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The Effect of Interactive Metronome Training on Children's SCAN-C Scores

by
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An Applied Dissertation Submitted to the
Fischler School of Education and Human Services
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Speech-Language Pathology

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Approval Page

This applied dissertation was submitted by Joel L. Etra under the direction of the persons listed below. It was submitted to the Fischler School of Education and Human Services and approved in partial fulfillment of the requirements of the degree of Doctor of Speech-Language Pathology at Nova Southeastern University.

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Abstract

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In this study, the effect of Interactive Metronome, a treatment for attention deficit that requires the subject to match a computer generated rhythm, on auditory processing in male and female children ages nine to fourteen was investigated. Eight children were administered the SCAN-C and then were given the 15-hour Interactive Metronome training and administered the SCAN-C again.

SCAN-C raw scores showed a significant increase (p = .002). SCAN-C subtests of dichotic listening showed greater improvements than the other subtests. It is suggested that Interactive Metronome may affect auditory processing disorders by influencing neurological organization. It was concluded that Interactive Metronome could be an effective treatment for disorders of auditory processing. Potential difficulties in the provision of Interactive Metronome were discussed. Additional research was suggested with larger and more diverse samples as well as different trainers. More research into the design of the Interactive Metronome training schedule was also suggested.

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Chapter 1: Introduction

Statement of the Problem

Children with auditory processing disorders (APD) may have difficulty following directions, perform poorly in academics, and have difficulty with selective listening (Tillery, Katz, & Keller, 2000). Smoski, Brunt, and Tamahill (1992) noted that children with APD are often considered to be poor listeners and inattentive. It is easy to see how children with such difficulties would present a significant challenge in the classroom.

Speech-language pathologists (SLPs) treat disorders of auditory processing in a variety of settings including schools, private practice, hospitals, and medical clinics. A number of direct and indirect therapies are commonly used to reduce the effect of APD. Treatments such as traditional language therapy and environmental modification have little empirical support for their effectiveness. Additional cost-effective treatment choices would be welcomed by many SLPs. To be truly attractive, such treatment options should be inexpensive to acquire and to administer. In addition, extensive training of the clinician should not be a prerequisite. The progress made in an ideal program should be easily measured. The clinician should also be able to use the program with a variety of ages.

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Purpose

The purpose of this applied dissertation study was to research the effectiveness of Interactive Metronome (IM) in the treatment of APD. IM is marketed as program that will improve sports performance, muscle coordination, and musical ability. It is also marketed as a treatment for processing disorders, presumably including APD. Clinicians need evidence-based support for their treatment decisions. IM can be a valuable tool for treating APD in any number of settings if its effectiveness can be demonstrated.

Research Question

This research was designed to determine whether IM would be an appropriate tool for the treatment of APD. The research question that was addressed was, Does IM training improve auditory processing as measured by performance on SCAN-C test items?

Definitions of Terms

According to the American Speech-Language Hearing Association (ASHA) working group on APD (ASHA, 2005), auditory processing “refers to the perceptual processing of auditory information in the central nervous system and the neurobiologic activity that underlies that processing and gives rise to electrophysiological auditory potentials” (p. 2).

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Attention deficit is a disorder characterized by inattention, impulsivity/inhibition, and overactivity (Semrud-Clikeman, 1999). The Diagnostic and Statistical Manual of Mental Disorders-4 (American Psychiatric Association, 1994) divides the attention deficit population into predominantly inattentive, predominantly hyperactive-impulsive, and combined. For the purpose of this study, which is primarily concerned with APD and not attention deficit, the informal designation of attention deficit by parents or teachers who believed that a child was having difficulty learning because of an inability to sustain attention was used.

Auditory short-term memory (for the purposes of this research) refers to memory that involves recall of auditory information for a relatively short time, such as a few seconds.

Auditory synthesis is the ability to merge or blend phonemes into words. Auditory synthesis is an important skill for reading especially multisyllabic words.

The SCAN-C is a screening test for auditory processing disorders. Because it does not require an audiometric booth, or extensive training, it is a test that can be administered by speech pathologists and other educational professionals.

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Auditory figure ground refers to the ability to perceive auditory signals in the presence of background noise. One of the SCAN-C subtests addresses auditory figure ground.

IM is a training program that uses computer generated rhythms to improve attention span.

Phonemes are the sounds of human speech. Phonemes differ sufficiently from each other that substituting one for another would change the meaning of the word.

Auditory discrimination refers to the ability of the auditory system to discriminate between phonemes. Another term might be phonemic perception.

Semantics refers to the meanings of words. Semantic perception refers to the ability to hear a word and discern its meaning.

Chapter 2: Literature Review

Defining the Topic

The topic of disordered auditory processing has created considerable controversy. One source of this controversy has been the definition of the disorder.

Keith (1999) cited an ASHA task force definition stating in general terms that APD is a deficiency in one or more mechanisms or processes relating to a variety of auditory behaviors. He listed a number of behavioral criteria including (a) difficulty with auditory discrimination, (b) deficiencies in remembering and manipulating phonemes, (c) difficulty understanding speech in the presence of competing noise, and (d) frequent requests for information to be repeated. In a technical report from ASHA (2005), the following definition was used: "(C)APD is a deficit in neural processing of auditory stimuli that is not due to higher order language, cognitive, or related factors" (p. 2). The report also reasserted the belief that APD exists as a valid diagnosis.

Thayer and Dodd (1996) described auditory processing as "a complex analysis of the acoustic signal and a reintegration of that information into auditory patterns or gestalts" (p. 37). The authors also pointed out that there is no clear distinction between the central and peripheral

hearing systems, which renders problematic the use of the term *central*. Further diagnostic uncertainty was introduced by some theorists who referred to phonological perception and others to semantic perception, both of which are affected by developmental factors.

Stark and Bernstein (1984) noted, “Central auditory processing refers most frequently to psychologically and behaviorally defined phenomena measured in relation to an auditory signal” (p. 57). Watkins (1990) preferred “difficulties in processing the speech signal in the absence of peripheral hearing impairment” (p. 63).

Jerger and Musiek (2000), in a consensus paper developed at the Bruton Conference, presented the definition of an auditory processing disorder as follows:

> A deficit in the processing of information that is specific to the auditory modality. It may be associated with difficulties in listening, speech understanding, language development, and learning. In its pure form, however, it is conceptualized as a deficit in the processing of auditory input. (p. 2)

Other childhood disorders such as hyperactivity, autism, and learning disabilities may present similar symptoms and are not well differentiated by tests that rely on behavioral responses.

A number of authors questioned whether APD exists as a distinct disorder separate from a language disorder

(Friel-Patti, 1999; Keith, 1984; Rees, 1973) or from pansensory processing disorders (Cacase & McFarland, 1998).

Diagnosis by Testing and Behavioral Observations

Because APD is not well defined, testing and evaluation procedures are also controversial. Smoski et al. (1992) surveyed teachers' observations of students' behavior characteristics to develop a list of the behaviors that identify APD in children. Similarly, Witkin, Butler, and Whalen (1977) broke down auditory processing into five behavioral factors in order to select appropriate testing methods. These factors include short-term auditory memory; auditory synthesis, which involves the synthesis of unconnected fragmentary information; auditory figure ground; and oral language processing. The authors were surprised to note that no single factor of auditory discrimination emerged as significant but that language processing factors were most significant.

In a second analysis of the data, another set of five factors emerged. They were oral reading, auditory figure-ground, speech-sound discrimination, nonverbal reasoning, and oral language processing. Witkin et al. (1977) made a number of recommendations for diagnosis of APD. They recommended caution in the use of observations of auditory behavior in the classroom by untrained observers for the

purpose of diagnosis, as in this study, instead of formal testing. They asserted the need for further studies of the relationship of APD to reading disabilities and the need to assess children with learning disabilities carefully on multiple factors, including auditory figure-ground.

In another use of behavioral observation for the purpose of diagnosis, Smoski et al. (1992) used a survey of teachers to develop a similar list of the behaviors that identify APD in children. They found that children with APD had a wide range of academic achievement including some who were above average and some who were below. Teachers were asked to rate APD children on the parameters of social behavior that are not necessarily related to APD. These included general disposition, ease of discipline, liking school, peer interaction and energy level. All of these were judged at or above average by teachers. Only concentration was rated below average. The authors also found a greater number of children receiving special reading help among the APD population.

The selection of appropriate testing has been discussed in a number of articles. Cacase and McFarland (1998) included pansensory processing disorders such as visual processing as well as developmental dyslexia, developmental dysphasia, attention deficit, and effects of

otitis media. All of these deficits share behavioral and neurological symptoms with APD.

Singer, Hurley, and Preech (1998) preferred the use of a test battery and found that the binaural fusion test was most effective in differentiating children with both learning disabilities and presumed APD from a control group. Witkin et al. (1977) recommended caution in the use of untrained observers such as classroom teachers in the diagnosis of APD. In the Smoski et al. (1992) study, however, classroom behavioral judgments were called for, which teachers are qualified to make. Cautious use of such data may still be advisable.

Musiek and Chermak (1994) recommended different tests for different types of patients. Patients were divided into groups based on age and site of lesion with appropriate test batteries assigned to each group. For children, the authors recommended tests of dichotic digits, frequency patterns, competing sentences, and pediatric speech intelligibility. For patients with neurological involvement, they recommended auditory brain stem response, interaural timing procedures, masking level differences, and synthetic sentence identification.

The SCAN-C (Keith, 2000) uses four subtests to identify children who may benefit from treatment for APD.

The four tests are filtered words, auditory figure-ground, competing words, and competing sentences.

Medical and Traditional Management

Tillery et al. (2000) investigated the effects of methylphenidate (Ritalin) on processing abilities of attention-deficit children. Attention was measured by a continuous processing test. The researchers found that, although attention was increased with the drug, there was no improvement in processing as measured by the staggered spondaic word test, the speech-in-noise test, and phonemic synthesis. Although it is reasonable to assume that improved attention will lead to improved processing, it appears that it is not always the case.

Greenspan (1999) included APD in considering treatment of children with attention disorders. He cited the distractibility of APD children and their frequent need for repetition of directions. Most of his recommendations were for environmental management rather than direct treatment.

Numerous therapeutic models for treatment of APD have been explored. Keith (1999) listed important behaviors that should be addressed in therapy. He recommended teaching students to follow directions, listen and anticipate, ask relevant questions, answer questions, and use written notes. He also stressed developing self-monitoring and

self-evaluation skills. He noted that treatment can be by management or remediation. Management includes environmental modifications, perceptual, cognitive, and compensatory training. Compensatory training includes speech-sound discrimination, auditory analysis, phonemic synthesis, and auditory figure-ground training. Cognitive training involves message comprehension skills. Perceptual training includes sound localization, auditory discrimination, auditory pattern recognition, temporal resolution, temporal masking, temporal integration, and temporal ordering.

Tallal (1984) recommended training in temporal auditory processing for children with phonemic processing difficulties. She argued that temporal processing deficits are the cause of phonemic processing deficits and that remediation must begin with improvement of temporal processing.

Tallal et al. (1996) used acoustically modified speech to slow and stress the distinctive differences between phonemes. To accomplish this, the waveform of the signal was changed. They compared children trained with this modified speech to children who used computer games designed to enhance processing thresholds. The group who were trained in temporal processing showed greater improvements in speech discrimination and language

comprehension.

In an apparent reference to Tallal et al. (1996), Craighead (1999) urged caution in the use of treatments that are not sufficiently supported by research. A similar caveat had been expressed by Rees (1973).

Chermak and Musiek (1992) used what they called a comprehensive approach. They recommended training of listening and problem solving skills. Long-term gains, they asserted, were best accomplished by the teaching of language-learning and metacognitive skills.

IM uses rhythm to increase attention and, as is claimed by the developer of the program, can also improve processing ability (Casilly, n.d.). This possible connection with language processing is also suggested by Shaffer et al. (2001), although no research has been published addressing that specific connection.

Improvement in golf swing accuracy was demonstrated by Libkuman, Otani, and Steger (2002), who compared IM-trained golfers with a control group who read golf improvement literature. The IM-trained golfers showed improvement measured by the distance of the golf ball from the pin. It was suggested that the difference in performance was due to improved timing of the golf swing.

Shaffer et al. (2001) investigated the effects of IM

on a number of dimensions of attention deficit and hyperactive disorder (ADHD) in children including language processing. They divided 56 boys diagnosed with ADHD into three groups. One group was trained with IM. Another group played video games. A third group received no formal intervention or therapy at all. The Interactive Metronome group showed significant improvement in a number of parameters including language processing, control of aggression, and attention.

Koomar et al. (2001), in a single case study, found IM to be an effective instrument for the improvement of timing and rhythm. The authors claimed these abilities are fundamental to developing complex problem-solving skills.

Summary

Although the precise nature of auditory processing disorders remains uncertain, the considerable effects of this disorder demand attention. It is not unlikely that APD plays an etiological role in a number of disorders. With its unclear definition, the cause of the APD itself becomes difficult to treat. Most of the treatments cited in the literature deal with the symptoms and do not treat the problem directly.

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Chapter 3: Method

The research question that was addressed was, Does IM training improve auditory processing as measured by performance on SCAN-C test items?

Testing and training took place in the office of this researcher and on the premises of the cooperating school, both of which are in a small northeastern city, population 39,000. The town is located in a county with a population of 266,466. Of this total, 6.4% of the population is below the poverty level (U.S. Census Bureau, 2004). The school is a parochial school with 116 children in prekindergarten through eighth grade. Neither the office suite nor the school's therapy room was sound treated, but both had a quiet environment appropriate for SCAN-C testing. The SCAN-C was standardized by its developer in both a quiet environment and an audiometric booth. No significant differences were found between the two conditions (Keith, 2000). Subjects were pretested with the SCAN-C test for auditory processing, treated with IM training, and posttested with the SCAN-C.

Population

Six male and two female subjects between the ages of 8-14 years were used for this study. All subjects were greater than 6 years of age, as that is the minimum age

recommended by IM for the training. None of the subjects was receiving any other treatment for APD. In order to participate, subjects had to be able to follow the directions required by the IM training program. Although 10 children were recruited, only 8 completed the training. All the children were considered by their teachers and parents to be deficient in attention. When soliciting subjects for this study, this researcher asked parents and teachers to refer students who they thought were attention deficit. They were told that, if the children made enough errors on a test of APD, they would receive treatment for attention deficit at no charge. No formal testing for attention was done. Since this study was not investigating attention deficit, it was not considered necessary to quantify or otherwise formalize the diagnosis of attention deficit. No investigation into the effect of IM training on attention deficit was attempted.

One male and one female subject had a diagnosis of Asperger's Syndrome. These children required additional time to learn to perform all the exercises required by the IM program but ultimately completed the training with results not unlike the other trainees.

Parents of subjects were interviewed prior to inclusion in the study in order to discuss the study and

acquire informed consent. Parents were questioned regarding their children's hearing, and no child with a reported hearing loss was included in the study.

Subjects underwent IM training, which took 15 to 17 one-hour sessions over a 6-week time period. Pre and post testing with the SCAN-C was conducted by this investigator, who is a qualified examiner as defined by the SCAN-C developer. The manual that accompanies the SCAN-C (Keith, 2000) requires that the user be "knowledgeable in the administration and interpretation of tests designed for special education programs for children with learning or processing problems" (p. 7) Examiners may include speech pathologists, audiologists, and other professionals such as special educators. Test-retest reliability was reported with an interval of 2 days to 6 weeks and ranged from .65 to .82 (Keith, 2003).

IM training uses rhythm to increase attention span. Trainees match a computer-generated tone using prescribed body movements over an increasing length of time. Trainees wear a switch on one hand and, for foot exercises, tap on a switch on the floor. The foot switch is connected to a junction box, which is connected to the computer. The hand switch is similarly connected using wireless technology. The 13 different left, right, and bilateral body movements

include clapping, tapping a hand against the ipsilateral thigh, tapping one or both toes, tapping with one or both heels, tapping with a toe while balancing on the other foot, and alternating a hand tap and a toe tap. Repetitions of each exercise increase with each session and reach as many as 2,000 repetitions of a particular exercise as well as a few hundred repetitions of other exercises per session. When doing 2,000 repetitions, the subject is concentrating on the rhythm for up to 37 minutes within the 1-hour session. In a given session, for example, a trainee might be instructed to clap two hands together 1,500 times, tap the left hand on the left thigh 300 times, tap two heels 300 times, and tap with the toes 300 times. Each session begins with a short-form test requiring 54 hand claps without the guide sounds and an additional 54 with the guide sounds.

Each 1-hour session included a variety of the movements and usually required a total of more than 3,000 taps or repetitions. The program for each session and session goals are described in a training guide (see appendix). The computer measured the accuracy of each tap and returned a score for each exercise that represented the average deviation in milliseconds from an exact match with the computer-generated tone over the course of the

exercise.

During training, the subjects received feedback through headphones on the accuracy of each tap. The feedback took the form of different sounds, known as guide sounds, in each ear. Taps prior to the reference beat generated a sound in the left ear and taps after the reference beat generate a sound in the right ear. There was a unique sound for taps that exactly matched the reference beat, another for sounds within 15 milliseconds of the reference, and another for sounds that were beyond the running average that was determined by the program during each exercise. The results were then used to determine progress in the training.

Training required at least 15 one-hour sessions. In this study, trainees were seen two to three times per week. Three of the subjects were unable to consistently complete all the prescribed exercises in every 1-hour session. Consequently, additional sessions were scheduled. Because of frustration apparent on the part of the subjects, as well as available time constraints, four of the subjects were still unable to complete as many repetitions as were prescribed by the program. IM training was conducted by this investigator, who was trained and certified by the IM company to administer IM training.

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Instrumentation

The SCAN-C Test for Auditory Processing Disorders in Children-Revised (Keith, 2000) is a screening test of auditory processing that is administered individually. Subjects listen through headphones to instructions and stimuli recorded on a compact disc. To respond, the subject needs only to repeat what is heard. According to a technical report (Keith, 2003), this avoids cross-modality confusion that might be present in the cognitively more demanding task of identifying pictures in an array and pointing to the correct one.

The test has four subtests. The filtered words and auditory figure-ground subtests are speech tests in which the stimulus words have been distorted or presented in the presence of background to reduce intelligibility and simulate real listening conditions. The competing words and competing sentences subtests are dichotic listening tests. Different words or sentences are presented simultaneously, one word or sentence to each ear.

The filtered words subtest tests the ability to hear distorted speech. The SCAN-C manual (Keith, 2000) states that a low-pass filter was used at “1000 Hz with filter roll-off of 32 dB/octave so that the high frequency wounds were eliminated” (p. 16). Children with auditory processing

disorder may misunderstand such speech. This difficulty may be the cause of some receptive language disorders (Keith). The child is asked to repeat words that sound muffled. The test stimuli are one-syllable words that have been low-pass filtered at 1000 Hz. Three practice and 20 test words are presented to the right ear. Then two practice words and 20 test words are presented to the left ear.

The auditory figure-ground subtest tests the ability to understand words in the presence of background noise. Children with auditory processing disorder often have difficulty understanding speech in noisy environments such as classrooms (Keith, 2000). In this subtest, single syllable words are presented in the presence of a competing conversation or story. The child is expected to repeat the stimulus words heard in the presence of this background noise. Two practice words and 20 test words are presented to the right ear, and then two practice and 20 test words are presented to the left ear.

In the competing words subtest, different monosyllabic words are presented in each ear and the subject is directed to repeat the word heard in one ear. The child hears two words simultaneously-one word presented to each ear. First, two practice word pairs and 15 test word pairs are presented. The child is instructed to repeat both words,

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repeating the word heard in the right ear first. Then, a second set of two practice word pairs and 15 test word pairs are presented. The child is directed to repeat both words, saying the one heard in the left ear first.

Competing words is a test of ear advantage or dominance, which has been shown to be related to maturational delays and neurological disorganization often seen in APD. The competing words subtest enables the examiner to assess the child's ability to understand competing speech signals (sometimes called binaural separation). The competing words subtest is a dichotic task that is used to assess function of neurologic pathways of the auditory system (Keith, 2000). Poor overall performance on this subtest may indicate a developmental delay in maturation or underlying neurological disorganization or damage to auditory pathways. The competing words subtest also assesses ear advantage. Left-ear advantage can indicate failure to develop left hemisphere dominance for language. Abnormalities shown by dichotic words test results are related to a wide range of specific disabilities, including auditory processing disorder and language disabilities (Musiek & Pinheiro, 1985).

Similar to competing words, *competing sentences* uses sentences in the same way to further examine ear dominance

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(Keith, 2003). This subtest, as in competing words, is designed to address neurological organization. This subtest allows a comparison with competing words but on a higher linguistic level since it requires the repetition of sentences instead of single words (Keith, 2000). Pairs of sentences are presented to the right and left ears simultaneously. Unlike the competing words subtest, the child is instructed to listen to and repeat only the stimuli presented in one ear, while ignoring stimuli presented to the other ear. First, two practice sentence pairs and 10 test sentence pairs are presented. The child is instructed to repeat only the sentence heard in the right ear. Then, another set of practice and test sentence pairs are presented. This time, the child is instructed to repeat only the sentence heard in the left ear.

The test provides a raw score that is interpreted as an age-normed standard score. The test places scores within one standard deviation of the mean as normal. Scores greater than one standard deviation from the mean are borderline, and more than two standard deviations from the mean are considered disordered. In the current study, the total and subtest raw scores were used. Since the test uses only three categories--normal, borderline, and disordered--the use of raw scores allowed a more sensitive indication

of changes in SCAN-C performance although it was not a claim to be diagnostic for APD. For this study, children were administered the SCAN-C while seated in a quiet room. The test CD was played on a Sony DEJ-621 portable CD player with Sony MDR-V600 circumaural headphones.

In a review of the SCAN-C (Berg & Spitzer, 2005), a problem was identified regarding construct validity. Auditory processing is concerned with what happens to the signal on the perceptual level. Ultimately, it is a precognitive skill. A child with no knowledge of English, however, would not do as well as a child with some knowledge of the meanings of English words. Being able to repeat the words is likely to imply some knowledge of their meaning. Additionally, the inclusion of both single-word and sentence dichotic listening tasks for comparison implies that there is some influence by higher cognitive processes.

Although the SCAN-C is a screening test, it was chosen for this study because it can be administered by this researcher who is not an audiologist. Other APD tests can be administered only by an audiologist in a soundproof environment. It was believed that, because the test is designed to identify disorders of auditory processing, improvement on the test would indicate a change in auditory

processing ability. The test has a total of 130 items. Although no inference is made for the diagnosis of APD by the SCAN-C, an assumption is made that improvement in SCAN-C total raw score implies improvement in the skills that comprise auditory processing.

The equipment required to administer the IM is available only from the IM company for a cost of $3,000. The package includes the software, hand and foot switches, the control unit, a set of circumaural headphones, earphones for monitoring the sounds by the trainer, and 100 hours of use. Additional hours are available for $10 per hour. The user must provide the computer equipment. IM presents a metronome beat to a subject through headphones. The frequency of the beat is adjustable by the trainer but is normally set at 54 beats per minute for most subjects as was done during this research with two exceptions. In the case of one of the subjects diagnosed with Asperger's, the tempo, normally set at 54 beats per minute, had to be slowed for 10 minutes to allow him to match his hand movements better with the metronome beat. One of the other subjects became agitated by the guide sounds and complained that the task was too difficult. The difficulty setting was changed to allow him to be as much as 200ms off the target beat for three of the earlier sessions. This subject

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finished the program with a performance that was comparable to that of the other subjects. Trainees wear headphones and a hand switch and, for some tasks, also tap on a foot switch on the floor.

Some exercises require the trainee to be standing. For exercises not involving balance, trainees may sit at the discretion of the trainer. The trainer is also permitted to modify the exercises to accommodate physical disabilities or achieve trainee-specific needs. For example, wheelchair-bound trainees would be able to perform all exercises seated and hemiparetic trainees might need to perform all hand exercises with only one hand. The switches allow the computer to measure the accuracy of each hand or foot tap. The program returns an accuracy score in milliseconds and also records the number of perfect matches. Scores can be grouped to obtain scores for performance on tasks involving only hands or only feet. During training, subjects receive feedback through the headphones that indicates the accuracy of their matching of the beat.

The program includes a short form assessment (SFA) and a long form assessment (LFA). The SFA is performed at the beginning of each session and includes 54 repetitions with two hands without the guide sounds and 54 repetitions with the guide sounds. This assessment helps the trainee to

concentrate on the metronome beat to the exclusion of the guide sounds. It also is an indication to the trainer of the extent to which the trainee is confused or distracted by the guide sounds. The LFA includes 30 repetitions of each of the exercises. The average millisecond score of the exercises in the LFA can be used to track progress and also to determine when the training has been successfully completed.

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Chapter 4: Results

Two sets of scores were generated by the subjects of this applied dissertation research project. Pre- and posttest total raw SCAN-C scores were compared for significant changes using a dependent samples student *t*-test. The IM program includes the LFA, which averages performance on all of the exercises and reports a millisecond score. This assessment was given before training, at Session 7 (which is called midterm), and after the last session. It was expected that, with improved accuracy and concentration, scores would decrease. All eight subjects showed a significant decrease in the IM millisecond scores when the total pretest and posttest results were compared.

The significance of this change in scores was demonstrated by a *t*-test wherein $t(14) = -4.22$, $p = .001$. Results of the IM LFAs are summarized and presented in Figure 1. The decrease in these scores indicates an improvement in the ability to sustain accuracy of the tapping over time.

Significant increases in scores were also obtained on the SCAN-C test. A *t*-test, $t(14)$, resulted in a t value of -3.90 and a probability of .002. The average increase in

SCAN-C scores for all subjects (*n* = 8) was 24%. The average increase for the males (*n* = 6) was 26% and for females (*n* = 2) was 21%. The average age of the eight subjects was 10 years. Those under 10 (*n* = 3) achieved an average increase in SCAN-C scores of 34%, whereas those 10 and over (*n* = 5) had an average improvement of 19%. Improvement on the SCAN-C was evident for all subjects as summarized in Figure 2.

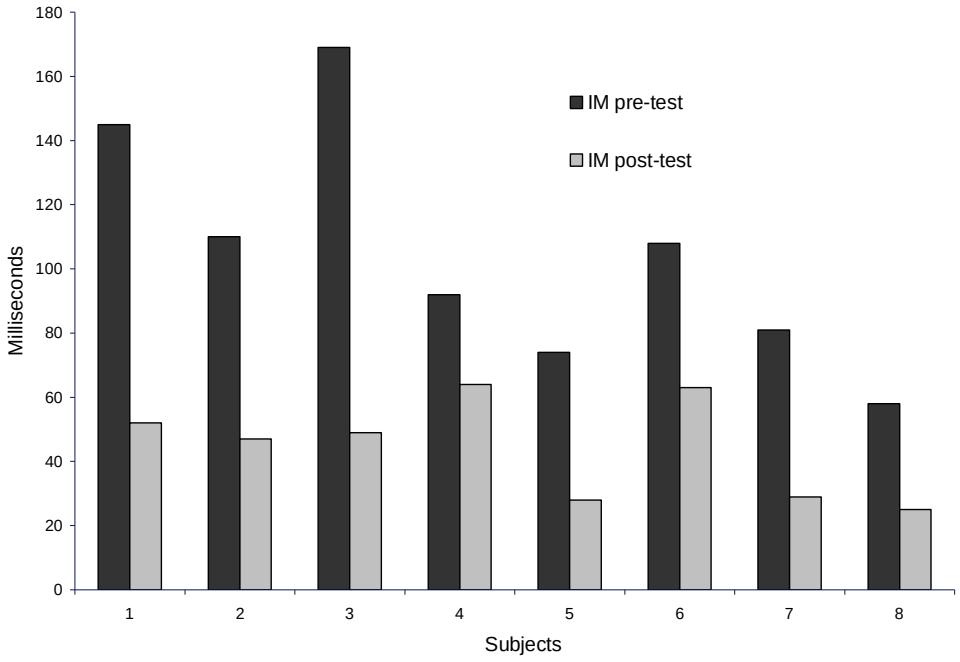

Figure 1. Changes in IM millisecond scores.

A comparison of subtest results was accomplished and summarized in Figure 3. Individual subtest scores were

averaged across subjects. It was expected that, because IM is a program that is designed to increase attention, most of the improvement should have been in the filtered speech and figure ground subtests, which are more sensitive to attention. However, the average increase in subtest scores was greater for Subtests 3 and 4, which are the tests of dichotic listening.

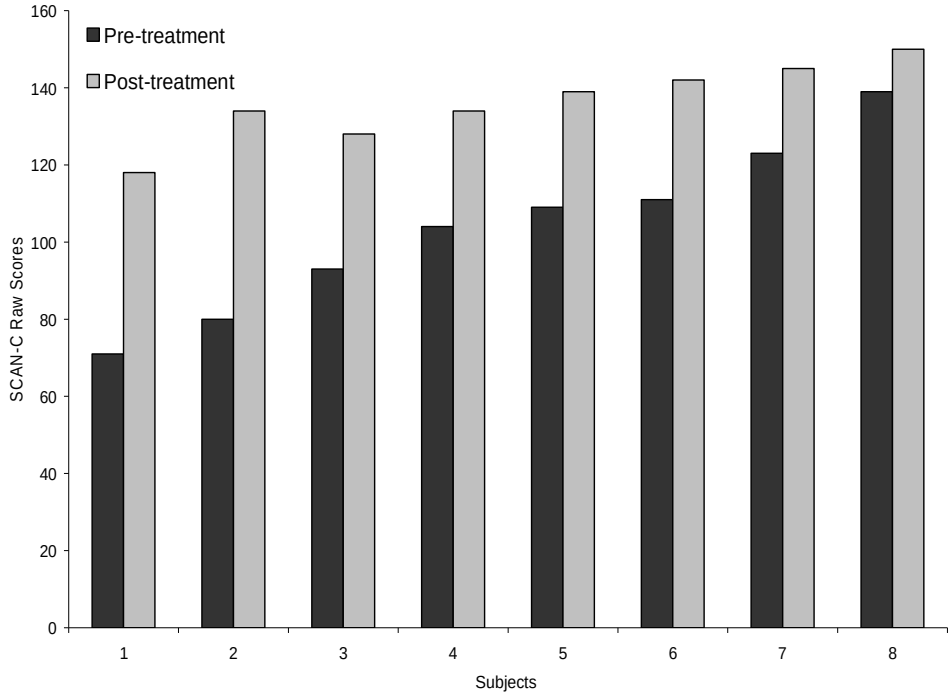

Figure 2. Changes in SCAN-C raw scores.

These tests are more related to neural organization. The implication, therefore, is that IM has an effect not only on attention but, perhaps to a greater extent, on neurological organization.

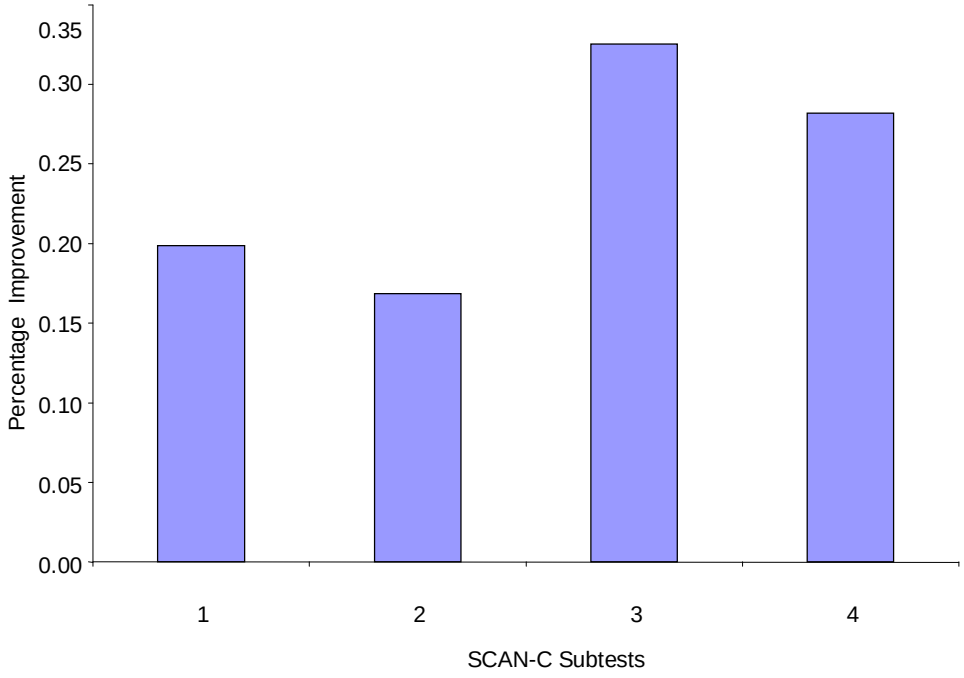

Figure 3. Percentage changes in SCAN-C subtests.

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Chapter 5: Discussion

Overview of Applied Dissertation

Treatment for APD is approached through a number of different strategies. These include direct therapy, environmental modification, and computerized instruction. There is a need, however, for research to support the efficacy of these treatments (ASHA, 2005). IM is a treatment that is being used for attention deficit. The current research was designed to determine if this treatment may also be effective for APD. The SCAN-C is a screening test for APD that can be administered by a speech-language pathologist. Changes in SCAN-C raw scores were used to indicate the effect that IM training might have on APD. As a result of this research, a strong correlation (p = .002) was demonstrated between IM training and improvement in SCAN-C scores. Percentage increases in SCAN-C scores were also compared by gender and age. Males achieved scores slightly higher than females, although the ratio of male to female subjects was 3:1, which might skew that result. Subjects younger than 10 years achieved scores higher than those achieved by those 10 or over.

Implications of Findings

Based on these results, IM can be considered an appropriate treatment for APD. However, during the

implementation of this research, some difficulties arose. The program requires considerable commitment by the trainer, the trainee, and in some cases, the parents and the children's teachers and school administrators. As noted, the program requires at least 15 one-hour sessions. The child needs to be brought to these sessions; therefore, someone must be willing and available to provide transportation. The busy schedules of parents and children sometimes made two to three sessions per week impossible. If administered in a school setting, the program would require the cooperation of classroom teachers to allow students who may already be at academic risk to make up work missed during time out of class.

During the implementation of this study, many sessions had to be rescheduled because of competing family and school activities. This caused the length of the program to be extended. In one case, a child was taken out of school on vacation for a week. When this child returned, some of the skills needed for IM had to be taught again. The child's absence from school also made missing instructional time for IM training problematic.

The IM program is somewhat demanding physically. It is also repetitious and, therefore, does not readily sustain the interest of a child. The ability of the trainer to

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motivate trainees becomes crucial, especially with younger children. At least one of the subjects complained of physical discomfort and needed rest periods during training. One child became very frustrated by the demands of the program and spent parts of the early sessions crying. With encouragement and temporary adjustment of the program settings, he was able to finish the training successfully.

In spite of these difficulties, IM remains a viable choice for speech-language pathologists, occupational therapists and other professionals treating APD. Although scheduling two to three 1-hour sessions per week can be difficult, the program can be completed in about 15 hours. There is no indication from this research that other interventions including direct therapy and environmental modifications should not be used in conjunction with IM.

Limitations

Because of the availability of subjects in the geographical area of this study and the expense and time required for training, only 8 subjects were used. This small sample makes it impossible to stratify and generalize results by gender, age, or diagnosis. A larger sample size would also make generalization of the results to the given population easier to support statistically.

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The IM program specifies a total number of repetitions for completion of the program. Because of practical considerations such as scheduling and behavior, not all the subjects completed the same number of repetitions. It is not known what effect, if any, this discrepancy might have had on the results.

In this study, all the IM training was done by the same trainer. Although this trainer was certified by IM to provide IM training, such training is also provided by individuals with a wide variety of professional backgrounds. Although the total number of repetitions would remain the same, differences might arise in methods of motivation. It is not known whether differences in backgrounds would result in differences in the approach to training and, consequently, different results.

All the subjects in this study were considered to have attention deficit. It is possible that, because of their poor attention skills, their performance was not representative of children who are not attention deficit.

The SCAN-C test was used to demonstrate a change in auditory processing ability. The test is not diagnostic but, rather, it is a screening test. No inferences can be made, therefore, regarding a diagnosis of APD. It was assumed, however, that changes in the raw scores on the

SCAN-C could be related to changes in auditory processing ability. This assumption remains untested.

Recommendations

A need for additional research is suggested by the results of this study. Recommendations include the following:

1. A similar study with a larger number of subjects would enable stronger statistical support for the results.

2. A larger study could compare performance by age, gender, and ethnicity. Differences may be found that would suggest ideal ages for implementation of IM treatment. Studies by gender would help establish expectations for male and female trainees.

3. Diagnosis of APD is commonly done by an audiologist. A study using pretests and posttests for APD administered by an audiologist could make more definitive statements about IM training's effect on APD.

4. All the subjects in the current study were considered to have an attention deficit disorder. Studies with other populations exclusively such as autism spectrum disorder or learning disability, as well as those with no other diagnosis, could provide additional information for generalization.

5. The IM training in this study was done by a speech-

language pathologist. Another study might compare results of training provided by other professionals such as occupational or physical therapists, psychologists, or educational specialists.

6. Although the IM program specifies a minimum number of repetitions, a specified tempo, a minimum number of sessions, a target millisecond score, and a menu of exercises, there is nothing in the literature to support any of these requirements. It is not clear whether more repetitions would bring about greater results and what would be the point of diminishing returns. Additionally, can similar results be obtained with fewer repetitions over fewer and longer or more and shorter sessions? The program also requires trainees to perform exercises using hands and feet. No specific explanation is offered as to the rationale behind this. Further research might test the value of involving the both arms and legs in the training. As the program is used for other goals such as improving athletic performance and balance, perhaps recommendations can be developed for a different menu of exercises prescribed to address specific needs.

7. In this research, posttesting was done upon completion of the training. No additional testing was done. A follow-up study might be done to determine carryover of

the effects. SCAN-C testing after 6 months and again after a year might show additional improvement, loss of improved performance, or stabilization.

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Appendix

Interactive Metronome Training Guide

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IM Training Guide

Standard 15 Session
Training Plan

Trainer Name: _____

Trainee Name: _____

Date of Birth: _____/_____/_____

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Session 1: (1,676 reps)

Initial Long Form Assessment

As you may recall from the IM Training Familiarization section, the IM Long Form Assessment includes 14 tasks that require the trainee to perform a variety of upper and lower body movements in time with the IM reference tone. It serves three purposes: to analyze existing capabilities; to gather baseline data needed to select the proper training plan; and to draw improvement comparisons since it is given before, midway through, and after the training program. The Long Form Assessment should take twenty to thirty minutes depending on whether you choose to have the trainee perform the optional "Attend Over Time."

Attend Over Time (AOT)

If you suspect that a trainee's assessment scores are only reflective of the very short duration of the Long Form, add the 'Attend-Over-Time' test to the end of each assessment administered.

Getting Started

Start a new trainee file by selecting “File” then

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"New" from the menu bar and naming the file with the trainee's initials followed by the last four digits of the social security number (or other identification number). There should be a total of seven digits (e.g. JJD4567). If he/she does not have a middle name, use "X" in the place of that middle initial. Then, from the menu bar, select "Edit" and enter the "Trainer" and "Trainee" information ("Trainee" same as the file name).

Note: Make sure the trainee is wearing comfortable clothing and non-skid shoes.

What to Remember ***(please read all items)***

- The date will be automatically entered for the session; the program will use the date the computer is using, so be sure it is correct.
- The metronome icon or "F2" on the keyboard will start and stop each task, but keep in mind that no data will be recorded should you need to stop a Long Form Assessment task before its completion.
- The trainee must complete all 14 tasks of the assessment in order to generate a "Long Form Calculations" report.
- The program will automatically advance to the next task upon completion of the previous one. Each task is numbered should you need to manually select the next one.

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- The first four tones of all LFA tasks (and some other tasks) are for practice. The system begins calculating with the fifth tone.
- If the hits do not register, stop the task to check the triggers and the motion being used.

What to Tell the Trainee

- "The reference tone you will hear sounds like a cowbell; this is the metronome beat that you want to hit. All your trigger hits should be **ON** the beat and not in reaction to it. The last task **will have other sounds, but just focus on the cowbell**."
- "While performing the tasks, do not watch the computer screen; concentrate only on the reference tone. "
- "During all tasks, try to avoid quick, ballistic, jerky movements. All motions should be continuous and fluid."
- "Try not to miss a beat, but if one is missed, keep going because the IM program will calculate only registered responses."
- "Do not touch the foot trigger before beginning any of the foot tasks because doing so will cause responses to be recorded incorrectly."

Do's and Don'ts during Training

- Securely place the hand trigger on the reported

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dominant hand.

- Make sure the trainee stands comfortably away from the computer desk.
- Do not allow the trainee to listen to the IM sounds or practice any motions prior to taking the Long Form Assessment (LFA).
- Before each task, briefly adjust the trigger, describe and demonstrate the correct movements, and explain how to activate the appropriate trigger correctly. **Note**: You may use the verbal descriptions in Appendix C.
- Do not open any other programs during training. All computer applications including screen savers should be shut off prior to the session.
- Once the task has started, you may physically demonstrate and correct the motion, but only during the first four count-in beats.
- Move through the tasks rapidly to maintain focus.

Begin the Assessment

1. With the trainee file open, select and click “Long Form Testing” from the Task Mode Selector drop-down menu.
2. Three boxes will appear above that field. Check the box labeled “Pre.”
3. Select task “1 - Both Hands” from the Task Selector drop-down menu.
4. Click the metronome icon or press the “F2” on the keyboard to begin.

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Long Form Assessments Scores Sheet

To best assess the needs of the trainee, you should take notice of the very early, early, very late, and late percentages as well as the timing tendency. You can use the form below or generate a “Long Form Calculations” report from the “Reports” menu.

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Date____/____/_____

Task **ms.** **Early % Late % Tendency**

1. Both Hands
2. Right Hand
3. Left Hand
4. Both Toes
5. Right Toe
6. Left Toe
7. Both Heels
8. Right Heel
9. Left Heel
10. Right Hand/Left Toe
11. Left Hand/Right Toe
12. Balance Right Foot
13. Balance Left Foot
14. Repeat #1 – with Guide Sounds

Pre tested Long Form Battery Calculations:

Hands average: _____ Feet average: _____

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Average: _____ Tendency: Early _____% Late _____%

Lowest Ms. Score: _____ Bursts: _____

IAR High: _____

Optional - Attend-Over-Time Test

Average: _____

IAR High: _____ Bursts: _____ SRO%: _____

Goal(s): During each session, along with Regular Training, the Short Form should be administered to measure the trainee's ability to stay on task for a short period of time. For this first session, help the trainee understand the guide sounds and learn the motions used in IM training. You may want to listen along with the trainer set of headphones and make sure he/she comprehends which sounds correlate to which type of response. Remind the trainee to focus on the metronome tone. For the hand exercises, demonstrate making continuous circles and tapping in the middle. For the foot exercise, show how to tap each toe and return it to the starting position. Once again, state that all motions should be smooth and not snappy or ballistic. Also, you should begin tracking the total number of

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repetitions in the area provided at the end of each session.

Short Form

1. Select Short Form Testing from the drop-down box.
2. From the next drop-down box, select and have the trainee complete the following tasks:

Ex. 1 – Both Hands (no Guide Sounds)

ms. avg. _____

Ex. 2 – Repeat #1 with Guide Sounds

ms. avg. _____

Regular Training

1. Select “Regular Training” from the drop-down box.
2. Select the appropriate task listed below.
3. Check the “Guide Sounds” box.
4. Manually select the number of repetitions, when necessary.
5. Have the trainee complete the following tasks:

Note: If the optional “Attend Over Time” test was given as part of the initial assessment, reduce the number of repetitions from each of the following tasks by 100.

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Ex. 1 Both Hands (200 reps.) **ms. avg.**_____

Ex. 1 Both Hands (300 reps.) **ms. avg.**_____

Ex. 4 Both Toes (300 reps.) **ms. avg.**_____

Ex. 3 Left Hand (300 reps.) **ms. avg.**_____

Date____/____/_____ reps to-date: required 1,676 completed _____

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Session 2: (2,408 reps.)

Goal(s): During this session, help the trainee correct timing tendencies (continually staying on one side of the beat). After the short form, regular training will begin with tasks to attempt countering the timing tendency. For those tasks only, instruct the trainee to hit opposite his/her tendency, but after a period of time to relax again. The trainee likely will move back toward the initial tendency noted, so explain that this is what he/she is learning to adjust.

Short Form

1. Select “Short Form Testing” from the drop-down box.
2. From the next drop-down box, select and have the trainee complete the following tasks:

Ex. 1 – Both Hands (no Guide Sounds)

ms. avg. _____

Ex. 2 – Repeat #1 with Guide Sounds

ms. avg. _____

Regular Training

1. Select “Regular Training” from the drop-down box.
2. Select the appropriate task listed below.
3. Check the “Guide Sounds” box.

4. Remove the check from the “Auto-Difficulty” box.
5. Manually select the number of repetitions, when necessary.
6. Have the trainee complete the following tasks:

Ex. 1 - Both Hands (500 reps.) **ms. avg.** _____

Ex. 4 - Both Toes (300 reps.) **ms. avg.** _____

7. Check the “Guide Sounds” box.
8. Check the “Auto-Difficulty” box.
9. Have the trainee complete the following tasks:

Ex. 2 - Right Hand (300 reps.) **ms. avg.** _____

Ex. 3 - Left Hand (300 reps.) **ms. avg.** _____

Ex. 4 - Both Toes (300 reps.) **ms. avg.** _____

Ex. 5 - Right Toe (300 reps.) **ms. avg.** _____

Ex. 6 - Left Toe (300 reps.) **ms. avg.** _____

Date____/____/_____ reps to-date: required 4,084 completed _____

Session 3: (2,508 reps.)

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Goal(s): Continue countering the timing tendency. The trainee should comfortably stay before or after the beat for at least eight reps. Explain that it is better to hit opposite the initial tendency than to stay far off beat for more than three reps. Warn the trainee when the third tap is not on the beat. During this session, explain what a Burst is (measure of capacity to focus, be attentive, and execute sequential activity); how to attain one (four consecutive hits within fifteen milliseconds of the reference tone); and the importance of increasing the number (indicates an improvement in these capacities). The trainee should aim for a goal of 4 bursts during this session.

Short Form

1. Select “Short Form Testing” from the drop-down box.
2. From the next drop-down box, select and have the trainee complete the following tasks:

Ex. 1 - Both Hands (no Guide Sounds)

ms. avg. _____

Ex. 2 - Repeat #1 with Guide Sounds

ms. avg. _____

Regular Training

1. Select the appropriate task listed below.
2. Check the “Guide Sounds” box.

3. Verify that there is no check in the “Auto-Difficulty” box.
4. Manually select the number of repetitions, when necessary.
5. Have the trainee complete the following tasks:

Ex. 1 - Both Hands (500 reps.) **ms. avg.** _____

Ex. 4 - Both Toes (400 reps.) **ms. avg.** _____

5. Check the “Guide Sounds” box.
6. Check the “Auto-Difficulty” box.
7. Have the trainee complete the following tasks:

Ex. 10 - Right Hand/Left Toe (500 reps.) **ms. avg.** _____

Ex. 11 - Left Hand/Right Toe (500 reps.) **ms. avg.** _____

Ex. 3 - Left Hand (300 reps.) **ms. avg.** _____

Ex. 7 – Both Heels (200 reps.) **ms. avg.** _____

Date____/____/_____ reps to-date: required 6,592 completed _____

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Session 4: (2,508 reps.)

Goal(s): Continue countering the tendency and then attempt to improve hand/foot control. Also, attempt to increase the number of bursts to 5.

Short Form

1. Select “Short Form Testing” from the drop-down box.
2. From the next drop-down box, select and have the trainee complete the following tasks:

Ex. 1 - Both Hands (no Guide Sounds)
ms. avg. _____
Ex. 2 - Repeat #1 with Guide Sounds
ms. avg. _____

Regular Training

1. Select the appropriate task listed below.
2. Check the “Guide Sounds” box.
3. Remove the check from the “Auto-Difficulty” box.
4. Set the “Difficulty” selector to **50**.
5. Manually select the number of repetitions when necessary.
6. Have the trainee complete the following task:

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Ex. 4 - Both Toes (400 reps.) **ms. avg.** _____

7. Check the “Auto-Difficulty” box.
8. Have the trainee complete the following tasks:

Choice of Hands Ex._____ (1000 reps.) **ms. avg.** _____

Ex. 10 - Right Hand/Left Toe (400 reps.) **ms. avg.** _____

Ex. 11 - Left Hand/Right Toe (300 reps.) **ms. avg.** _____

Ex. 2 - Right Hand (300 reps.) **ms. avg.** _____

Date____/____/_____ reps to-date: required 9,100 completed _____

Session 5: (2,408 reps.)

Goal(s): The trainee should continue hitting on the beat and correcting motions such as controlling heel movements. Explain that this session is preparation for the upcoming Midterm Long Form Assessment and he/she should strive to improve In-A-Rows. **All Regular Training sessions from this point on should be performed with the "Guide Sounds" and "Auto-Difficulty" boxes checked, unless otherwise recommended**. Burst Goal = 6

Short Form

Ex. 1 - Both Hands (no Guide Sounds)
ms. avg. _____
Ex. 2 - Repeat #1 with Guide Sounds
ms. avg. _____

Regular Training

Ex. 4 - Both Toes (400 reps.) **ms. avg.** _____
Ex. 1 - Both Hands (1200 reps.)
ms. avg. _____
Ex. 12 - Bal. Rt. Foot/Tap Lt. Toe (100 reps.)
ms. avg. _____
Ex. 13 - Bal. Lt. Foot/Tap Rt. Toe (100 reps.)
ms. avg. _____
Ex. 7 - Both Heels (200 reps.) **ms.**

avg. _____

Choice of Foot Ex._____ (300 reps.) **ms.**

avg. _____

☐ *Check here* if a *personal best* was achieved on the 1200 reps. task.

Date____/____/_____ reps to-date: required 11,508 completed _____

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Session 6: (2,408 reps.)

Goal(s): Catch up on the required number of reps. to this point. Before starting the session, calculate the total number of reps. completed so far, and if it is short of the expected number, add extra at your discretion. You may want to explain the necessity of completing the required number to the trainee. Burst Goal = 12

Short Form

Ex. 1 - Both Hands (no Guide Sounds)
ms. avg. _____
Ex. 2 - Repeat #1 with Guide Sounds
ms. avg. _____

Regular Training

Ex. 1 - Both Hands (500 reps.) **ms. avg.** _____
Choice of any Ex._____ (1000 reps.)
ms. avg. _____
Ex. 13 - Bal. Lt Foot/Tap Rt. Toe (100 reps.)
ms. avg. _____
Ex. 12 - Bal. Rt. Foot/Tap Lt. Toe (100 reps.)
ms. avg. _____
Ex. 8 - Right Heel (300 reps.) **ms. avg.** _____
Ex. 9 - Left Heel (300 reps.) **ms.**

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avg. _____

☐ *Check here* if a *personal best* was achieved on the 1000 reps. task.

Date____/____/_____ reps to-date: required 13,916 completed _____

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Session 7: (2,376 reps.)

Goal(s): Perform the Midterm Long Form Assessment. There is an additional, warm-up which, at your discretion, can be performed prior to the assessment or immediately afterwards. After reviewing the results of the midterm, determine whether the trainee has shown the ability to return to the beat quickly (within two or three beats). If this is not the case and you feel it necessary, discuss adding extra sessions to help the trainee with this goal. For the remaining sessions, the Burst goal should be attained **during one task instead of throughout the session**. Burst goal - 16

Short Form

Ex. 1 - Both Hands (no Guide Sounds)

ms. avg. _____

Ex. 2 - Repeat #1 with Guide Sounds

ms. avg. _____

Warm-up

Select the three tasks the trainee has the most difficulty with. With regular training selected, have him/her perform 200 reps each for a total of 600 reps. Since this is a warm-up, there is no need to record the scores.

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Long Form Testing

1. Select and click “Long Form Testing” from the Task Mode Selector drop-down menu.
2. Check the box labeled “Mid.”
3. If not already showing, select task “1 - Both Hands” from the Task Selector drop-down menu.
4. Click the metronome icon or press the “F2” on the keyboard to begin.

Regular Training

Choice of any Ex._____ (1000 reps.)
ms. avg. _____

Select the worst scoring task from the Midterm (not ex. 12 or 13)
Ex._____ (200 reps.) **ms. avg.** _____

☐ *Check here* if a *personal best* was achieved on the 1000 reps. task.

Date____/____/_____ reps to-date: required 16,292
completed _____

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Long Form Assessments Scores Sheet

Date____/____/_____

Task	**ms.**	**Early %**	**Late %**	**Tendency**
1. Both Hands				
2. Right Hand				
3. Left Hand				
4. Both Toes				
5. Right Toe				
6. Left Toe				
7. Both Heels				
8. Right Heel				
9. Left Heel				
10. Right Hand/Left Toe				
11. Left Hand/Right Toe				
12. Balance Right Foot				
13. Balance Left Foot				
14. Repeat #1 – with Guide Sounds				

Midterm Long Form Battery Calculations:

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Hands average: _____ Feet average: _____

Average: _____ Tendency: Early _____% Late _____%

Lowest Ms. Score: _____ Bursts: _____ IAR High: _____

Optional - Attend-Over-Time Test

Average: _____

IAR High: _____ Bursts: _____ SRO%: _____

Session 8: (2,408 reps.)

Goal(s): The trainee should attempt to improve the three worst scoring tasks from the midterm (except tasks 12 and 13). Burst goal -18 (during one task)

Short Form

Ex. 1 - Both Hands (no Guide Sounds)
ms. avg. _____
Ex. 2 - Repeat #1 with Guide Sounds
ms. avg. _____

Regular Training

Worst Midterm Ex. _____ (200 reps.)
ms. avg. _____
2nd Worst Midterm Ex. _____ (200 reps.) **ms. avg.** _____
3rd Worst Midterm Ex. _____ (200 reps.) **ms. avg.** _____
Choice of Hands Ex._____ (1500 reps.)
ms. avg. _____
Ex. 3 - Left Hand (200 reps.) **ms. avg.** _____
☐ *Check here* if a *personal best* was achieved on the 1500 reps. task.

Date____/____/_____ reps to-date: required 18,700 completed _____

Session 9: (2,508 reps.)

Goal(s): The trainee should continue improving on the worst Midterm task (not Ex. 12 or 13) and practice getting "back on beat" within one tone.

Burst goal - 22 (one task)

Short Form

Ex. 1 - Both Hands (no Guide Sounds)

ms. avg. _____

Ex. 2 - Repeat #1 with Guide Sounds

ms. avg. _____

Regular Training

Worst Midterm Ex._____ (200 reps.) **ms. avg.** _____

Choice of any Ex. _____ (2000 reps.)

ms. avg. _____

Worst Midterm again Ex._____ (200 reps.) **ms. avg.** _____

☐ *Check here* if a *personal best* was achieved on the 2000 reps. task.

Date____/____/_____ reps to-date: required 21,208 completed _____

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Session 10: (2,508 reps.)

Goal(s): This session, continue improving on the worst Midterm task (not Ex. 12 or 13). Burst goal - 20 (one task)

Short Form

Ex. 1 - Both Hands (no Guide Sounds)
ms. avg. _____
Ex. 2 - Repeat #1 with Guide Sounds
ms. avg. _____

Regular Training
Choice of Hands Ex. _____ (1500 reps.)
ms. avg. _____
Worst Midterm Ex._____ (300 reps.) **ms. avg.** _____
Ex. 7 - Both Heels (300 reps.)
ms. avg. _____
Ex. 4 - Both Toes (300 reps.)
ms. avg. _____
☐ *Check here* if a *personal best* was achieved on the 1500 reps. task.

Date____/____/_____ reps to-date: required 23,716 completed _____

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Session 11: (2,508 reps.)

Goal(s): Burst goal - 20 (one task)

Short Form

Ex. 1 - Both Hands (no Guide Sounds)

ms. avg. _____

Ex. 2 - Repeat #1 with Guide Sounds

ms. avg. _____

Regular Training

Choice of Hand/Toe Ex. _____ (1000 reps.)

ms. avg. _____

Ex. 4 - Both Toes (500 reps.) **ms. avg.** _____

Ex. 7 - Both Heels (500 reps.)

ms. avg. _____

Ex. 3 - Left Hand (400 reps.)

ms. avg. _____

☐ *Check here* if a *personal best* was achieved on the 1000 reps. task.

Date____/____/_____ reps to-date: required 26,224 completed _____

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Session 12: (2,508 reps.)

Goal(s): At this point, the trainee should be able to make corrections within one or two reps and should not be off the beat by more than 30 ms. in any direction. Continue working to correct this if it is not the case. Also, to keep interest and/or renew enthusiasm, you may want to allow the trainee to pick one task for this session. Burst goal - 30+ (one task)

Short Form

Ex. 1 - Both Hands (no Guide Sounds)

ms. avg. _____

Ex. 2 - Repeat #1 with Guide Sounds

ms. avg. _____

Regular Training

Choice of any Ex. _____ (2000 reps.)

ms. avg. _____

Ex. 7 - Both Heels (400 reps.) **ms. avg.** _____

☐ *Check here* if a *personal best* was achieved on the 2000 reps. task.

Date____/____/_____ reps to-date: required 28,732 completed _____

Session 13: (2,508 reps.)

Goal(s): Once again, to keep interest and/or renew enthusiasm, you may want to allow the trainee to pick one task for this session. Burst goal - 30+ (one task)

Short Form

Ex. 1 - Both Hands (no Guide Sounds)

ms. avg. _____

Ex. 2 - Repeat #1 with Guide Sounds

ms. avg. _____

Regular Training

Choice of any Ex. _____ (2000 reps.)

ms. avg. _____

Worst Midterm Ex._____ (200 reps.) **ms. avg.** _____

2nd Worst Midterm Ex._____ (200 reps.) **ms. avg.** _____

☐ *Check here* if a *personal best* was achieved on the 2000 reps. task.

Date____/____/_____ reps to-date: required 31,240 completed _____

Session 14: (2,508 reps.)

Goal(s): If the trainee has reached the training goals in terms of millisecond average, explain that the remaining sessions are important to anchor the achievement. If the goals have not been met, discuss extending the number of sessions and why it is important. Burst goal - 30+ (one task)

Short Form

Ex. 1 - Both Hands (no Guide Sounds)

ms. avg. _____

Ex. 2 - Repeat #1 with Guide Sounds

ms. avg. _____

Regular Training

Choice of any Ex. _____ (2000 reps.)

ms. avg. _____

Worst Midterm Ex._____ (200 reps.) **ms. avg.** _____

2nd Worst Midterm Ex._____ (200 reps.) **ms. avg.** _____

☐ *Check here* if a *personal best* was achieved on the 2000 reps. task.

Date____/____/_____ reps to-date: required 33,748 completed _____

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Session 15: (2,076 reps.)

Goal(s): This normally will be the last session and will include the Post test Long Form Assessment. The Regular Training tasks are listed immediately under the Short Form but can be administered before or after the assessment according to your discretion. Burst goal - 40+ (one task)

Short Form

Ex. 1 - Both Hands (no Guide Sounds)
ms. avg. _____
Ex. 2 - Repeat #1 with Guide Sounds
ms. avg. _____

Regular Training

Ex. 4 - Both Toes (300 reps.)
ms. avg. _____
Ex. 7 - Both Heels (200 reps.)
ms. avg. _____
Choice of Hands Ex._____ (1000 reps.)
ms. avg. _____

☐ Check here if trainee got a personal best on the above 1000 rep task.

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Long Form Testing

1. Select and click “Long Form Testing” from the Task Mode Selector drop-down menu.
2. Check the box labeled “Post.”
3. If not already showing, select task “1 - Both Hands” from the Task Selector drop-down menu.
4. Click the metronome icon or press the “F2” on the keyboard to begin.

Date____/____/_____ reps to-date: required 35,824

completed _____

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Long Form Assessments Scores Sheet

Date____/____/_____

Task	**ms.Early %**	**Late %**	**Tendency**
1. Both Hands			
2. Right Hand			
3. Left Hand			
4. Both Toes			
5. Right Toe			
6. Left Toe			
7. Both Heels			
8. Right Heel			
9. Left Heel			
10. Right Hand/Left Toe			
11. Left Hand/Right Toe			
12. Balance Right Foot			
13. Balance Left Foot			
14. Repeat #1 – with Guide Sounds			

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Post test Long Form Battery Calculations:

Hands average: _____ Feet average: _____

Average: _____ Tendency: Early _____% Late _____%

Lowest Ms. Score: _____ Bursts: _____

IAR High: _____

Optional - Attend-Over-Time Test

Average: _____

IAR High: _____ Bursts: _____ SRO%: _____

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Additional Sessions

If a trainee has not met the completion goals, and you are able to extend the number of sessions, use the Session 14 format for those sessions. For the last session, follow the Session 15 format.

Notes or Observations:

Session Short Form Records

	SF date	Task 1	Task 2
Day 1			
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			
Day 8			
Day 9			
Day 10			
Day 11			
Day 12			
Day 13			
Day 14			
Day 15			

Additional Sessions

	SF date	Task 1	Task 2
Day 16			
Day 17			
Day 18			
Day 19			
Day 20			
Day 21			
Day 22			
Day 23			
Day 24			
Day 25			

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IM Training Program Personal Best Achievements

Best Short Forms Pt 1 _____

Date ____/____/_____

Pt 2 _____ Date

____/____/_____

Best 500 rep task Exercise # ____ ms. ____

Date ____/____/_____

Best 1000 rep task Exercise # ____ ms.

____ Date ____/____/_____

Best 2000 rep task Exercise # ____ ms.

____ Date ____/____/_____

Best In-A-Row ____ Exercise # ____ ms. ____

Date ____/____/_____

Best 4 Bursts ____ Exercise # ____ ms. ____

Date ____/____/_____

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Best IAR % ____ Exercise # ____ ms. ____

Date ____/____/_____

Best IAR # ____ Exercise # ____ ms. ____

Date ____/____/_____

Pre tested overall ms. avg. ____ Post test overall ms. avg. ____

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