with the task of teaching fluency, the teacher uses a variety of strategies to assist students in becoming better readers. When those strategies fail and traditional methods are ineffective the educator is forced to look for alternatives to help the student accomplish reading fluency. The purpose in investigating fluency for this research is to determine if a nonacademic treatment that targets timing in the brain would improve processing time and increase the rate at which a reader decodes words.

A review of the literature includes what fluency is and why it is important, how teachers and researchers have attempted to improve fluency, how processing speed may affect fluency, and possible non-academic treatments, including Interactive Metronome.

Definition of Fluency

Reading fluency has three key elements: rate (words per minute), accuracy (number of words correctly identified), and prosody or rhythms and tones of spoken language (Diamond, 2008; Hudson et al., 2005). Traditionally, fluency is determined by combining the rate and accuracy at which a reader attempts a passage.

Importance of Fluency

Reading fluency is so essential that Chall’s (1983) seminal model of reading characterized the attainment of reading fluency as one of the earliest stages of reading achievement, making it one of the foundational pieces that must be in place for success.
Moreover, Logan (1997) suggests that reading fluency is necessary so that reading performance is seemingly effortless, autonomous, and achieved without full consciousness or awareness. This allows the reader to focus on comprehending rather than decoding text.

**Fluency Interventions**

The literature suggests many strategies that can be used to assist in the intervention and development of fluency. Repeated readings have shown to improve fluency in multiple studies (Dowhower, 1987; Herman, 1985; Hudson et al., 2005; Rasinski, 1990). The repeated reading technique has many different approaches and is one of the most studies methods for increasing reading fluency (Hudson et al., 2005). Two main techniques are timed repeated reading as well as repeated reading with recorded models. Timed repeated readings were first described by Samuels (1979) and consists of selecting an appropriate passage at the student’s instructional level, setting a rate criterion, and having the student read and reread the passage until the criterion is reached (Hudson et al., 2005). Repeated readings with recorded models provides the student with a fluent model such as listening centers via audiotaped books or books on the computer.

Other strategies include: modeling, partner reading, choral reading, and explicit instruction on self-monitoring (Harn & Chard, 2008; Hudson et al., 2005). Modeling requires teachers to, “model (a) why the strategy is used (conditional knowledge) by providing specific reasons for the strategy selection; (b) how the strategy is used (procedural knowledge) by providing explicit instruction absent of ambiguity; and (c) what strategies to select in specific situations (declarative knowledge) by selecting the appropriate strategy to match the situation and/or not being too rigid with how to use the
strategy” (Regan & Berkeley, 2012, p. 277). Partner reading consists of two students sitting side-by-side reading a text. This strategy allows for students to make sense of reading through “organizational, disputational, word strategy, meaning making and personal talk” (Brown, 2006, p. 29). Choral reading is a strategy classroom teachers can use in which they have the entire class read aloud from the same teacher selected text. The teacher models the pronunciation, reading rate, and prosody. The teacher provides feedback to the students through explanation and by modeling problem words and phrases as well as praising students who read with fluency and encouraging the class to read with one voice (Paige, 2011). Finally, self-monitoring involves observing one’s own reading behavior and recording that behavior (Mace, Belfiore, & Hutchinson, 2001). These strategies can be used individually or in combination with one another, with a single student or in a classroom.

Processing Speed and Fluency

Processing speed refers to the speed at which individuals execute cognitive tasks, particularly elementary cognitive tasks (Salthouse, 1996). Elementary cognitive tasks are tasks such as tapping a small metal probe between two targets as quickly and as accurately as possible or sorting cards by a given attribute (e.g. suite or color for example) (Roberts & Pallier, 2001). Processing speed has been of special interest over the past 20 years as it relates to reading difficulties. “Research suggests that the nonphonological component of processing speed contributes to the automaticity and/or efficiency of the reading process” (Ritter, Colson, & Park, 2012, p. 9).

Fuchs and colleagues indicate that, “for good readers, rapid word recognition short-circuits the conscious attention mechanism; the automatic spreading-activation
component of contextual processing dominates” (2001, p. 242). Simply put, good readers do not have to divert brainpower to figuring out the words they are reading. This process is automatic and therefore the brain can spend more energy processing what it is reading. In contrast, Fuchs et al., says that “poor readers rely on their conscious–attention mechanism, they expend their capacity in prediction processes to aid word recognition” (2001, p.242). This leaves little capacity for poor readers to process what they read as they are spending all of their cognitive efforts to decode words.

Non-Academic Treatments

One intervention that has received considerable attention, both positive and negative, is the Fast ForWord method (Tallal, Miller, Jenkins, & Merzenich, 1997; Taub McGrew & Keith, 2007). The Fast ForWord method has multiple delivery options including a computer lab model, classroom/blended-learning model, before and after school model, home/school model and a summer school model (Fast ForWord Products, 2014). The Fast ForWord program boasts that it develops and strengthens memory, attention, processing rate, and sequencing (Fast ForWord Products, 2014). The program is delivered over a series of 5 weekly 30-minute sessions via the computer, in which the student works through exercises to improve key cognitive and reading skills (BrainPro, 2014). Critics of Fast ForWord state that studies of the intervention all used a different test to determine a change in reading ability, which raises questions regarding the reliability of the results (Veale, 1999).

Another intervention that addresses fluency is the use of synchronized metronome tapping, which links research on mental interval timekeeping and academic achievement (Buhusi & Meck, 2005; Taub et al., 2007). This thesis will focus on synchronized
metronome tapping, specifically the Interactive Metronome method. Current literature indicates that the Interactive Metronome can increase temporal processing or rather “timing in the brain,” thereby increasing rate, accuracy and timing-- all aspects of reading fluency (McGrew, 2013).

Interactive Metronome describes their program as a neuroscience-based computerized treatment technique that requires individuals to maintain synchrony of both hands and feet while listening to auditory tones (Interactive Metronome, 2013). During treatment, participants listen to a reoccurring metronome beat via headphones and match tapping/clapping motions using hand and foot triggers to the beat presentation. Participants receive immediate feedback regarding the accuracy of their tracking primarily through an auditory guidance system that uses varying tones to indicate how closely the student’s physical responses correspond to the metronome beat. The synchronized metronome tapping treatment is designed to minimize the lag time between the start of a regularly occurring beat and the participant’s response to the beat (Interactive Metronome, 2013), which in theory also promotes improved temporal processing (Ritter et al., 2012). According to the director of Interactive Metronome, the improved temporal processing impacts and improves neural efficiency, allowing the reader to have an improved reading speed and accuracy, which in turn, will affect the reader’s ability to comprehend the text he or she has read (McGrew, 2013).

Recent studies have focused on the effects of Interactive Metronome as it relates to reading achievement in the areas of reading fluency and comprehension. Ritter et al., (2012) found that students who received traditional language and reading intervention and 15 minutes of Interactive Metronome treatment (each day for a total of 4 hours
during the 4-week intervention) showed a strong correlation between the IM treatment and the post GORT-4 Comprehension subtest’ (Ritter et al., 2012). It is important to note that the control group did make statistically significant gains alongside the IM group, however researchers report that the IM group made greater gains (Ritter et. al., 2012). Work by Taub and colleagues (2007) supports the findings of Ritter and colleagues that IM helps students read previously known words faster. However, no improvement was found in overall word recognition skills.

Shaffer and colleagues (2001) studied the effect of Interactive Metronome training on children with ADHD and used the Wide Range Achievement Test (WRAT-3) to assess reading and writing. Specifically, children were evaluated on decoding and spelling. Each participant underwent 15 one hour Interactive Metronome treatments, 1-per day, over periods ranging from 3 to 5 weeks. The researchers also studied a similar group of children who played video games for the same time period as the Interactive Metronome group. Another group served as the control and received no treatment. The Interactive Metronome group showed more improvement than the video game group, and no improvement was shown with the control group suggesting that the Interactive Metronome treatment produced an additional benefit above and beyond the experience of the video game and control group participants (Shaffer et al., 2001).

The previously described results led me to the hypothesis that IM would positively impact the fluency of struggling readers.
Methodology

Participants and Setting

This study took place in a private, not-for-profit reading clinic setting in the south central United States. Health professionals, teachers, and parents refer participants to receive reading intervention in this setting. The treatment was to be conducted twice weekly over 15 weeks for 30 minutes each session. Participants received traditional reading intervention the other 30 minutes of each session.

Selection of Participants. The inclusion criteria for this study were (a) participant was currently in grades 3-7; (b) participant had a GORT-5 reading fluency score that was at least 1 year below grade level of their current same grade level peers; (c) no evidence of a co-morbid intellectual disability as measured by the Kaufman Brief Intelligence Test.

Participants. The first participant, Participant A, was an 11 year old Caucasian female attending a public school whose current grade level was 5.6 at the beginning of the study. GORT-5 results indicated that Participant A had a fluency grade level equivalent of 2.2. This was a 3.4 deficiency. According to the GORT-5, this placed Participant A in the 5th percentile, which is the “poor” category. Participant A was also given the Kaufman Brief Intelligence Test, Second Edition (KBIT2), which provided an IQ Composite of 80. The IQ composite score was a combined score achieved using the verbal (87) and nonverbal (79) scores. There was not a significant difference between the verbal and nonverbal score. The KBIT2 categorizes an IQ Composite score of 80 to be in the 9th percentile and to be below average.

The second participant, Participant B, was a 9-year-old Caucasian male, attending a public school whose current grade level was 3.6 month. GORT-5 results indicated Participant B had a fluency grade level equivalent of 2.2. This was a 1.4 deficiency.
This placed Participant B in the 16th percentile, which is the “below average” category. Participant B’s, KBIT2 provided an IQ Composite of 99. The IQ Composite score was a combined score achieved using the verbal (105) and nonverbal (93) score. There was not a significant difference between the verbal and nonverbal score. The KBIT2 categorizes an IQ Composite score of 99 to be in the 47th percentile average range.

The third participant, Participant C, was a 9-year-old Hispanic male, attending a private school whose current grade level was 3.6. GORT-5 results indicated that Participant C had a fluency grade level equivalent of 2.0. This was a 1.6 deficiency. This placed Participant C in the 9th percentile, below average. Participant C’s KBIT2 provided an IQ Composite of 110. The IQ Composite score was a combined score using the verbal (119) and nonverbal (98) scores. There was a significant difference of <.01 between the verbal and nonverbal score, slightly more than 1 standard deviation. The IQ Composite score of 110 is in the 75th percentile average.

Research Design

A multiple baseline single subject across participants design was selected because the intervention used in the study, once introduced, cannot be removed. An uncontrolled baseline was constructed in that the researcher simply began observing and recording data without changing the existing practice. Kennedy (2005) suggests that when stable baselines are established, and the independent variable is introduced sequentially across participants, a functional relation can be determined. The multiple baselines allow for a clear analysis of what change, if any, occurs when the treatment is introduced whether it is 3, 6, or 9 sessions, this helps to indicate that the baseline sessions, on their own, are not effective even over an extended period of time.
Measures. Based on reviewed literature, curriculum based measures (CBM) were selected as the measure due to its prominent reliability and wide acceptance in the field (Deno, 2003). CBM, were developed for use by educators to evaluate student progress as well as instructional effectiveness (Deno, 1985, p.221). Peabody Curriculum-Based Measurement passages and word counts were obtained from Vanderbilt University for ability level reading for grades 1-7. These passages consisted of a 2-3-page passage, which represented the level of difficulty expected for each year of competence. These CBM were selected to assess accuracy and rate by calculating correct words per minute.

Procedures

In this study, fluency data (rate and accuracy) were collected on an average of twice a week on different days at the end of each session and data were measured in (CWPM), a commonly used measure to calculate reading fluency (Fuchs, Fuchs, Hamlett, Walz, & Germann, 1993). The students were given an oral reading fluency probe validated for the purpose of calculating fluency. The passages were novel (i.e., new to the student) and the reading level was at the student’s instructional level. The participants were timed for one minute, and the oral fluency rate was calculated as the total number of words correctly read. Omissions, substitutions, mispronunciations and words that took longer than 3 seconds to read were counted as errors. Accuracy was also calculated into a percentage by dividing the total words read by the words read correctly. The students read aloud for one minute and were scored on their correct words per minute as well as their accuracy.

Training

Training on the Interactive Metronome treatment was obtained in June 2014 by
the researcher to gain a clinical understanding of the treatment and to ensure proper implementation with participants (topics covered are listed in Appendix A).

Baseline

During the baseline condition, the reading intervention was “business-as-usual” for each 60-minute session. The intervention was personalized, multisensory, diagnostic and prescriptive. The instructor continually monitored the verbal, nonverbal, and written responses of the student; the program was prescriptive in that the focus was based on the resolution of the student’s difficulties and built upon the student’s progress (Academy of Orton-Gillingham, 2014). At the end of each session participants read a novel text from the CBM’s to determine reading fluency (CWPM and accuracy percentage) for that session.

Interactive Metronome treatment

When participants entered the session they were instructed to complete a series of exercises using Interactive Metronome based on their progress thus far. Participants listened to a reoccurring metronome beat via headphones and matched tapping/clapping motions using a 2 handed circular clapping motion exercise as a “warm-up” exercise for 1-2 minutes for 2-3 consecutive rounds. Depending on the phase (see Appendix B) the participant was in, the participant completed exercises in various durations using different combinations of hands and feet movements in segments lasting anywhere from 3 to 7 minutes, depending on the phase. Towards the end of the 30 minutes, participants would “cool-down” with a similar procedure to the “warm-up” at the beginning of the session.

The IM system captured data by the triggers the participants activated to calculate and record how closely the participant synchronized his/her motions to the rhythmic
reference beat. The results were then displayed as a numerical score in milliseconds (ms) that provided a measure of the basic neurological and motor planning, sequencing, and timing capacities. Lower Interactive Metronome millisecond scores indicated better performance.

During the 30-minute reading intervention portion of each session, participants received the same intervention as during the baseline sessions only with the reduced amount of time. At the end of each session participants read a novel text from the CBM’s to determine reading fluency for that session.
Results

This study analyzes the effect of a non-academic treatment, Interactive Metronome, on reading fluency. Data were collected for each participant on Correct Words read Per Minute (CWPM). Appendix C displays CWPM data for all three participants. Appendix D displays accuracy data for all three participants. Accuracy was determined by dividing the total words read by the words read correctly.

Participant A established a stable baseline after 4 sessions, and then the independent variable (Interactive Metronome) was introduced. After 6 sessions, participant B, who also established a stable baseline, began receiving the treatment. Finally after 9 sessions, Participant C began receiving the treatment. It was theorized that this design would establish a functional relation between Interactive Metronome and an improvement in reading fluency. Participation in this study ended after 30 sessions that consisted of 30 minutes of Interactive Metronome and 30 minutes of reading intervention.

Participants A and B completed all 30 treatment sessions successfully. Participant C had scheduling conflicts and transportation issues and was only able to complete 24 treatment sessions. Participants A and B achieved the target of 15 hours of Interactive Metronome treatment and 15 hours of traditional reading intervention in addition to their baseline sessions.

Participant A

Participant A began with a four-session baseline. During this baseline the participant read an average of 88 CWPM. Once Interactive Metronome was introduced Participant A read at or above her average baseline score 26 of the 30 sessions where
Interactive Metronome was a part of her session. When Participant A’s CWPM after treatment are averaged, Participant A read an average of 99 CWPM. This change from 88 CWPM to 99 CWPM over the 30 sessions was a 12.5% increase in correctly read words. According to Hasbrouck – Tindal Oral Reading Fluency Norms (Appendix E) average weekly improvement (AWI) for Participant A should have been at least 0.7 words growth per week. Participant A gained 0.7 correctly read words per week during her intervention.

For accuracy, Participant A began with a 95% accuracy rate of words attempted. Once Interactive Metronome was introduced, Participant A read at or above her baseline average accuracy 23 of the 30 sessions. When Participant A’s accuracy rate of correctly read words after treatment began are averaged, Participant A read with an accuracy of 96.5%, which is a 1.5% increase in accuracy over the course of the treatment.

Participant B

Participant B began with a 6-session baseline. During this baseline the participant read an average of 74 CWPM. Once Interactive Metronome was introduced Participant B read at or above his average baseline score 22 of the 30 sessions where Interactive Metronome was a part of his session. When Participant B’s CWPM after treatment began are averaged, Participant B read an average of 81 CWPM. This change from 74 CWPM to 81 CWPM over the 30 sessions was a 9.4 % increase in correctly read words. Participant B gained 0.4 correctly read words per week. The average weekly improvement for Participant B should have been at least 0.8 words growth per week. This was calculated based on the data that all 3 readers were less than the 25th percentile
and therefore the 10th percentile number should be the most accurate averages for these students.

For accuracy, Participant B began with a 98% accuracy rate of words attempted. Once Interactive Metronome was introduced, Participant B read at or above his baseline average accuracy 20 of the 30 sessions. When Participant B’s accuracy rate of correctly read words after treatment began are averaged, Participant B read with an accuracy of 98% which is a 0% increase in accuracy over the course of the treatment.

Participant C

Participant C began with a 9-session baseline. During this baseline the participant read an average of 63 CWPM. During Participant C’s baseline there were 2 outlying data points that were not part of the stable baseline. These outliers were due to the Participant’s inability to be fully engaged in the session because of inattentiveness. Upon this observation the researcher made the decision to proceed with the treatment, despite the outlying data. Once Interactive Metronome was introduced Participant C read at or above his average baseline score 17 of the 24 sessions where Interactive Metronome was a part of his session. When Participant C’s CWPM after treatment began are averaged, Participant C read an average of 69 CWPM. This change from 63 CWPM to 69 CWPM over the 24 sessions was a 9.5% increase in correctly read words. Furthermore, Participant C gained 0.5 words per week where 0.8 were expected.

For accuracy, Participant C begins with a 91% accuracy rate of words attempted during the baseline sessions. Once Interactive Metronome was introduced, Participant C read at or above his baseline average accuracy 17 of the 24 sessions that he completed. When Participant C’s accuracy rate of correctly read words after treatment began are
averaged, Participant C read with an accuracy of 92.75% which is a 1.9% increase in accuracy over the course of the treatment.
Conclusion

Data gathered from the CBMs provided CWPM and accuracy data, which was analyzed and used to determine the extent to which IM improved reading fluency. With each participant there is overlapping data. Kennedy defines overlap as “the percentage or degree to which data in adjacent phases share similar quantitative values” (Kennedy, 2005, pg. 204). The overlapping data is the variability each participant showed in his or her CWPM and accuracy percentage data. Each participant had unstable data rather than a steady incline. This is clear evidence that the data did not change. In order for a functional relation to be established the independent variable, Interactive Metronome, when introduced would have needed to show a stable change with a steady incline once the treatment was introduced. The lack of observed change suggests the intervention is not functionally related to an increase in reading fluency.

Discussion and Implications

Although many reading intervention programs exist today, students still struggle with reading fluency despite the efforts of educators, reading specialists and parents. This study proposed that reading intervention for fluency would be more effective when paired with Interactive Metronome. Literature suggested that Interactive Metronome is an effective non-academic intervention that produces long-term effects in processing speed in a short amount of time.

This study analyzed the effect of a nonacademic intervention when added to reading intervention. This single subject multiple baseline design examined the effects of the interactive metronome treatment on three separate participants over the course of 24 to 30 sessions. The researcher investigated the changes in CWPM as well as accuracy of
This study differed from current literature in that it looked at the treatment session to session rather than at pre and post treatment data. This study allowed the researcher to see what change occurred during treatment.

The results of this study indicate that Interactive Metronome was not an effective treatment for fluency when paired with reading intervention in the modality in which it was presented. The results of this study add to existing literature on the effectiveness of Interactive Metronome. Interactive Metronome is not a successful intervention for fluency when done this way. The single subject design of this study was unable to capture the results that other research studies using Interactive Metronome reported. The data collection in this study was very rigorous with a great deal of attention given to the exact change that occurred session to session. With this attention per session participant behavior (mood, attention, motivation and stamina) increased the variability between sessions across all participants. Other limitations of this study include varied attendance among the participants with one participant failing to complete all sessions within the allotted time. Furthermore due to the nature of the single subject design, the results cannot be assumed to apply to all populations as these subjects had diagnosed reading disorders and had been receiving intervention for 6 months or more with little to no gains. Further research on the treatment is warranted to better understand if any positive impact can continue to be attributed to Interactive Metronome.

Implications for Research

This study had a multiple baseline single subject design. The research presented here did not suggest a functional relation between reading fluency improvement and Interactive Metronome. The use of the multiple baseline single subject design allowed
for a close look at each session during the treatment portion of the study. Previous studies focused on a pre and posttest design that allowed the researchers to see how the treatment was effective holistically. This study indicates that looking at each session, as a part, did not provide congruent data with other studies that looked at the overall effect of the treatment. Future research on Interactive Metronome could include an experimental design with a pre- and post-test measure and a treatment and a control group to establish whether a true relationship exists between IM and comprehension as this study focused only on rate and accuracy.
Literature Cited


doi: 10.1002/pits.20270

APPENDIX A

Interactive Metronome Training Topics

- The relevance of temporal processing and neural synchronization as it pertains to ortho/neuro rehabilitation and education.
- Discussion on peer-reviewed research studies that support the efficacy of incorporating treatment for temporal processing/neural efficiency into educational efforts that are aimed at improving cognitive, communicative, behavioral, sensory, motor, and learning skills.
- Information regarding candidacy for IM assessment/treatment based upon the knowledge of areas of function influenced by the ability to process time.
- Administration and interpretation of IM assessments.
- Instruction to develop individualized goals for IM treatment that are both functional and measurable; as well as create and execute individualized IM treatment plan.
- Modifications to the IM treatment approach based upon patient needs and response to treatment in order to facilitate a positive experience and successful outcomes.
- Training on producing and interpreting IM assessment and treatment reports.
- Selecting sensitive pre and post assessment tools to measure effectiveness of IM and generalization of gains to functional contexts (such as reading comprehension and fluency) (Interactive Metronome, 2013).
### APPENDIX B

**Phases of Interactive Metronome Intervention**

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<thead>
<tr>
<th>Phase</th>
<th>Goal</th>
<th>Promotion Standard</th>
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<tr>
<td>Phase 1</td>
<td>Move through exercises rhythmically while synchronizing with the reference tone. Exercises are done with hands only.</td>
<td>Clap in a circular, rhythmical fashion with good motor planning and sequencing.</td>
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<td>Phase 2</td>
<td>Learn to process and respond to the guide sounds. Exercises are done with hands only.</td>
<td>Understands what the guide sounds mean and respond to them appropriately to self-correct.</td>
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<td>Phase 3</td>
<td>Achieve best possible timing and rhythm with both hands in order to improve focus, cognitive processing and motor coordination. This is the most important step before introducing specific skills related to reading.</td>
<td>When the participant’s task average has significantly improved and the participant knows what it feels like to have good timing and rhythm with their hands, they are ready to move to phase 4.</td>
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<tr>
<td>Phase 4</td>
<td>Generalize timing skills to other areas, improve focus and fine motor skills/coordination, improve sustained attention and cognitive effort, and work on specific skills related to reading. This will be done with the hands, toes, heels, bilateral body movement and balance.</td>
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Adapted from *Interactive Metronome Certification Provider Training Manual, 2013.*
APPENDIX C

Correct Words Per Minute Across Sessions Data

![Graphs showing correct words per minute across sessions for three participants: A, B, and C.]}
APPENDIX D

Percent of Accuracy Across Session Data

![Graph showing accuracy across sessions for three participants.]

- Participant A
- Participant B
- Participant C

The graph illustrates the percent of accuracy for each participant across different sessions, with accuracy ranging from 80% to 100%.
## APPENDIX E

*Hasbrouck-Tindal Oral Reading Fluency Norms (2005)*

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<th>Percentile</th>
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DATE: December 16, 2014

TO: Denise Lewis, BS
FROM: Western Kentucky University (WKU) IRB

PROJECT TITLE: [681434-2] Reading Intervention Using Interactive Metronome Treatment
REFERENCE #: IRB 15-234
SUBMISSION TYPE: Amendment/Modification

ACTION: APPROVED
APPROVAL DATE: December 16, 2014
EXPIRATION DATE: August 31, 2015
REVIEW TYPE: Full Committee Review

Thank you for your submission of Amendment/Modification materials for this project. The Western Kentucky University (WKU) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Full Committee Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

This project has been determined to be a Minimal Risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of August 31, 2015.

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact Paul Mooney at (270) 745-2129 or irb@wk.edu. Please include your project title and reference number in all correspondence with this committee.
The letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Western Kentucky University (WKU) IRB’s records.
APPENDIX G

Informed Consent

Project Title: Reading Intervention Using Interactive Metronome Treatment

Investigator: Denise Lewis, Western Kentucky University, School of Teacher Education, Literacy Masters Candidate, 859-899-3343

Your child is being asked to participate in a project conducted through Western Kentucky University and The Reading Room. The University requires that you give your signed agreement to participate in this project.

The investigator will explain to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask any questions you have to help you understand the project. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have.

If you then decide to participate in the project, please sign on the last page of this form in the presence of the person who explained the project to you. You should be given a copy of this form to keep.

1. Nature and Purpose of the Project: The purpose of this research is to better understand how Interactive Metronome (IM), a computer based, non-academic treatment benefits reading intervention for those who continue to struggle despite intervention and increases success. Children will receive traditional reading intervention as well as 15 hours of Interactive Metronome experience. The Interactive Metronome is a research-based intervention that improves “timing in the brain,” thus improving a child’s ability to read quickly and accurately thereby helping the child understand what he/she is reading.

2. Explanation of Procedures: The first several sessions will consist solely of reading intervention. The Interactive Metronome will then be introduced into the bi-weekly session and will alter the session to include 30 minutes of traditional reading intervention and 30 minutes of Interactive Metronome treatment. Each child will receive 15 hours of Interactive Metronome and more than 18 hours of reading intervention throughout the course of the study. The participant will wear headphones and try to match the rhythmic beat heard with specific hand and foot motions using hand and foot triggers. The IM computer will record how closely the participant was able to synchronize his/her motions to the rhythmic beat.

3. Discomfort and Risks: There are minimal known or anticipated risks to a student who participates in this study. The only exception is that those with seizure disorder may experience adverse effects, and therefore should not participate. It should be noted that no instances of seizures have been reported and this is only precautionary. Students identified for IM treatment will have demonstrated that standard instruction has not been effective. For this reason, the use of IM during their clinical session will not inhibit reading outcomes, but will rather have the potential to improve the child’s reading outcomes.
4. **Benefits:** The anticipated benefits to subjects who participate in this study are improved reading fluency, thus, improved reading comprehension abilities and improved self-concept. In addition, field knowledge of fluency will also be gained.

5. **Confidentiality:** All data will be kept in a locked file cabinet at The Reading Room in Lexington, KY. Participants will only be identified using a pseudonym on all documents. The Reading Room will comply with the requirements of the Family Educational Rights and Privacy Act (FERPA) and the Protection of Pupil Rights Amendment (PPRA).

6. **Refusal/Withdrawal:** Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty. Furthermore, your participation will have no effect on any current or future services you receive from The Reading Room or The Curious Edge Foundation.

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

Child’s Name (Printed) ________________________________

_________________________________________  ________________________
Signature of Participant                      Date

_________________________________________  ________________________
Witness                                      Date

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Paul Mooney, Human Protections Administrator
TELEPHONE: (270) 745-2129
INFORMED ASSENT DOCUMENT
FOR RESEARCH INVOLVING MINORS

I, ___________________________________, understand that my parents (mom, dad, or guardians) have given permission (said it's okay) for me to take part in a project about Interactive Metronome under the direction of Denise Lewis.

I am taking part because I want to. I have been told that I can stop at any time I want to and nothing will happen to me if I want to stop.

Signature ___________________________ Date ________________

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Paul Mooney, Human Protections Administrator
TELEPHONE: (270) 745-2129