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Early Effects of the Tomatis Listening Method in Children with Attention Deficit

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Early Effects of the Tomatis Listening Method in Children with Attention Deficit

A clinical dissertation

presented to the Graduate Faculty of Antioch University Seattle

as partial fulfillment of the requirements

for the Degree

Doctor in Psychology

By

Liliana Sacarin, M.S., M.A.

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I certify that I have read this manuscript and that, in my judgment, it is fully adequate in scope and quality as a dissertation for the degree of Doctor in Psychology.

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An Abstract of

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This study investigated the early effects of the Tomatis Method, hypothesizing improvement in processing speed, phonological awareness, reading efficiency, attention, behavior and brain physiology by the end of Phase 1 of the Tomatis Method. This study documented the effects of the first phase of the Tomatis Method on children with ADD ages 7-13. Of the 25 participants, 15 received solely the Tomatis treatment while 10 served as controls and were stabilized on ADD medication three months prior to and throughout the study. Therefore, this research study compared Tomatis versus non-Tomatis intervention, not ADD medication treatment with Tomatis intervention. The Tomatis group received 15 consecutive 2 hour sessions; participants received no additional vestibular or visual-motor exercises throughout the research. Results revealed statistically significant improvements for the Tomatis when compared to the non-Tomatis group: the experimental group showed significant improvement in processing speed, phonological awareness, phonemic decoding efficiency when reading, behavior, and auditory attention. A statistically significant increase in slow brain activity at central and parietal midline recording sites in the Tomatis group was observed when comparing pre- and posttreatment theta/beta ratios within each group. Taken in isolation, these are paradoxical findings as they do not concur with the gains documented. The peak alpha

frequency values and the *z*-scored theta/beta ratios of the pre- and post- qEEGs for each participant in the Tomatis group were further explored. The paradoxical increase in theta/betha ratios obtained from individual raw values were not observed to the same extent when using z-scores. The *z*-scores suggested that the theta/beta ratio, although higher for the Tomatis group after training, remains within the average range for all participants. The individual analysis showed that the changes observed still fell within normal values, which may serve to explain the behavioral gains. To conclude, the significant improvements noted in cognition, attention and behavior, strongly suggest that the Tomatis Method has positive effects in children with ADD. These early changes in brain physiology require further research. This dissertation is accompanied by a supplemental qEEG reports file in PDF format. The electronic version of this dissertation is available through the OhioLink ETD Center, www.ohiolink.edu/etd.

Dedication

To my parents, Elena and Eugeniu Sacarin, and my brothers, Cristinel and Gabriel Sacarin who supported me throughout these years; to Bruce Haley, who fully stood by my side from the application through the proposal part of my doctoral study.

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Individual_qEEG_Reports.pdf PDF 44,635kb

List of Abbreviations

ADD	Attention Deficit Disorder
ADHD	Attention Deficit Hyperactivity Disorder
APP	Audio-psycho-phonology
ASD	Autism Spectrum Disorder
BASC-II	The Behavior Assessment System for Children – Second Edition
CD	Coding Subtest
CI	Confidence Interval
CPT	Continuous Performance Test
CTOPP	Comprehensive Test of Phonological Processing
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition
EEG	Electroencephalography
ERP	Event Related Potentials
EO	Eyes open
$f0$	Fundamental frequency
FFR	Frequency following response
FFT	Fast Fourier Transformation
fMRI	Functional Magnetic Resonance Imaging
IVA-Plus	Integrated Visual and Auditory Continuous Performance Test
LR	Linear Regressions
MEG	Magneto Encephalography
MSRD	Monroe Sherman Reading Diagnostic
N200	Negative Wave 200 Milliseconds
PACS	Phonological awareness composite score
P300	Positive Wave 300 Milliseconds
PRS	Parent Rating Scale
PDD	Pervasive Developmental Delay
PDE	Phonemic decoding efficiency
PIC	Personality Inventory for Children
qEEG	Quantitative Electro-Encephalogram
SWE	Sight word efficiency
SAE	Standard American English
TOWRE	Test of Word Reading Efficiency
TLT	Tomatis Listening Test
TOVA-A	Test of Variables of Attention- Auditory
VEP	Visual evoked potentials (VEP)
WISC-IV	Wechsler Intelligence Scale for Children – Fourth Edition
WISC-R	Wechsler Intelligence Scale for Children-Revised
WRAT	Wide Range Achievement Test

Chapter I Introduction

The Tomatis Method of Sound Stimulation

Training of the human auditory system through music and sound as an educational activity seems intuitive and is historically widely accepted. What has been less obvious is that in addition to auditory processing, other neural systems can be affected by musical experiences and sound stimulation training. Recent neuroscience research suggests that sound and music stimulation have positive effects on cognitive functions such as attention, memory, learning, and language development (Patel, 2006). These findings open a different perspective on human peak-performance training, and more importantly, on therapeutic applications of sound and music stimulation for individuals who present attention, learning, motor and language development challenges.

Kraus and Banai (2007) have also shown that broader cognitive functions beyond language development are strongly related to auditory processing, which is a response to our sound milieu. According to these researchers, the auditory system is involved in complex physiological interactions across both cortical and subcortical anatomical areas; this involvement suggests that auditory processing is dynamic, and influences higher cognitive functioning such as attention, memory, and contextual framework, while at the same time being influenced by these cognitive functions. Very early and long-term experiences with one's mother tongue shapes both speech perception and one's auditory processing capabilities (Fais, Kajikawa, Amano, & Werker, 2009; Kuhl, 1979; Liu, Tsao, & Kuhl, 2009; Rivera-Gaxiola, Silva-Preyra, & Kuhl, 2005). The same is true for early and long-term musical or sound stimulation training (Kraus & Banai, 2007).

The world's first and most widely used method of sound stimulation was developed by the French ear nose and throat physician and surgeon Alfred Tomatis in the 1950s. Tomatis tirelessly perfected his method and technology until his death in 2001. A prolific author, he published 11 books and numerous articles on his theories, clinical experience, and research findings. However, although the Tomatis Method spans a half century of successful clinical testimony in 250 centers around the world, there still exists insufficient experimental research to clearly identify its effects on the brain's physiology, cognition, language, sensory-motor processing, and behavior.

The Tomatis Method of sound stimulation uses Mozart, Gregorian Chant, Strauss waltzes, the mother's voice, and children's songs in its initial (passive) phase of training, and one's own voice in the later (active) phase of the program. The Tomatis Method uses the Electronic Ear, a device as originally developed by Alfred Tomatis that provides filtered, gated and timed sound stimulation via headphones and the subject's cranial bone conductors. The sound is contoured such that when it drops in amplitude below a certain level, low frequencies are amplified while mid- and high-range frequencies are filtered out. This occurs on Channel One of the Electronic Ear. When the amplitude rises just above this set point, the opposite occurs: lows are removed while the rest of the frequency spectrum is amplified. This occurs on Channel Two. The gating pivot filter of 1000 Hz was fixed in the original Electronic Ear. In addition to the described sound gating that occurs on these two parallel channels, the Electronic Ear contains timing mechanisms between the bone and the air output of sound. The timing mechanism encompasses delay and precession timing, which together with the gating controls the delivery of sound in an interchangeable form between the air and the bone. More precisely, when the gate switches from Channel One to Channel Two, the bone conduction output is switched to first in time for a pre-determined period. This means the listener first experiences the switch of the bone conduction from one channel to the other. Thus, the bone hearing precedes the air conduction or headphones switch from Channel One to Channel Two. The switch of the air conduction from Channel One to Channel Two occurs only milliseconds later and is part of training the mid-ear and the brain to perceive mid-range and higher frequencies with improved accuracy. The described timing mechanism is called *precession*. In addition, there is a timing mechanism called *delay*. This means that the bone conduction is the last one to be perceived when switching occurs back from Channel Two to Channel One. The delay and precession timing can be individualized for each person. In the newest Electronic Ear models, gating pivot filters are also adjustable; such a model was used in this research.

For Tomatis, the training of the listening function was the central piece when optimizing learning including language, speech and voice processing, coordination and rhythm. He pointed out that the ear's function stretches far beyond listening, which he considered a voluntary, active act and distinct from hearing (Sollier, 2005). Tomatis (1974) described three integration levels in his neurophysiologic model of the ear-brain connection: the vestibular, visual and cochlear integrators. He pointed out that the second (optic) cranial nerve, the third (oculomotor), the fourth (trochlear), the sixth (abducens) and the eleventh (accessory) connect with the eighth (vestibular cochlear) nerve, participating in reception and integration of information from the ear and other sensory systems (Tomatis, 1974).

The vestibular integrator regulates the sense of balance and therefore the muscle tone regulation in the body and is the foundation for good motor coordination. The vestibular system situated in the internal ear transmits information to the brainstem through the vestibular subdivision of the eighth cranial nerve. The afferent connections between the hair cells in the semicircular canals of the vestibular system with the vestibular nuclei in the rostral medulla and caudal pons can be stimulated and trained with sound. Due to the Tomatis sound training, functions such as balance, muscle tone regulation, and coordination, to name a few, are meant to be positively affected (Solier, 2005).

Tomatis (1974) referred to the visual integrator as the neurophysiological process through which information from the ear and the eyes is integrated, leading to human visual and spatial perception. For instance, specific pathways connect the vestibular nuclei with the sixth and the fourth cranial nerves and the oculomotor nuclei participating in the vestibulo-ocular reflex. The internal ear is involved through this and other neurophysiological mechanisms in the functioning of the eye. Eye movements such as fixating on an object, tracking while the body is stationary (such as when one is reading), or tracking while moving the body at the same time (such when walking and reading a sign) are not realizable without integrating undistorted information from the internal ear. When training with the Tomatis Method, visual perception and visual-motor functioning are assumed to be positively affected once the vestibular function and muscle tone regulation are improved (Sollier, 2005).

Tomatis (1974) pointed out that connections between the reticular formation and the vestibular nuclei regulate attention and arousal; thus, attention is meant to improve when using the Tomatis Method of sound stimulation (Sollier, 2005).

The cochlear integrator consists of connections between the ear and the brain affecting speech, language learning and processing, including voice control. Sound reaches the brain from the cochlea via the eighth cranial nerve and the geniculate body of the thalamus, projecting ultimately into the auditory primary cortex. Tomatis (1974) elevated the importance of the thalamus in understanding the ear-brain connection and the feed-forward, feed-back mechanisms involved in this complex neural system. The relay nuclei in the thalamus relate information from the ear to the cortex. Similarly, efferent pathways from the cortex relate information back to the thalamus and then to the ear and voice control mechanisms (Tomatis, 1974). Besides improving listening, i.e. attending to and processing spoken language, the Tomatis Method is meant to improve speech and singing ability, in addition to processing language when reading (Sollier, 2005). Having trained with Tomatis and worked with his method for over a decade, the principle investigator has witnessed how children with learning challenges and developmental disorders such as Pervasive Developmental Delay (PDD), Attention Deficit Disorder (ADD), and Asperger's Syndrome have benefited from this program. However, from a scientific point of view, questions about the Tomatis Method's effects or which component influences which human functions remain unsatisfactorily answered. The more we understand how the Tomatis Method affects the brain in terms of the neural mechanisms that are being stimulated, and what cognitive and sensory-motor functions are related with this neuro-physiologic substrate, the more effective and efficient our clinical intervention will become. The most relevant questions for clinical practice are: (1) *Would this particular client benefit from work with the Tomatis Method?* and (2) *What is the most optimal training protocol for this particular client such that the least amount of treatment will yield maximum benefits?*

Understanding whether children with a specific diagnosis, such as ADD, can benefit from the Tomatis Method contributes to the first clinical question. Investigating the early effects of the Tomatis Method could be helpful to elucidate the question of the intensity and length of stimulation needed to obtain results in children with ADD.

While Tomatis (1981) provided a neurophysiologic explanatory model for his method and its effect on sensory-motor and emotional regulation, attention, memory, language, and cognition, its underlying physiological processes have not been fully understood. Vervoort, De, and Van (2007) are the only authors to report findings using neurophysiologic measures such as electroencephalograms (EEG) and event-related potentials (ERPs) while investigating effects of the Tomatis Method of sound stimulation. These authors presented single case studies in their publication of four severely delayed children treated with the Tomatis Method; the reported changes are presented in the Literature Review section of this dissertation. However, neurophysiologic measures have not yet been part of controlled research using a quasi-experimental group design that investigates the effects of the Tomatis Method. Further research is needed to explore specific effects of the Tomatis Method on the brain's physiology and how these effects relate to cognitive and other behavioral changes.

The main purpose of this exploratory study was to use a control group design while investigating the early effects of the Tomatis Method that occur in the first phase of the program. Specifically, I was interested in evaluating the impact of the first phase of the Tomatis program on certain measures of cognition, behavior, and attention, as well as on the quantitative analysis of the electrical activity of the brain. This research was conducted with 25 children ages 7-13 years old who have been diagnosed with attention deficit disorder (ADD) by physicians and psychologists. The 15 children in the experimental group were not medicated for ADD and received the first phase of the Tomatis Method treatment of sound stimulation. The first phase was comprised of 15 listening sessions of 2 hours each which were administered over a three week period. The 10 children who did not receive the Tomatis Method treatment during the study served as controls. It was challenging to find families with children diagnosed with ADD who were willing to participate when asked to serve as controls. The controls were stabilized on attention deficit medication prior to participation by their attending physicians and continued with their prescribed daily intake of medication throughout the study without alteration.

Concerta (18mg), Adderal (25 mg), Vyvanse (50mg) and Guanfacine (1.5 mg) were the various attention-regulating medications that participants in the control group were stabilized on prior to and during the study. Dosage varied from 1.5 mg for Guanfacine to 50 mg for Vyvanse depending on the medication and prescription for each child. It was a requirement that research participants in this group continue their medical treatment for attention deficit and maintain the prescribed dosage throughout the study.

It is important to address here that this study did not intend to compare two treatments such as Tomatis versus medication. Instead, this study compares the Tomatis treatment in the experimental group with the exclusion of Tomatis treatment in the control group.

Theoretical Background for the Tomatis Method

The Tomatis Effect. Alfred Tomatis received the recognition of the French Academy of Sciences in 1957 for his discovery in the field of medicine of the "Tomatis Effect." Tomatis described three principles as the core of his method of sound stimulation; these principles represent what he considered to be the neurophysiological/neuropsychological aspects of perceptual differentiation and learning:

1. The voice can only reproduce what the ear perceives. Thus, the ear has the leading role in controlling the voice.

2. When the ear is retrained to integrate frequencies it formerly did not clearly perceive, the voice automatically acquires these new frequencies.

3. If retraining of the ear occurs for a sufficient length of time, its new range of perception can become permanent.

Prior to discovering the Tomatis Effect and developing the Tomatis Listening Test (TLT) and the Electronic Ear, Tomatis accumulated professional experience working as an ENT physician while treating two distinct professional groups, both of whom seemed to present similar clinical findings (Tomatis, 1978). One group consisted of workers in an airplane factory, while the other group was comprised of opera singers. The aviation workers exhibited hearing problems as a result of continuous exposure to loud noise. The opera singers were also exposed to continuous loud sounds, mainly from their own voices when practicing or performing, and exhibited voice problems (Tomatis, 1978). These problems manifested in the form of the singers losing their ability to replicate certain frequencies with the same ease that they had been able to earlier in their singing careers. Tomatis concluded that both groups had the same presenting problem, because the issues Tomatis captured when investigating their hearing were reflected in their voice prints. As the singers' ears were not as sensitive to certain frequencies anymore (unable to perceive certain frequencies when presented at a low intensity or volume), their voice prints seemed to lack these same frequencies.

Tomatis' clinical and theoretical work resulted in his establishing the field of audio-psycho-phonology (APP). In the beginning, as an ENT doctor, Tomatis specialized in audiology. As he became exposed to opera singers, he expanded his research into the area of phonology, focusing on voice control and resonance. However, his field of interest expanded to a third dimension, psychology. As Tomatis began working with children diagnosed with autism, dyslexia, learning disabilities, and minimal cerebral dysfunction (later called ADD), he added this final aspect – psychology – to what has become the field of Audio-Psycho-Phonology (APP):

> And so, "audio-phonology" was born, spread its wings and took off…. It became obvious to me how important the involvement of psychology was in the hearing / listening progression as well as in language which began to unveil its true

> dimensions… at this point, I decided it was time to replace the hyphen separating "audio" and "phonology" to add a third dimension to the ear and the voice. And so, audio-psycho-phonology was conceived and developed. (Tomatis as quoted by Cummings, 1985)

Audio-Psycho-Phonology as Tomatis' Research Field

APP is the cross-disciplinary field that Tomatis developed in parallel with his sound stimulation technology and method. He contributed this theoretical model for a method of sound stimulation to the field of APP.

APP is based on the neuro-physiology of sensory processing and its influence on human sensory-motor and psycholinguistic abilities, as well as behavior and learning. Tomatis' APP is an interdisciplinary explanatory model that ties the role of the vestibular-cochlear system to healthy psychological functioning, and to optimal motor, language and communication development. The most recent neuroscience research on sensory-motor processing and awareness seems to support his integrative model (Patel, 2006). This author suggests that music and language rhythms both require grouping and timing in similar fashion, and both use a similar neurophysiological substrate. Moreover, humans are capable of recognizing periodicity within complex auditory stimuli and can synchronize their movements to this pattern. This indicates that recognition of and structured anticipation to temporal patterns is a basis for language, music and movement. Contrary to today's accepted theoretical models which assert that subcortical and cortical vestibular processing, visual, auditory, and other modalities are largely independent from one another, Tomatis (1981) pointed out that integrated, multi-sensory processing is involved in developing human perception, awareness and healthy psycho-emotional functioning.

Tomatis' (1981) idea that sound plays an integrative role in the central processing of other perceptual modalities is supported by recent neuroscience findings, presented below. Calvert, Spence, and Stein (2004) synthesized findings that suggest that vision alters other sensory modalities and that sound modulates visual perception in multiple ways. For instance, the authors discussed research which evidenced that brain areas involved in the early part of auditory processing project to cortical areas that involve early visual processing. These findings substantiated the occurrence of early multimodal sensory processing, which might explain, for example, mechanisms through which the auditory system announces an anticipated visual stimulus. In their publication, they also pointed out studies that explored inputs from the auditory, visual and somatosensory systems into the posterior part of the auditory cortex and the varying laminar response pattern of each sensory system. For example, the somatosensory and auditory inputs have a feed-forward pattern while the visual input has a feed-back pattern. Finally, these authors discussed studies which show multisensory integration even at the neuronal, or so called cellular level. One such study by Shams, Kamitani, Thompson, and Shimojo (2001) compared visual evoked potentials (VEP) with and without sound stimulus and concluded that sound does alter visual perception. For instance, when a single flash is presented at the same time with two auditory signals, the person perceives the single visual input as two inputs, or two flashes. These researchers suggested that sound alters temporal aspects of visual perception and that the same cortical physiological substrate is involved during the real visual event and the illusory visual perception (Shams et al., 2001). Sound also influences the perception of vision in motion. The authors also showed that a visual structure is captured in the form of auditory perception, suggesting that visual cortical processing is tightly connected to multimodal processing.

Summarizing, these findings suggest that there exist neurophysiological links between sound and vision, and that visual cortical processing does not take place independent of the processing of other sensory modalities. This theory is consistent with what Tomatis had suggested throughout many of his books, long before these findings; Tomatis (1972, 1974, 1980, 1989) described a neurophysiological dynamic and interactive model as the basis for his method. He believed that his method not only affects the processing of auditory information, but also the processing of visual, tactile, kinesthetic, and vestibular information. He pointed out that through his method of sound stimulation, auditory processing and the processing of other sensory systems are improved. Tomatis believed that, as a result of these perceptual changes, behavior, communication, and social interaction can be affected.

Chapter II Literature Review

As relevant as it is to review studies focusing on the various applications of the Tomatis Method, it is also important to present recent findings addressing neuro-scientific models of how sound is processed, how music affects neuro-physiology, and the role of sound stimulation on learning, attention, and behavior. In addition, studies are also reviewed in which electrophysiological measures, such as the analysis of EEGs, have been used to explore physiological patterns in children with ADD. Current findings of studies using the Tomatis Method will be presented first, followed by a section addressing research on neuro-physiological methods and patterns. A section about findings of effects of music on the brain concludes this literature review.

Tomatis Method Research

There is research investigating the efficacy of the Tomatis Method on a variety of learning and communication challenges in children, such as learning disabilities, dyslexia, communication disorders, and autism. To my knowledge, there have been no studies yet to address children with ADD. Similarly, there is no peer-reviewed controlled study that has focused on the effect of the Tomatis Method of sound stimulation on brain physiology. Furthermore, there is no published research that specifically addresses the early effects of the Tomatis Method of sound stimulation.

In my opinion, the first phase of the Tomatis Method lends itself to research as it is an intensive but brief intervention, thus allowing controlling for confounding variables such as outside treatments like tutoring, speech and language therapy, occupational therapy and others, which many children with ADD receive concomitantly. The training is comprised of 30 hours of sound stimulation and has the scope to set up the foundation for new perceptual learning. The child is intensively exposed to new, unfamiliar auditory and perceptual patterns, and new levels of perceptual differentiation. I compare this with intensive and exposure to any new skill humans have to learn, such as riding a bike or learning to write.

In my experience, changes in the results of the TLT are already noted after five to six sessions (10-12 hours of sound stimulation). By the end of the 30 hours of Tomatis sound training, even more marked changes in the TLT are usually recorded. Hand in hand with these changes, in the great majority of cases, parents report behavioral changes during the first phase of the program or immediately thereafter.

A limited number of research studies have been conducted and have helped establish the efficacy of the Tomatis Method in children with a variety of developmental and learning challenges such as Learning Disability, Autism Spectrum Disorder (ASD) or Auditory Processing Disorder. However, researchers have encountered various challenges when designing and conducting their studies, the primary challenge being the length of the intervention. The complete Tomatis Method intervention extends over three phases and can last over six months. Depending on case severity, the intervention can extend over more than the three intervention phases. Therefore, it has proved challenging in research to ensure a high internal validity, especially when the target populations mentioned often require multiple and concomitant treatment approaches, some of which are long-term and intensive. In addition, parents have sometimes not been willing to have their child in a control group, since they sought immediate help for their children (Gilmor, 1999). Findings of previous research studies are presented below.

Unfortunately, most peer-reviewed studies on the Tomatis Method exhibit a variety of limitations, thus reducing their internal validity. Examples of validity problems include:

insufficiently matched experimental and control groups in the Rourke and Russell (1982) study; lack of random assignment in the Gilmor (1984) study; and flaws in the study design conducted by Cummings (1985). Additionally, findings which address the efficacy of the Tomatis Method seem inconclusive and difficult to generalize. Most of these studies were conducted on children who either presented with learning issues or had been diagnosed with ASD. These studies will be discussed next.

Meta-Analysis Study

Seeking to evaluate the scientific credibility of clinically reported efficacy of the Tomatis sound stimulation technique, Gilmor (1999) conducted a meta-analysis involving five research studies from the 1980s, in which the method developed by Alfred Tomatis was used. All of the 231 participants in the five studies were children who presented a variety of learning and communication disorders. Four of the studies suggested that the Tomatis Method had positive effects on children's linguistic, psychomotor, cognitive, personal and social adjustment, and auditory processing skills. A fifth study did not support these positive findings. Four of the studies were conducted in Canada, and one in England.

The first study was a survey in which Gilmor (1984) compared standardized pre- and posttest results which captured changes in aptitude, achievement and general adjustment abilities. The following tests were used: Wechsler Intelligence Scale for Children-Revised (WISC-R); the Wide Range Achievement Test (WRAT); the Monroe Sherman Reading Diagnostic (MSRD); and the Personality Inventory for Children (PIC). The research was conducted with 102 children ages 6-14 years old. Gender was not reported. Participants presenting learning and communication challenges received sound stimulation training at the Tomatis Listening Center in Toronto. According to the author, children were posttested after receiving 100 hours of sound stimulation, approximately 12 months after the pretest. The pre- and posttest comparison suggested improvements in learning, communication abilities, and general adjustment, while parents seemed to have observed similar improvements in their children (Gilmor, 1999). It is noteworthy that not all children were tested with all of the instruments above; instead, 40 children were tested with the WISC-R, 57 with the WRAT, 45 with the PIC, and 25 with one subtest of the MSRD while 24 with another subtest. The reported overall improvements corroborate the findings from these subgroups.

A study which also reported favorable findings was conducted at the University of Windsor, Ontario, on 25 children with learning disabilities ages 9-14,16 of which received the Tomatis Method intervention and 9 served as controls. The subjects were neither randomly selected nor assigned. Rourke and Russell (1982) tested the participants every quarter during an entire year and reported that the treatment group exhibited better results than the controls in the following areas: general adjustment, problem-solving abilities and hand-eye coordination.

A third study supporting the efficacy of the Tomatis method was conducted in 1982 by Wilson, Iacoviello, Metlay, Risucci, Rosati, and Palmaccio (as cited in Gilmor, 1999) at the North Shore University Hospital in Canada. This study was comprised of 26 preschool children ages 42 to 69 months old exhibiting language impairment, and included matched controls. The proportion of girls to boys was not reported. The authors reported significantly greater improvements in the performance of the experimental group captured in auditory processing tests. Similar results were found in the general communication domain according to parent and teacher observation. The duration of the study was nine months and though the authors attempted to conduct a later follow-up, they failed to do so due to lack of interest by participants' families (Gilmor, 1999).

Mould (1985) conducted a study on 92 boys ages 10-15 years old diagnosed with severe dyslexia, who exhibited significant challenges in reading and who were students of an in-residence public school in England. Standardized test results in the areas of aptitude, achievement, and adjustment showed appreciable gains in the experimental group in comparison to the controls over a two-year period (Gilmor, 1999).

Gilmor (1999) acknowledged that all of the above studies had methodological limitations: lack of random assignment of participants to an experimental or a control group, and lack of a control sample or insufficiently matched controls. In addition, there were too few significant findings; thus, none of the authors could with certainty assert that the reported positive trends could confer sufficient scientific support to the efficacy of the Tomatis Method (Gilmor, 1999). Cummings (1985) went much further and suggested that maturation, a responsive comprehensive school program and a supportive and involved atmosphere around both the experimental and the placebo control group were the sole contributions to the significant changes in both groups.

However, Kershner, Cummings, Clarke, and Hadfield (1990) at the Ontario Institute for Studies in Education, came to a different conclusion about the efficacy of the Tomatis Method. This study relied on Richard Cummings' doctoral dissertation and used a sample of 32 participants (26 boys and 6 girls) ages 8-14 years old. Cummings (1985) reported that the 16 underachieving participants, who attended a school version of the Tomatis Method, made no significant gains when comparing standardized measures of academic and linguistic skills of the matched and randomly assigned controls. However, Cummings (1985) reported that both groups made significant improvements over a period of 22 months, when comparing pre- to posttest results on academic and linguistic measures. Gray Oral Reading, Monroe-Sherman Paragraph

Meaning and Word Discrimination Tests, and the Auditory Analysis, Auditory Closure, Syllabification, Verbal Fluency, the Reading and Arithmetic subtests of the WRAT, and Personality (WIG parent scale) and Dichotic Listening were used in the research. Cummings (1985) reported that both groups made significant improvements on all of the measures, but that the control group still exhibited better auditory processing, and thus concluded that the Tomatis Method's efficacy was not supported.

A closer look at Cummings' (1985) research design will help determine whether Gilmor's (1999) critique of control group contamination seems valid. According to Cummings (1985), the treatment and control participants attended the same school; thus, all the children participating in the study received the intensive, individualized school program. Over a seven-month period, treatment participants received one-and-a-half hours of sound stimulation including active training for four days a week. The study seems to suggest that the students were withdrawn from class activities in order to receive the listening training program (LTP).

The control group received a placebo special tutorial program (STP) which occurred two times a week, and lasted for forty minutes (Cummings, 1985). A teacher instructed the children in groups of three to four; thus, the control group was withdrawn from regular class instruction much less often than the experimental group. According to Cummings (1985), the main activity of the placebo was reading out loud with audio-vocal feedback; however, the sound was not processed via the Electronic Ear. In this context, children were also working on a task in which they were asked to rapidly name random letters. Less frequently used were auditory memory training tapes, which were designed to train auditory memory through listening and following increasingly complex instructions. Finally, controls received a program of relaxation taught through tapes which used verbal and visual instructions. The author also mentioned that the placebo treatment encompassed a minimal amount of direct instructions in oral, silent reading and comprehension.

Although Cummings (1985) specified that strong efforts were made to treat both groups in the same manner, it is obvious that he neglected to control for unequal amounts of school instruction. Over 16 weeks, the LTP group missed five hours more of class instruction per week than the control group. Furthermore, the placebo treatment included auditory training tasks, to which students were regularly exposed, as well as some reading and comprehension instruction. Only the controls attended these various instruction-focused interventions. It is debatable whether this was a control group or another form of intervention. It would have been more appropriate to report Cummings' findings in the light of a different paradigm in which the Tomatis Method and a remedial instruction program would have been compared, instead of calling the controls' program a placebo. While the limitations are important for further research, they do not invalidate the improvements recorded in both groups, including those of the experimental participants who received the Tomatis Method intervention.

Gilmor (1999) attributed the great variance found across these studies to the following three factors: the manner in which the Tomatis Method intervention was implemented, the manner in which the control and the treatment groups were formed, and level of treatment the control groups received. The author used a psychometric meta-analysis method to reduce statistical and methodological artifacts which he believed contributed considerably to the great variance in results. By determining and eliminating this variance, the author estimated the true variation across the five studies. This analysis led to the conclusion that the Tomatis Method had a significant positive impact in children with learning and communication challenges. Gilmor (1999) cautioned that even the results of a meta-analysis need to be regarded from a critical perspective, since most studies used a small sample size. In addition, the subject selection was randomized in only one study, although in the others, the control and the experimental groups were well matched. Summarizing, the meta-analysis confirmed the favorable trend suggested in all but one of the individual studies. The Tomatis Method proved significantly beneficial in the linguistic, psychomotor, personal and social adjustment, and in the cognitive domains. The auditory processing domain exhibited insignificant improvement in this meta-analysis because of contradictory findings in the Cummings (1985) study.

Autism Studies

Joan Neysmith-Roy (2001) conducted a study with six boys, ages 4-11 years old, who were diagnosed with autism and were categorized as severely affected. The author reported findings of positive behavioral effects of the Tomatis program in five of the six children, all of whom were prelinguistic in their communication pattern as they began the program. In order to measure changes, the author used the Children's Autism Rating Scale (CARS) as well as a ten-minute video recording of each participant in two play conditions at the end of each phase of the Tomatis program.

Neysmith-Roy (2001) reported that positive behavioral changes were noticed in three boys. At the end of the research, one boy was considered as no longer diagnosable on the autism spectrum, two boys were categorized within the milder range of the disorder, and the other three boys remained within the severe range of the spectrum. In the following prelinguistic areas, however, positive changes were reported for five boys: adaptation to change, listening response, nonverbal communication, emotional response, and activity level (Neysmith-Roy, 2001). The author pointed out that the younger children were more responsive to the Tomatis stimulation and also suggested that the Tomatis program could benefit the preparation of learning and language development for children with autism.

Gerittsen (2008) reanalyzed the data of the study conducted by Corbett, Shickman, and Ferrer (2008), which focused on children ages 3-7 years who were diagnosed on the severe range of the ASD. Corbett et al. (2008) conducted a study with 11 participants and used a randomized, double-blind, placebo-controlled, crossover design during which they administered standardized tests. The goal of the study was to investigate the efficacy of the Tomatis Method on the communication and behavior of children diagnosed with ASD who were considered low functioning. The intervention part of the study consisted of 90 hours of Tomatis sound listening which was administered to each of the two groups during the experimental portion of the study. During the placebo portion of the study, participants listened to Mozart and Gregorian chanting via compact discs. Unlike during the Tomatis treatment, the commercial CDs were not frequency and time-modulated by the Electronic Ear, nor was the sound delivered via air and bone conduction that also included the required gating, delay and precession timing between air and bone as explained earlier in this thesis. Those authors concluded that the results failed to show any effect of the Tomatis Method on language in children with severe ASD. Corbett et al. (2008) pointed out certain shortcomings of their study, such as a very small and heterogeneous sample. In addition, the authors pointed out that differences in participant age and level of functioning may have also played a role in their responsiveness to treatment and would have needed to be considered more carefully when selecting both the treatment and placebo groups.

According to Gerittsen's (2008) reanalysis, researchers failed to choose an appropriate study design and data analysis methodology given the limited sample size, heterogeneity of the sample and nature of the intervention. A crossover research design is well suited when researching short-acting medication effects. However, this type of design leads to un-interpretable results in interventions with cumulative effects beyond the actual intervention time. In fact, in his reanalysis, Geritsen (2008) used a single subject design and thus concluded that six children had significantly benefited from the Tomatis Method. Gerittsen (2008) pointed out that the small sample size did not lend itself to group statistical analysis and that a single subject design would have been more appropriate. It was noted that previous peer-reviewed research using a single subject design when conducted on a small sample was able to show significant effects of the Tomatis Method for a subgroup of children with severe ASD.

Reviewing clinical significance of the findings on an individual case basis, Gerittsen (2008) concluded that 6 out of 11 children diagnosed with ASD benefited from the Tomatis Method. One participant who was nonverbal prior to the Tomatis Method intervention exhibited verbal expression, while another was able to spontaneously repeat words after the intervention. In addition, increase in expressive and receptive language were reported in other participants. Finally, a decrease in atypical behavior and an increase in attention were reported in four children. While internal validity is highly desirable for any researcher, Gerittsen (2008) showed that clinical significance seems equally important when it comes to determine whether a treatment can be considered evidence-based for a subgroup of individuals within a certain diagnostic category. A researcher must also think from the perspective of the parent with a severely impacted child who participates in studies, for it is each child who experiences individual gains. The effects of a tested intervention matter foremost to that child and the family. In summary, an intervention cannot be evaluated solely from the perspective of thinking in categories such as group-statistic, norms and averages.

Auditory Processing Disorder Study

Ross-Swain (2007) investigated the effects of the Tomatis Method on children and young adults with speech and language challenges who were diagnosed using tests from the professional field of speech and language pathology. The author diagnostically categorized the investigated populations as individuals with auditory processing disorder (APD). The 41 participants, ages 4-19 (18 females and 23 males) were tested prior to and after 90 hours of Tomatis sound stimulation. Significant findings were reported when comparing pre- and posttest results in the following areas: auditory sequencing, interpretation of directions, auditory discrimination and auditory cohesion including auditory short-term memory. However, this study presents a number of challenges. Although the author concluded that the Tomatis Method is an efficacious intervention for children and young adults with APD, neither a randomized selection of participants nor a control group was used in this research design. In addition, no confounding variables were considered in the analysis and discussion of the outcomes.

Study on Musicians

du Plessis, Burger, Munro, Wissing, and Nel (2001) studied the effects of the Tomatis Method of sound stimulation on young musicians in a pilot project. The study was conducted on student-musicians, both vocalists and instrumentalists, from two universities in South Africa. The average age was 22.9 years. There were 28 participants: 12 males and 16 females. There were 18 students in the experimental group, who received 87.5 hours of Tomatis sound stimulation, and 10 in the control group, who did not receive any Tomatis or a placebo treatment. Participants were not randomly assigned. Proportion of male to female and age range for each group were not reported. The following parameters were measured: listening aptitudes on the TLT, a non-standardized tool; psychological well-being on the Profile of Mood States; vocal enhancement as observed by teachers and the other participants; and musical proficiency, which includes instrumental proficiency. The experimental and the control groups were administered an assessment in these areas both before and after finishing the experiment.

The authors concluded that the Tomatis sound stimulation rendered significantly favorable outcomes in all the above parameters when comparing the experimental group's gains with the controls. Although both groups were culturally diverse, and included male and female musicians, the different training and musical experience of the experimental groups and the controls seemed insufficiently clarified in regard to between group variability. The authors realized the limitation of their research findings and suggested replication using a larger sample as well as the use of randomization when selecting participants. In addition, pretest sensitization did not seem to be accounted for by the authors.

Study on Severe Psychomotor and Neurological Dysfunction

Vervoort, De, and Van (2007) are the only authors to report findings using neurophysiologic measures to investigate the Tomatis Method of sound stimulation as a treatment. The four single cases presented were young children with severe developmental issues and global delays in language, communication, and psychomotor functioning. The Tomatis sound stimulation treatment protocols were intensive and extended over several years. For instance, for the child in the first presented case, the Tomatis therapy began at age two and continued through age seven. This child received six Tomatis Phases of five days each on average per year. The child was able to successfully complete the first TLT at age five. This outcome was presented in the study and compared with subsequent TLT results. The second case began the Tomatis Method intervention at age 2 and completed 37 Tomatis Phases by age 7. This child was first able to be tested with the TLT at age seven. The third case received intensive Tomatis Method treatment over 1.5 years. This child was diagnosed with ASD, and presented with severe speech and language and psychomotor delays. Finally, the fourth case received the first Phase of the Tomatis Method followed by several six-day additional Phases every six weeks over the year. This child was not able to perform a TLT as he was only two years at the time of the study.

EEGs recorded with eyes closed, along with auditory ERPs recorded with an oddball paradigm, were used to track changes in brain activity. The ERPs were used to track automatic stimulus discrimination (N200) as well as meaningful stimulus processing (P300) during the course of the Tomatis intervention. In addition, changes in the TLT were tracked and compared to the gains in brain functioning. The authors concluded that for the cases presented, brain activity as analyzed by qEEG increasingly normalized during the course of the intervention. For instance, during the Tomatis intervention, the qEEG for one of the children went from mostly in the theta range (with highest power left at P3 and O1) to the alpha and beta ranges and reached a symmetrical response in the right and left temporal sites. The intervention stretched over two years and the EEG recordings occurred at a distance of two years from one another. Another child presented less interhemisperic asymmetry as Tomatis treatment continued. In addition, those children exhibited better automatic discrimination while ERP amplitudes and latencies were increasingly normalized. Progress in speech and communication, eye contact, attention was reported as a result. The authors concluded that changes in brain electrophysiology and TLT were correlated. This study presented clinical cases and therefore was exploratory in nature.

In my view, the merit of this research is that it pioneered documenting electrophysiological changes, which are suggestive of effects of the Tomatis Method of sound stimulation on brain functioning. The authors were able to also show parallels between the TLT, the brain physiology and the descriptions of observed behavior and speech development. At the same time, the research lacks internal validity. For instance, it would have helped to have multiple baselines using standardized, observation-based, behavioral measures before engaging those children in the Tomatis treatment. On the other hand, given the severity of the cases, immediate intervention was required, and withholding treatment would have been unethical. It appears from the case presentations that without a certain level of Tomatis intervention those children would not have matured sufficiently to perform on the TLT in the first place. The TLT was part of the data collection in two of the cases. Sollier (2005) describes the TLT in detail; however, as this test is not a measure in the current study a closer description will not be discussed herein.

Electrophysiological Aspects of Brain Activity and Their Measurement

An EEG recording is a noninvasive technique used to investigate specific timing and frequency of neural events. Different patterns of EEG activation are associated with a variety of cognitive functions, emotional states, modulation of arousal and wakefulness, motor actions and developmental stages. Capturing the electrical activity of the brain with a high temporal resolution in such a noninvasive way has been employed since 1929, but more efficiently so and with sophisticated computerized technology for the past 30 years.

When groups of aligned neurons in open fields synchronize their firing in the cortex, they can reflect a net polarization which occurs in certain brain areas that can be detected with electrodes (sensors) placed on the scalp. In other words, through electrodes placed on the scalp, the EEG displays electrical activity captured as postsynaptic potentials of pyramidal cells, which form open field neural networks. Such spatio-temporal polarization can be rapid, slow, or oscillatory in nature. The cortical sources of the EEG recording vary in depth and orientation, both affecting the strength or the attenuation of the waveforms observed in the EEG. Moreover, according to Banaschewski and Brandeis (2007), auditory brainstem-potential recordings are proof that upon averaging, smaller structures located sub-cortically may also be captured in the EEG using electrodes on the scalp. In reality, the precise source of the EEG or specific components within it requires extremely complex mathematical algorithms, and is not within the scope of this research.

The EEG is typically displayed as voltage changes against time, showing "waveforms." These waveforms are characterized by a specific number of oscillations or cycles per second and by certain amplitudes. It is customary to analyze EEG recordings by observing the activity within a particular frequency or frequency band. However, while certain behavioral patterns or cognitive functions have been associated with a specific frequency band, certain relationships or ratios of different frequency bands in various cortical areas may also inform and characterize complex behavior (Loo & Barkley, 2005).

Different EEG frequency bands are typical of certain cortical locations or topography, developmental stages, and functional states of the brain. As shown in Table 1 (Banaschewski & Brandeis, 2007), these characteristics can be summarized for the following frequency bands: delta < 4 Hz, theta 4-7 Hz, alpha 8-12 Hz, beta 13-30 Hz, and gamma 30-70 Hz. As presented by the authors in Table 1 when analyzing EEG recordings, scientists and clinicians describe brain activity in terms of dominant frequency, amplitude and shape, as well as their location or scalp distribution. The EEG has been very useful to describe and attempt to understand certain functional states such as sleep, relaxation, thinking, concentration, or conditions of the diseased brain, such as epilepsy or encephalopathy.

Table 1

Overview of EEG Frequency Bands, Their Topography, and Development and Functional Characteristics (Banaschewski & Brandeis, 2006).

Frequency Bands	Delta (<4 Hz)	Theta (4-7Hz)	Alpha (8-12 Hz)	Beta (13-30 Hz)	Gamma (30-70 Hz)
Topography			Posterior	Frontal	
Developmental characteristics	Predominant during neonatal period and early childhood	Predominant during neonatal period and early childhood	Increases until early adolescence	Continues to mature until adulthood	
Functional state	e.g. sleep, decreased vigilance	e.g. sleep, decreased vigilance	e.g. relaxation	e.g. concentration, neuronal excitability	e.g. feature binding

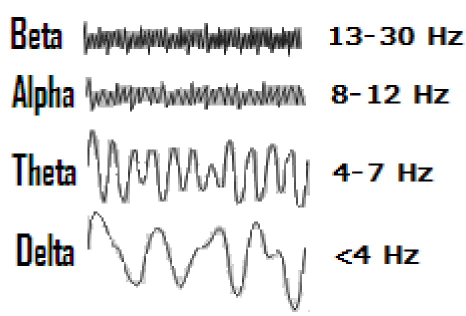


Figure 1. Brain wave rhythms

However, using frequency bands to describe the brain's electrophysiology provides a simplified and therefore a limited view. Steriade (2006) pointed out the complexity of intracellular brain activity and proposed a different conceptualization for brain rhythms other than the frequency bands common when describing brain electrophysiology. This researcher expanded the understanding of brain oscillations beyond states of vigilance, focusing also on fast and slow brain activity during sleep. Steriade (2006) reported, for instance, that fast beta and gamma brain oscillations are also produced during sleep. In addition, this author pointed out that slow-wave sleep activity plays a role in memory consolidation of experiences that took place during wakefulness. Studying the different connectivity and electrophysiological properties of various neurons (cortical, thalamic, thalamocortical and reticular), this researcher described complex wave-patterns and frequencies. These patterns have higher fidelity to real brain functioning and differ greatly from the strictly defined frequency bands (Steriade, 2006).

Research using EEG recordings has greatly advanced, and qEEG is one of the neurophysiological investigation methods that has successfully accompanied neuropsychological testing for the purpose of diagnosing certain neurological or psychiatric conditions. A number of conditions have been explored using this method and certain patterns of firing have been suggested as characteristic for particular disorders. Patterns for ADD in children and adults have been explored and defined in a number of studies (Clarke, Barry, McCarthy, & Selikowitz, 2001b; Kropotov, 2009; Lubar, 1991; Satterfield, Cantwell, Lesser, & Podosin, 1972).

While spatial resolution, which serves in locating the sources of neural activity, is best served by neuro-imaging methods such as functional Magnetic Resonance Imaging (fMRI), and Magneto Encephalography (MEG), temporal resolution is best captured in EEG measurements. EEG recordings can capture changes in the brain's activity in the order of milliseconds (Loo & Barkley, 2005).

ADD-specific electrophysiological patterns. Specific to the present research study are the electrophysiological patterns described for individuals with ADD. Recorded when awake, relaxed and with eyes closed, the brain's electrical activity in adults exhibits clear moments of the alpha rhythm over posterior recording sites (such as parietal and occipital), particularly shortly after closing the eyes. According to Banaschewski and Brandeis (2007), this rhythm has been generally found and reproduced in children and adults when a relaxed level of wakefulness is attained. Niedermeyer (1997) and other researchers have suggested that this form of arousal is critical in controlled attention; in addition, neuroscientists have observed long-term, stable, individual frequency patterns in certain areas of the brain (Banaschewski & Brandeis, 2007; Marshall, Bar-Haim, & Fox, 2002).

From a developmental perspective, EEG patterns change over time. For instance, as maturation takes place, slow activity is reduced over different areas of the brain and under different levels of arousal. As a result, the EEG indicates both an individual's arousal or attention and maturity or developmental level. Banaschewski and Brandeis (2007) have suggested that the extensive research in children with ADHD led to similar findings. The EEG measurements in children diagnosed with ADHD recorded when at rest exhibits increased slow activity such as delta and theta; at the same time, faster activity such as alpha is decreased (Banaschewski & Brandeis, 2007). Monastra et al. (1999) have reported general cortical activity slowing in individuals with ADHD, particularly over frontal recording sites. In addition, the arousal levels of the prefrontal cortex exhibit significant maturation delay. This prefrontal maturation delay is supported by neuroanatomical documentation using magnetic resonance scans. In this study, researchers investigated 223 children with ADHD, comparing their scans with those of an equal number of typically developing children (Shaw et al., n.d.).

Moreover, EEG studies have been used to identify and differentiate various ADD subtypes (Clarke, Barry, McCarthy, & Selikowitz, 2001a). When analyzing EEG recordings of children diagnosed with ADD, researchers have identified three distinct clusters (Clarke et al., 2001a). One cluster is characterized by cortical hypoarousal (Lubar, 1991; Satterfield et al., 1972). Deficits in relative beta waves across all sites with concomitant increases in relative theta comprise the main neurophysiological pattern for this cluster (Clarke et al., 2001a). A second group exhibits a maturation lag. During childhood in typically developing children, it is expected that EEG recordings present increasingly faster brain waves as the child's age advances. Children in this cluster, however, have an EEG profile showing increased relative slow waves such as delta and theta while also having a decreased relative alpha overall. The decrease in beta is most pronounced in the central area of the scalp (Clarke et al., 2001a). The third cluster, unlike the first two clusters, exhibits what is considered a cortical hyperarousal. This is characterized by excess beta activity at the frontal and central sites (Clarke et al., 2001b). Kropotov (2009) also distinguishes between four different subgroups of qEEG profiles in individuals with ADD that differ from each other and also from the normative data. Kropotov (2009) mentions the subgroup that exhibits an unusual excess in beta activity, mostly frontal, while the researcher adds a subgroup that shows an increase of alpha activity at the posterior, central or frontal sites. The four ADD neurophysiological profiles are presented in Table 2.

Banaschewski and Brandeis (2007) reported that some studies have even tried to identify a specific neurophysiological signatures for each of the ADD subtypes. Studies have reported a predominant pattern of slow activity over frontal and central recording sites in children with ADHD combined type and inattentive type. This suggests a pattern of delayed maturation. The impulsive type shows a prominent increase in frontal (13-30 Hz) beta activity, which does not seem related to brain maturation patterns (Banaschewski & Brandeis, 2007).

In summary, due to its high temporal resolution, the EEG is a research instrument which can provide reliable measures of an individuals' arousal regulation capability and developmental level when compared with a normed database. In addition, EEG measurements can help investigate several deficient neural networks by following multiple frequency bands, exploring if and how they are affected by the Tomatis sound stimulation training.

Table 2

Overview of EEG Profiles and Their Topography in ADD

Subgroup	Neurophysiological Profile	Topography
1 Hypoarousal	Deficits in relative β and increase in relative θ	At all sites
2 Maturation lag	Increase in relative (slow waves) Δ and θ and relative α power Decrease in β	At all sites At central sites
3 Hyperarousal	Excess in β	At frontal and central sites
4 Increase in α	Increase in α	At posterior, central or frontal sites

Music Effects on the Brain

It is generally agreed upon that music and language share acoustically intricate sound patterns and complex neurophysiological mechanisms of perception, processing and production. Both clinicians and researchers have attempted to understand the relationship between sound, music, language, attention, memory, cognition, and motor skills. In his latest book, Oliver Sachs

(2007) presented medical case studies as he attempted to unravel the mysteries of how music impacted the brains of neurologically affected patients. Some of his cases describe how after the loss of function in a hemisphere, speech was not understood, yet comprehension of singing was.

Wong, Skoe, Russo, Dees and Kraus (2007) have suggested that musicians were better at encoding pitch patterns used in language, thus being more apt in their language learning skills. These researchers followed subcortical auditory processing in the inferior colliculus and showed its important function for prosody and meaning discernment in musicians and non-musicians (Wong et al., 2007). The fundamental frequency ($f0$) of any auditory stimulus is encoded in the inferior colliculus. These researchers compared long-term musicians and non-musicians by measuring the frequency following response (FFR) to pitch pattern relating to language using scalp electrodes at the level of the rostral brainstem. While attending to a video, participants were presented with three stimuli in Mandarin Chinese, differing only in $f0$: a level tone, a rising tone, and a falling tone, which although seemingly very close sounding (mi), had very different semantic meanings. The musicians perceived sound structures with higher fidelity and learned lexical tones more easily than people who did not have long-term exposure to music (Wong et al., 2007). While this ability is particularly important when learning to listen to and accurately replicate sounds in a foreign language, it may also have relevance when one presents immaturity in his or her listening function, and as a result in the individual's speech and language development. These researchers pointed out, however, that well-developed encoding of pitch patterns does not aid in learning grammar and syntax (Wong et al., 2007).

Better capability of encoding pitch patterns findings were also reported when comparing native speakers of a tonal language such as Mandarin Chinese with native English speakers. The Mandarin Chinese speakers exhibited a better capability of encoding linguistic pitch patterns than the English speakers. Wong et al. (2007) concluded that long-term training or exposure to complex pitch patterns, such as when practicing music or when a tonal language is one's mother tongue, increases one's ability to encode speech prosody.

While previous studies on adults provided evidence that musical training enhances language processing as captured at the level of the cortex, Wong et al. (2007) paralleled such effects at the level of the auditory brainstem. Thus, it is possible to entertain the notion that musical or sound training may have educational and therapeutic benefits for training the linguistic encoding of pitch.

Rationale for Study

Tomatis Listening Centers around the world have accumulated clinical evidence suggesting that the sound stimulation method developed by Alfred Tomatis positively influences development in children in general and children with learning, sensory-motor integration, attention and concentration, and communication challenges in particular (Sollier, 2005). Although a few peer-reviewed studies confirm these positive effects on children, research data are scarce and focuses either on a few case studies, or does not sufficiently satisfy the requirements for rigorous scientific investigation. Not only is the existing research on the Tomatis Method of sound stimulation minimal, but all previous studies on the Tomatis Method have focused exclusively on behavioral domains such as linguistic, psychomotor or social adjustment, neglecting neuro-physiological and attentional measures.

In the light of recent findings about how music affects the brain's physiology and other cognitive functions, it is important to explore this method also using neuro-physiological measures. Understanding more fully how the Tomatis Method affects the brain, and how this relates to observed attentional, cognitive, behavioral and sensory-motor changes, could advance the clinical application of sound stimulation training. The intent of this exploratory research project is to provide further documentation about the Tomatis Method, its effects and its effectiveness, by using an experimental or Tomatis group and a control or non-Tomatis group.

Goals of the Study

The primary goal of the study was to explore effects of the first phase of the Tomatis Method of sound stimulation on cognition, behavior and brain physiology of children diagnosed with ADD. High temporal resolution electro-physiological recording methods such as qEEG were used to explore the effects on brain physiology. In addition, the performance on different attentional, cognitive, and linguistic standardized measures of the experimental and the control groups were compared. Pre- and post- qEEG recordings of control and experimental groups were also compared.

Research Questions

On the assumption that using the first phase of the Tomatis Method on children with ADD would already have a number of effects, the following research questions were addressed:

1. To what extent does the first phase of the intervention impact specific cognitive domains and behavioral parameters as corroborated by brief neuropsychological test findings? The investigated cognitive domains are: processing speed, phonological processing, and phonemic decoding and sight word efficiency skills when reading. Based on clinical experience, I hypothesized improvements in the above neuropsychological domains for the Tomatis group. I expected that the visual-motor based processing speed would improve. Phonological processing accuracy together with visual-motor processing speed will also be reflected in reading speed and reading phonemic decoding, including sight word reading speed.

2. Does the first phase of the Tomatis Method affect attention as measured with a continuous performance test, which requires ongoing and flexible attendance to both auditory and visual stimuli? I hypothesized improvements in auditory and visual attention for the Tomatis group. I expected that children will be able to sustain performance accuracy over time while flexibly engaging the visual and auditory systems.
3. What are the specific effects of the Tomatis Method on the brain at the end of the first phase of the program, as captured in quantitative qEEGs during eyes open (EO) recordings? I hypothesized that the Tomatis group would exhibit changes in the EEG measurements, with faster brain wave activity with a posterior to frontal gradient. At the same time, I expected that the non-Tomatis group would exhibit no significant changes in the EEG.
4. Can this study show that the Tomatis Method of sound stimulation is an important intervention for children with ADD and can stand along other evidence-based treatment approaches? I hypothesized that the Tomatis Method is an important treatment approach for children with ADD by working directly and efficaciously on perceptual differentiation and maturation. Perceptual maturation is required in order for behavioral maturation and therefore the Tomatis Method should be among the first interventions used for children with ADD.

Chapter III Methods

Overview

This research study aimed to explore the early effects of the Tomatis Method of sound stimulation on brain physiology, and cognitive and behavioral parameters in children ages 7-13 years diagnosed with ADD. The 25 participants were assigned to two groups: a non-medicated group that received Tomatis training and a medicated group. As an exploratory study, this research specifically focused on the description of the effects of the Tomatis Method on (a) on cognitive, attention, and behavioral changes as captured in standardized and widely used objective neuropsychological tests, and (b) the electrophysiological activity of the brain as captured by the quantitative analysis of the EEG.

Design

This experiment used a between group design. A total of 25 children who met the selection criteria described in the participants section were assigned to either a Tomatis group or a non-Tomatis group.

The experimental group received the first phase of the Tomatis sound stimulation training while the control group did not receive Tomatis Method training. The non-Tomatis group, however, was receiving pharmacological treatment for ADD as prescribed by the children's attending physicians. The dose and medication remained unchanged during the entire duration of the experiment. In addition, to ensure consistency and control for daily biorhythm variations, all data collections were scheduled to take place at the same time of the day. In order to control for researcher bias, a research assistant administered the measures that were not computerized. Since the research assistant was aware of which participants were assigned to each group the study did not meet criteria of a double-blind research design. Additionally, some of the administered tests were computer-controlled. Computer-controlled tests belong to the double-blind category, as software does not exhibit bias and no humans administer the stimuli, measure the responses, or interact with the subject during the test-taking part of the administration. Finally, some measures contained a form A and a form B for the same subtest, thus helping to offset any test-retest training effect in participants, as children were given form A in the pretest session and form B in the posttest session.

Table 3 illustrates the study sequence as proposed by Heppner, Kivlighan, and Wampold (1999). In this table, G1 represents the Tomatis group, while G2 represents the non-Tomatis (medicated) group. The test or retest sequences are represented by O, while X stands for the treatment. Participants were assessed at two different times: just before the beginning of the Tomatis program (T1) and immediately after the first phase of the Tomatis program (T2).

The first phase of the Tomatis Method was comprised of 15 consecutive sound training sessions which took place Monday through Friday for 3 weeks. Each sound training session was two hours long. During the two hours, children were exposed to four different patterns of stimulation for 30 minutes each.

Table 3

Research Design Illustrating the Test and Retest Sequences

Group	*T1* Pretest	*3 weeks* Tomatis Phase I	*T2* Post Test 1
G1	O1	X	O2
G2	O3		O4

G1 - the experimental or Tomatis treatment group
G2 - the control or non-Tomatis group

Participants

Demographic information. Twenty five children ages 7-13 years of age participated in this research (M = 10.58, SD = 1.79, 32% girls); 15 in the Tomatis (G1) group (M = 10.44, SD = 1.75, 47% girls) and 10 in the non-Tomatis (G2) group (M = 10.80, SD = 1.94, 10% girls). Two additional prospective participants were recruited for the Tomatis group; however, one chose not to complete the study due to a lack of time, while the other failed to perform on the Continuous Performance Test (CPT) and was excluded from the study. Table 4 encompasses demographic information, including clinical characteristics for participants in both groups.

Table 4

Demographic and Clinical Characteristics of Research Participants: Tomatis (G1) and Non-Tomatis (G2) Groups

Participant characteristic	Tomatis *(G1)* N 15		Non-Tomatis *(G2)* N 10	
	Male	Female	Male	Female
Number of Participants	8	7	9	1
Age				
Mean	10	11	11	9
Range	7.7 – 12.8	8.9 – 12.9	8.7 - 13.7	9 - 9
Diagnosed by				
Physician	3	5	9	1
Psychologist	5	2	0	0
Attention Medication	0	0	9	1

Participants were recruited from invitation letters (Appendix A) distributed to practitioners in the greater Seattle area, including pediatricians, family physicians, developmental optometrists, and neuro-psychologists specializing in developmental child disorders. In addition, parent-teachers associations were also contacted. Boys and girls from the greater Seattle area, ranging in age between 7 and 13 years, were invited to participate. In order to control for effects of language processing, which would be captured in some of the cognitive test battery, it was required that the children and their parents be native speakers of American English.

Participant recruitment and selection. A letter was mailed to parent-teacher associations and a number of practitioners in the greater Seattle area. In addition, ADD resources in Washington State were contacted with the request to post this information on their website and to distribute it using their mailing list. These practitioners gave the letter to parents in their practices whom they felt might be interested in this study. This letter contained information about the study and invited parents who might not be aware of the Tomatis sound stimulation technique to have their child undergo the Tomatis Method. Interested parents who desired further information were instructed to contact the investigator directly.

The following criteria were used to select the participants for the study:

1. Children ages 7 to 13 years were selected for participation in this study. This age range was selected because intervention is especially needed in children of grade-school age. In addition, the selected neuropsychological measures, especially the CPT, are standardized for children older than 6 years of age.
2. Children and their parents were required to have English as their primary language. The neuropsychological tests selected for this study are language-dependent and have been normed for Standard American English (SAE).
3. Children were to have been diagnosed with Attention Deficit Disorder by either a physician or a psychologist.
4. Children were not to have been previously diagnosed with a neurological disorder (e.g., seizures, head trauma, tumors), nor could they be identified as having a hearing disorder.
5. Prior to beginning the study, children in the medicated group were to have already been adjusted to their prescribed attention deficit medication for a minimum of three months. Children in the Tomatis group, although diagnosed for ADD, were not to

have been medicated for attention deficit prior to beginning the study. However, since insufficient non-medicated participants were available, a previously medicated child was selected, since the family had stopped the ADD medication at least one month prior to the start of the study.

6. Children were not to receive other therapeutic interventions during the course of the study, with the exception of one participant in the Tomatis group who had been receiving occupational therapy once per week for 6 months preceding the study.
7. All participating children were to be free of sinus, ear and throat infections or seasonal allergies at the beginning of the research study and during the data collections.

In an initial interview, parents who were interested in the study received official Institutional Review Board-approved consent forms so that their child could participate in the research project. In addition, written child assent was also obtained. A copy of the consent letter is attached as Appendix B and the child assent form is attached as Appendix C.

While the Tomatis sound stimulation training requires a substantial financial commitment, participation in the experiment was offered free of charge for both the Tomatis and non-Tomatis groups (after the final testing session, at the end of this research study, all children from the non-Tomatis group were offered the opportunity to attend the first phase of the Tomatis sound stimulation training). In addition, all participating families were offered the option to view a summary of the research findings. During this research study, the participants in the non-Tomatis group had three appointments at the center: a preliminary meeting to determine and discuss their participation in the study and two data collection sessions.

Variables

Independent variable. The Tomatis Method of sound stimulation was the independent variable in this experiment. Participants in the experimental group received Phase I of the Tomatis sound stimulation program, traditionally a three phase program. The non-Tomatis group did not receive the Tomatis Method training for the duration of the study.

As trained by Tomatis, the principal investigator wrote individualized listening program protocols based on the TLT results, which were obtained for each child prior to beginning the intervention. Those programs were administered using Tomatis' Electronic Ear. The sound was delivered from the Electronic Ear through headphones with a bone transducer located on the bow and resting on the central area of the skull. Thus, the sound stimulation occurred through both air and bone conduction, at times concomitantly, while at other times individually, as controlled by the delay and precession timing and gating functions within the Electronic Ear.

In addition, the sound was delivered such that the intensity of input was reduced in increments of 10 percent in one ear in comparison with the opposite ear. In his listening protocols, Tomatis suggested an incremental reduction of the input to the left ear, as his theoretical model calls for primarily stimulating the left hemisphere, thus lateralizing the right ear in the listener with the goal of establishing right ear dominance. Tomatis believed that this lateralization process supports development of voice control, motor control, and linguistic functions (Tomatis, 1981).

As stated previously, the Electronic Ear filters the sound differentially depending on amplitude. When overall amplitude drops below a certain level, low frequencies are boosted while mid and higher range frequencies are attenuated. When overall amplitude rises above a specified level, lows are then attenuated while the rest of the frequency spectrum is boosted. This shift or gating, in Tomatis' listening model, trains the listener to develop improved perception in the mid- and higher frequency ranges. As a result, attention, vestibular functions (such as balance and coordination), and language processing (which includes listening and reading) are presumably improved.

In addition, the Electronic Ear also contains nine high-pass filter settings, which filter out low frequency ranges in increments of 1000 Hz up to 9000 Hz. Only the frequencies above the set filter are allowed to pass. These filters are used in addition to the gating described above in order to individualize the training protocols for each phase of the program. The protocol depends on the TLT, the results, and on the phase of the program.

As stated previously, the Tomatis Method uses Mozart, Gregorian chants, Strauss waltzes, and children's songs. It also uses the voice of the child's mother in its initial (passive) phase, and the subject's own voice in the later (active) phase of the program.

Dependent variables. The dependent variables in this study fell into three categories: neuro-cognitive, behavioral, and electrophyiological. The neuro-cognitive set of dependent variables consisted of the following: speed of processing, phonological awareness, auditory and visual attention, and reading as measured in neuropsychological testing. In addition, behavior as rated by parents accounted for the behavioral variable of this study. The electrophysiological brain activity variables measured were the theta/beta bands ratios of the EEG recorded at midline frontal (Fz), central (Cz) and parietal (Pz) sites of the international 10/20 system during rest with eyes open (EO). The dependent measures are described in the Instruments subsection of this chapter.

Confounding variables. The confounding variables were the additional interventions that the children participated in during the experiment such as counseling, neurofeedback, speech and language, and occupational therapy. In order to control for this factor, families were asked that children in the Tomatis group take a break from these activities or minimize the participation in these programs for the duration of the experiment. Children in the non-Tomatis group were in medical treatment for ADD and were prescribed specific attention deficit medication and dosage for daily administration as previously stated in Chapter 1.

Psychometric Instruments

A battery of neuro-psychological tests and subtests was designed to assess changes in child performance before and after the first phase of the Tomatis sound stimulation program. The same battery of tests was used during the two data collection sessions for the non-Tomatis group. While various neuropsychological tests had the scope to measure objectively child performance, parental perceptions of child behavior were also captured in a standardized rating scale. Table 5 shows all the instruments used in the two meetings of data collection or testing sessions for each participant.

Table 5

Instruments Used during the Pretest and Posttest Sessions

Name of Instrument	Test/Subtests Used / Specifics
Coding	From WISC-IV (pencil and paper)
CTOPP	Elision, Blending Words (used a CD)
TOWRE	Complete test (form A or form B)
BASC-II (PRS)	Complete test (parent form)
IVA Plus	Complete test (computerized)
qEEG	At rest, eyes Open (computerized recording)

Neurophysiological measures. An EEG was collected with the child in a resting state with eyes open (EO) for approximately 6 minutes. Participants were seated comfortably in a soft chair and asked to sit as still as possible. The EEG data was acquired from 19 sites on the scalp and the Deymed cap, using the Deymed TruScan Acquisition computerized system. More specifically, the EEG was recorded from the frontal (Fp1, Fp2, F3, F4, Fz, F7, F8), temporal (T3, T4, T5, T6), midline frontal (FZ), midline central (CZ), midline parietal (PZ), parietal (P3, P4), and occipital (O1, O2) recording sites according to the International 10-20 System of Electrode Placement. Impedances during the recording were kept at or below 10 KiloOhms and the sampling rate for the recording was 256 Hz with a band pass filter set at 0.5 to 100.0 Hz. A linked ears (LE) montage was used for recording and computing the EEG spectra. During the recording, participants were asked to focus on a fixed point at approximately 50 centimeters in front of them.

Neuropsychological measures. Neuropsychological assessment for this study focused on the following domains: processing speed, phonological processing, reading decoding skills, and attention. The investigator selected the tests and subtests described below for their sensitivity to dysfunction in the measured areas.

Coding subtest. Coding (CD) is one of the two processing speed subtests of the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV). This subtest measures perceptual (visual) and grapho-motor processing speed and requires sustained attention paired with adaptation to novel learning. During the CD subtest the child is directed to complete the test as quickly and as accurately as possible while being timed for 120 seconds. Individual internal consistency for the reliability of the CD subtest is in the range of 0.80-0.89. The average internal consistency coefficient for the Processing Speed Index, of which CD is a part, is 0.97. The practice effect after one month is reported in the test manual. Coding is one of the subtests that has the largest training effect gains for the age group 6 to 7 years old but not for the age group 8 years old and above. The test-retest reliability for CD is in the range of 0.80-0.90.

Construct validity for the WISC-IV is supported by confirmatory factor analysis and by exploratory factor analysis. Correlations between the WISC-IV and 9 other measures were made, Correlation quotient for CD was 0.77 in relationship with a previous version of this test, the WISC-III.

Comprehensive test of phonological processing (CTOPP). The CTOPP was developed by Wagner, Torgesen and Rashotte (1999a). Since the development of this test, a consensus has formed suggesting that certain aspects of phonological processing may challenge children with learning difficulties, including dyslexia and other learning disabilities. The CTOPP is widely used for evaluating phonological processing skills. In this study, the Elision and Blending Words subtests from the CTOPP were used. The administration of these two subtests collectively was approximately four minutes and the specific purpose was to explore whether the Tomatis method has an effect on phonological awareness skills. The Elision and Blending Words subtests yield the phonological awareness composite score (PACS). By using each subtest, the effects of the Tomatis method on phonological awareness were explored.

Elision subtest. The Elision subtest has 20 items and measures the participant's ability to repeat a word and then repeat a particular segment of the word by omitting a designated sound or sounds. For instance, when asked to drop the /l/ sound from the word "land," the participant would then say "and."

Blending words subtest. The Blending Words subtest has 20 items, measuring the participant's ability to put together separately presented sounds in order to form words. For example, "d" and "oll" would be given to the participant and then he or she would be asked to blend these sounds to form "doll." The series of separate sounds was presented from an audio-recorder.

According to the test manual, a 0.80 reliability criterion is satisfied by the composite scores, while the CTOPP individual subtests reach this reliability most of the time (76%). Employing more than one single subtest to calculate composite scores is a viable way of increasing reliability. The reported test-retest reliability over time was between 0.70-0.97 for subtests and between 0.78-0.95 for composite scores. Construct validity is reported based on confirmatory factor analysis and age group differentiation.

Test of word reading efficiency (TOWRE). TOWRE was developed by Wagner, Torgesen, and Rashotte (1999b) and has the scope to measure two distinct forms of word reading skills, phonemic decoding and sight word identification. Together, these skills constitute the ability to accurately and fluently identify and pronounce printed words. Phonemic Decoding Efficiency (PDE) and Sight Word Efficiency (SWE) are the two word reading skills subtests for examining reading success in children and young adults ages 6 through 24 years old.

Reading experts have conveyed that success in reading depends on strong visual and phonemic skills. Helping children develop their phonemic analysis abilities is considered an important step in these children becoming successful readers (Zeece, 2006). According to Kouri, Selle, and Riley (2006), when words are not recognized by a child, it is optimal that they first use their phonemic decoding skills prior to confirming their analysis of contextual information. In contrast, students with poor reading skills rely mainly on context in order to identify written words. These students exhibit a lack of phonemic decoding and visual word recognition skills. This study examined the effects of the Tomatis Method on the speed and accuracy of phonemic decoding.

Phonemic decoding efficiency subtest. The PDE measures the ability to rapidly and accurately sound words out. It assesses the number of printed non-words which can be accurately decoded and pronounced in a time interval of 45 seconds.

Sight word efficiency subtest. The SWE investigates one's ability to rapidly identify familiar words visually as complete units or sight words. It captures the number of real printed words that can be accurately identified in 45 seconds. The administration time of each subtest is approximately five minutes, which includes an allotted time for preparation and practice. The two subtests each have two forms of equivalent difficulty. Therefore, administration of the second form for retesting controls for the test-retest training effect that can occur when an identical form is used for both pre- and postassessments. Validity estimates reported in the test manual have a median of 0.91 for school grades 1 through 3. Alternate form reliability is reported at a median of 0.97 for school grades 1-3.

Behavioral measures. The Behavior Assessment System for Children – Second Edition (BASC-II) was designed to assess various aspects of child behavior. Psychologists use the BASC-II to identify and diagnose disorders pertaining to children and adolescents. The Parent Rating Scale (PRS) is one of the BASC-II scales. A paper and pencil tool, the PRS assesses behavior including attention problems in children and young adults ages 2-25 years old as perceived by their parents. The PRS used in this study is comprised of 139 items for children ages 6-11 years old and 160 items for children and young adults ages 12-21 years old. This test uses a multiple choice response format. Completion time for this measure is approximately 15 minutes. The Attention Problems scale and the Behavior Symptom Index (BSI) from the BASC-II were used. The BSI compares the overall level of challenging behaviors of a child to the behaviors of other children of same age and gender. Consequently, these results indicate both the presence and severity of problem behaviors when compared to a sample of peers. The test manual reports median reliabilities ranging between 0.80-0.87 for the PRS subscales. Test-retest reliability ranged from 0.72-0.88 for the subscales and from 0.78-0.92 for the composite scores. Concurrent validity was reported when correlating the BASC-II with a number of behavioral observation rating scales, including the Conners Parent Rating Scale. The reported correlation for the BSI and the Connors Global Index was 0.79 at the child and 0.65 at adolescent level. Subscale correlations were between 0.41-0.84 for the child and 0.35-0.64 for the adolescent levels.

Integrated visual and auditory continuous performance test (IVA-Plus). IVA-Plus is a computer-based test developed by Sanford and Turner (1994) as an evaluation tool, primarily for ADD, although it is also used for other conditions in which attention and self-control abilities are impaired. The test measures symptoms of ADD, such as attention and impulse control, which are captured in both the visual and the auditory perceptual modalities.

The test procedure requires that the participant click a mouse as soon as he or she either sees or hears the number "1," which represents the target stimulus. Conversely, when the participant sees or hears the number "2," he or she is asked to refrain from or not to click the mouse, as this number represents the non-target stimulus. The target and the non-target stimuli presentation occurs in a pseudo-random combination of visual and auditory stimuli, thus making it impossible to predict which signal will succeed another. Each auditory stimulus has a duration of 500 milliseconds (ms), while the visual presentation lasts 167 ms for each stimulus. The visual symbols are approximately 1.5 inches high and are presented on a colored monitor.

The test encompasses five subparts of 100 auditory and visual trials, totaling 500 trials with a duration of 1.5 seconds each. The main section of the test measures impulsivity and inattention. In order to measure impulsivity, the first part of the test contains 50 trials, during which the test taker is required to respond to a set of signals with a ratio of targets to non-targets of 5.25 to 1. Represented through percentages, 84% of the stimuli are targets, while 16% are non-target stimuli. Thus, after responding as fast as possible to a series of audio or visual target stimuli, the test taker has to inhibit their response when the non-target stimuli is presented visually or aurally.

The second part of the test, which measures inattention, is also comprised of 50 trials and includes a reversed ratio of target to non-target stimuli (i.e., 1 to 5.25). Thus, sequences of non-target stimuli will either be aurally or visually presented, causing the test taker to wait longer for a target stimulus than in the previous part of the test. According to the test authors, this sequence of impulsivity testing followed by inattention testing controls for practice and fatigue effects by allowing the test taker some physical rest. IVA-Plus was normed for ages 6 to adult with a test duration of approximately 13 minutes.

Procedure

Upon contacting the investigator with an interest to participate in the study, families with unmedicated children who were diagnosed with ADD were screened in an initial phone interview. The child's age, diagnosis, and status as being non-medicated were corroborated in order to determine whether or not they would be eligible to participate in the Tomatis group. In the case of families who contacted the investigator to have their medicated child participate in the study, the same questions were asked in an initial phone interview, as were questions regarding the type and dosage of the child's ADD medication. If the child met the criteria of a prospective participant, the parent was informed of participating conditions and the required time investment. The parent and the child were then invited to attend a preliminary meeting with the investigator in order to sign the informed consent and child assent forms, as well as to complete a TLT. In this meeting, the informed consent and assent forms were reviewed with both the child and parent. Any further questions or concerns regarding participation in the study were addressed. The investigator briefly reviewed a completed questionnaire by the parent which confirmed that the child had been diagnosed with ADHD/ADD by either a physician or a psychologist. The name of the physician or psychologist who established the diagnosis was also noted. At the end of this meeting the parent, child, investigator, and research assistant determined the time for the first data collection appointment, which was always scheduled in the early afternoon between 2:00 and 4:00 pm.

Testing sessions. Testing took place at the Sacarin Center and was conducted during a 60-80 minute session. For both the Tomatis group and the non-Tomatis group, the two data collections (i.e., pretest and posttest sessions) took place approximately 3-4 weeks apart. For the Tomatis group, the pretest session occurred a few days before the participant began attendance in phase I of the 3-week Tomatis sound stimulation program. Participants in the non-Tomatis group continued taking their daily dose of attention regulating medication between testing sessions and did not receive any sound stimulation intervention during this time. These participants did not attend any sessions at the Sacarin Center between the two data collections.

Tomatis Method listening program Phase I. During the first phase of the program, participants came to the Sacarin Center after school for 15 days (Monday through Friday for three consecutive weeks) and attended a two-hour listening session each day. Parents did not attend the sessions except to drop off and pick up their children. The children were supervised by a trained assistant while they were at the Center. During the two-hour listening sessions, the assistant ensured that each child wore their headphones properly without disruption (i.e. the bone transducer was placed on the head as required for the entire session). Participants in the Tomatis group were encouraged to draw, paint, and work on art projects during the listening sessions, and at times were allowed to play board games or work on puzzles. Writing, reading or other sensory-motor activities such as swinging, balancing on a balance board, or practicing brain-gym and visual tracking exercises were not part of the activity options. Such activities were considered confounding variables. Participants assigned to the Tomatis group listened to the Tomatis program using modulated and filtered music of Mozart, Gregorian chanting and waltzes. During the three weeks following their first data collection appointment, the non-Tomatis participants continued their prescribed daily medical treatment for attention regulation. Unlike the children in the Tomatis group, they did not attend any Tomatis listening sessions at the Sacarin Center, nor did they participate in any other sound stimulation programs at home or elsewhere during the study.

Statistical Analysis

A parametric and a nonparametric statistical analysis were performed. For each of the neuropsychological domains as well as for the behavioral measures, the difference in standard scores between the posttest and the pretest for each participant were first obtained. Independent *t* tests assuming unequal variances were then applied for exploring the differences between the Tomatis and the non-Tomatis groups. Furthermore, in order to submit the data to additional statistical analysis rigor, the Wilcoxon rank-sum test (WRS) was applied. WRS is a non-parametric statistical test, which is allowed especially given the fairly small samples and unequal number of participants in the two groups.

Finally, a linear regression (LR) analysis was performed. Regression analyses are much more common with large samples or data sets, but this type of research analysis is also prevalent in the fields of epidemiology, social psychology and economics for exploratory small-sample clinical research. LR analyses were performed in this study, despite the small sample size, with the goal of controlling for the possibility of additional confounding variables.

As optimal gender and age matching between the Tomatis and the non-Tomatis groups was not attainable in the participant selection process, further analyses were utilized to control for gender and age as well as for gender, age, and gender-age interactions.

The NeuroGuide normative database was used to remove artifacts and analyze the raw EEG recordings (Thatcher, Walker, Biver, North, & Curtin, 2003). A visual inspection and NeuroGuide automatic algorithms for eye blinks and drowsiness were used in order to remove artifacts from each EEG recording. A band pass filter of 1-40 Hz was used to reduce artifacts. A Fast Fourier Transformation (FFT) was then performed using NeuroGuide software to obtain total and relative power at each site for each frequency band (delta 1-3 Hz, theta 3-7 Hz, alpha 7-12 Hz, beta 12-18). The various frequency ratios including the theta/beta ratio were calculated for the midline sites (FZ, CZ, PZ). The NeuroGuide software also provided a split-half and test-retest reliability analysis once the raw EEG was free of artifacts. This was performed for each edited recording to confirm the test-retest reliability at a 90% confidence interval or higher. Finally, using the NeuroStat feature of NeuroGuide, paired *t* tests were calculated for each of the groups: Tomatis and non-Tomatis. The purpose of this analysis was to compare the findings between the two groups and to explore the effects of the first phase of the Tomatis method on brain physiology. The NeuroStat and NeuroBatch allow only a comparison of the raw scores of each participant and do not provide a comparison with the normative database for the *t* test calculations. Therefore, a comparison for each child and each recording with the normative database was also performed.

Chapter IV Results

Cognitive, Behavioral, and Attention Measures

Present findings require a clear frame of reference concerning the confidence interval (CI) used for the statistical analysis. In this study, results that met the 95% confidence intervals were considered statistically significant ($p \leq 0.05$). Given the small sample, results that neared significance ($0.05 < p \leq 0.1$) were considered marginally significant. Clinical significance of the outcomes will be addressed in the Discussion section.

Processing speed. The CD subtest from the WISC-IV, which is a pencil and paper task, was used to measure processing speed. Table 6 illustrates the results. The *t* test analysis indicated significant changes from pre- to posttest scores ($p = 0.01$) in the performance of the CD subtest when comparing the Tomatis ($M = 2.3 \pm 0.4$) with the non-Tomatis group ($M = 0.1 \pm 0.6$). The WRS confirmed the significance difference between the two groups ($p = 0.02$) of the above findings concerning processing speed.

Table 6

Processing Speed: Comparison of Pre- to Posttest Changes in Outcomes Between the Non-Tomatis and Tomatis Groups

Processing Speed Outcomes	Changes in coding Standard scores
Mean ± SE	
Non-Tomatis	0.1 ± 0.6
Tomatis	2.3 ± 0.4
Difference	2.2
Tomatis – Non-Tomatis (95% CI)	(0.6, 3.8)
P t test	0.01
P WRS test	0.02

Further analysis of the standardized scores in the CD subtest presented in Appendix D shows that 14 participants in the Tomatis group had a higher score, while one performed the same in the posttest when compared with the pretest. Out of the 10 participants in the non-

Tomatis group, 4 had higher scores, 1 performed the same and 5 had lower scores in the posttest. The CD performance for the Tomatis group in the pretest had a mean of 6.4 ± 2.72. This standard score is in the "below average" range when compared with their peers. In the posttest, the performance for the Tomatis group had a mean of 8.66 ± 1.53, which placed their results in the "average" range. The mean of the pretest performance for the non-Tomatis group was 8.6 ± 2.01, which placed these participants in the "average" range when compared with their peers. In the posttest, the mean for the non-Tomatis group was 8.7 ± 1.49. These participants were stabilized on medication throughout the research study.

Phonological processing. The PACS composite score of the CTOPP was used to assess phonological processing. This composite refers to phonological awareness and is comprised from the results of two subtests: Elision and Blending Words. Table 7 illustrates those results. The Tomatis group showed significantly improved phonological awareness ($M = 8.0 \pm 2.0$) when compared with the non-Tomatis group ($M = 1.0 \pm 2.1$, $p = 0.02$). The nonparametric statistical analysis confirmed the significant improvement in phonological awareness ($p = 0.04$).

Table 7

Phonological Processing: Comparison of Pre- to Posttest Changes in Outcomes Between the Non-Tomatis and Tomatis groups

Phonological Processing Outcomes	CTOPP Composite scores
Mean ± SE	
Non-Tomatis	1.0 ± 2.1
Tomatis	8.0 ± 2.0
Difference	7.0
Tomatis – Non-Tomatis (95% CI)	(1.0, 13.0)
P t test	0.02
P WRS test	0.04

In the standard scores of the CTOPP presented in Appendix D, important individual variation was observed in both the Tomatis and the non-Tomatis groups.

Reading efficiency. The TOWRE was used to investigate effects of the first phase of the Tomatis Method on two aspects of reading accuracy and efficiency: phonemic decoding and sight word efficiency. Those results are illustrated in Table 8. Both the *t* test and WRS test indicate a significant difference between the two groups in the change from pre- to posttest scores ($p = 0.04$). In the PDE subtest when reading, the change in performance of the Tomatis group ($M = 3.7 \pm 2.9$) was significantly higher than that of the non-Tomatis group ($M = -5.5 \pm 3.0$). On the other hand, as the *t* test ($p = 0.13$) and the WRS test ($p = 0.13$) indicate, the SWE subtest performance did not significantly improve when comparing changes in performance between the pre- and the posttests of the two groups. Nevertheless, an improvement in performance on the SWE subtest in the Tomatis group ($M = 7.1 \pm 3.0$) over the non-Tomatis group ($M = 0.6 \pm 2.9$) is evident as preliminary findings, given that this is only the first phase of the Tomatis Listening Program of sound stimulation.

Further analysis of the standard scores in the SWE subtest presented in Appendix D shows that 11 participants in the Tomatis group had a higher score, one performed the same, and 3 had lower scores in the posttest. Out of the 10 participants in the non-Tomatis group, 4 had higher scores and 6 had lower scores in the posttest. The mean for the SWE subtest performance for the Tomatis group in the pretest was 96.66 ± 17.56. This standard score falls in the "average" range. In the posttest, the mean for the Tomatis group's performance was 103.73 ± 14.41, which placed their results in the upper half of the "average" range. The mean performance for the non-Tomatis group was 101.5 ± 11.30, which placed these participants in the middle of the "average" range when compared with their peers. In the posttest, the Non-Tomatis group had a mean of 102.1 ± 14.26, which was very close to their pretest performance. These participants were stabilized on medication throughout the research study.

Table 8

Reading Efficiency: Comparison of Pre- to Posttest Changes in Outcomes Between the Non-Tomatis and Tomatis Groups

Reading Efficiency Outcomes	TOWRE Phonemic Decoding Efficiency	TOWRE Sight Word Efficiency
Mean ± SE		
Non-Tomatis	-5.5 ± 3.0	0.6 ± 2.9
Tomatis	3.7 ± 2.9	7.1 ± 3.0
Difference	9.2	7.0
Tomatis – Non-Tomatis (95% CI)	(0.5, 17.8)	(-2.1, 15.1)
P t test	0.04	0.13
P WRS test	0.04	0.14

In the standard scores of the TOWRE presented in Appendix D, important individual variation was observed in both the Tomatis and the non-Tomatis groups.

Behavioral observation. Parental behavior observation was captured in two domains of the BASC-II. Those results are illustrated in Table 9. On the BASC-II a negative change in scores between the pre- and posttests means children presented fewer attention problems or behavioral symptoms as observed by their parents. The effects of the first phase of the Tomatis Method on the Attention Problems scale and the BSI, which respectively give insight on whether there are problem behaviors and their level of severity, were analyzed. Parents perceived children in the Tomatis group (M = -6.2 ± 1.6) as significantly more attentive (p = 0.02) when compared with children in the non-Tomatis group (M = -1.5 ± 0.9). The WRS test results indicated only marginal significance (p = 0.08) for the Attention Problem scale. In investigating overall behavioral problems, the analysis showed that parents noted significant improvement (p = 0.02) in the overall behavior of Tomatis participants (M = -6.7 ± 1.5) versus that of the non-Tomatis group (M = -1.8 ± 1.3). Similarly, the WRS test pointed to a significant level (p = 0.05) of positive change in the behavior of the Tomatis group when compared to the slight improvement in the behavior of the non-Tomatis group as perceived by parents.

Table 9

Behavioral Observation: *Comparison of Pre- to Posttest Changes in Outcomes Between the Non-Tomatis and Tomatis Groups*

Behavioral Observation Outcomes	BASC-II Attention Problems Scale	BASC-II Behavioral Symptoms Index
Mean ± SE		
Non-Tomatis	-1.5 ± 0.9	-1.8 ± 1.3
Tomatis	-6.2 ± 1.6	-6.7 ± 1.5
Difference	-4.7	-4.9
Tomatis – Non-Tomatis (95% CI)	(-8.4, -1.0)	(-8.9, -0.8)
P t test	0.02	0.02
P WRS test	0.08	0.05

Further analysis of the *t* scores in the Attention Problems domain presented in Appendix D shows that 11 participants in the Tomatis group had a lower score in the posttest, 3 performed the same, and 1 had a higher score. Unlike all of the other measures, in the BASC-II, lower scores indicate observed improvements in behavior. Out of the 10 participants in the non-Tomatis group, 4 had lower scores in the post test, 5 remained the same and 1 had a higher score. The Attention Problems performance mean for the Tomatis group in the pretest was 66.53 ± 6.11. This *t* score is in the "at risk" range. In the posttest, the mean performance for the Tomatis group was 60.33 ± 6.07, which bordered on the "average" range, requiring a score of 59 or below. The pretest mean performance for the non-Tomatis group was 66 ± 6.94, which placed these participants in the "at risk" range when compared with their peers. In the posttest, the non-Tomatis group had a mean performance of 64.5 ± 5.83, which was very close to the pretest performance and remained in the “at risk” range. These participants were stabilized on medication throughout the research study.

Further analysis of the *t* scores in the BSI domain presented in Appendix D shows that 11 participants in the Tomatis group had a lower score in the posttest, 3 performed the same, and 1 had a higher score. Out of the 10 participants in the non-Tomatis group, 5 had lower scores in the posttest, 3 remained the same, and 2 had a higher score. The mean BSI performance for the Tomatis group in the pretest was 61.66 ± 8.61. This *t* score is in the “at risk” range. In the posttest, the mean performance for the Tomatis group was 55 ± 7.22, which was well within the “average” range, requiring a score of 59 or below. The mean performance for the non-Tomatis group was 66.8 ± 11.75, which placed these participants in the “at risk” range when compared with their peers. In the posttest, the non-Tomatis group had a mean performance of 67.8 ± 9.95, which was very close to the pretest performance and remained well in the “at risk” range. These participants were stabilized on medication throughout the research study.

Attention. The computerized IVA-Plus test was administered to measure attention over time. Table 10 illustrates those results. Changes in Auditory Attention quotient (AAQ), Visual Attention quotient (VAQ) and Full Scale Attention quotient (FSAQ) in both groups were examined by calculating the difference of standard scores between the posttest and the pretest performances for every participant in both the Tomatis and the non-Tomatis groups.

Auditory Attention quotient (AAQ). An independent *t* test applied to the difference in standard scores indicated a significant difference ($p = 0.03$) between the change in performance for the Tomatis group ($M = 2.5 \pm 3.5$) when compared with that of the non-Tomatis group ($M =- 20.1 \pm 8.7$). The non-parametric WRS test yielded a similar result ($p = 0.02$), supporting the statistical significance of the improvement of the AAQ for the Tomatis group in comparison to the non-Tomatis group.

Visual Attention quotient (VAQ). While there was a slight increase in performance for the Tomatis group ($M = 0.6 \pm 3.4$) in comparison to the non-Tomatis group ($M = -10.9 \pm 7.6$), the difference between the two groups in engaging their visual attention over time did not reach significance ($p = 0.2$). The exact same result was yielded by parametric and non-parametric statistical analysis methods.

Full Scale Attention quotient (FSAQ). The FSAQ is comprised of the AAQ and the VAQ. When asked to engage both auditory and visual attention, the difference in performance between the Tomatis ($M = 1.8 \pm 3.1$) and the non-Tomatis groups ($M = -17.1 \pm 9.2$) neared significance levels on the WRS test ($p = 0.06$) and on the t test ($p = 0.08$), thus are considered marginally significant.

Table 10

Attention: Comparison of Pre- to Posttest Changes in Outcomes Between the Non-Tomatis and Tomatis Groups

Attention Outcomes	Attention Quotient Full Scale	Attention Quotient Auditory	Attention Quotient Visual
Mean ± SE			
Non-Tomatis	-17.1 ± 9.2	-20.1 ± 8.7	-10.9 ± 7.6
Tomatis	1.8 ± 3.1	2.5 ± 3.5	0.6 ± 3.4
Difference	18.9	22.6	11.5
Tomatis – Non-Tomatis (95% CI)	(-2.5, 40.3)	(2.1, 43.1)	(-6.5, 29.5)
P t test	0.08	0.03	0.2
P WRS test	0.06	0.02	0.2

In the standard scores of the IVA-Plus presented in Appendix D, important individual variation was observed in both the Tomatis and the non-Tomatis groups.

Finally, the LR analysis was additionally performed to adjust the differences in performance between the Tomatis and non-Tomatis groups. More specifically, controls were established for gender, age and gender-age interaction, as well as for gender and age only. As illustrated in Table 11, the majority of the results remained statistically significant when adjusted for gender, age and gender-age interaction. The outcomes for speed of processing ($p = 0.04$), phonological processing ($p = 0.02$), behavioral attention problems ($p = 0.045$) and behavioral symptoms ($p = 0.02$) remained statically significant at a 95% CI or higher, while changes in auditory attention remained only marginally significant ($p = 0.09$) at 91% CI. Furthermore, while phonemic decoding on the reading task did not show statistically significant levels in this analysis, these outcomes did show marginal significance in the LR analysis when controlling solely for gender and age.

Similarly, when adjusted only for gender and age, all of the aforementioned outcomes presented statistical significance in both speed of processing ($p = 0.03$) and phonological processing ($p = 0.03$), or they exhibited marginal statistical significance in AAQ ($p = 0.06$), BSI ($p = 0.06$), reading phonemic decoding efficiency ($p = 0.08$), and the Attention Problems ($p = 0.1$). When controlling for gender and age, or for gender, age, and gender-age interaction, the found statistical significance for the FSAQ was not supported given the small sample.

Table 11

Linear Regression Adjustments for (1) Gender, Age, and Gender-Age Interaction and (2) Gender and Age

	LR Adjustments Gender, age, and gender-age interaction		LR Adjustments Gender and age	
Instrument/ Subtest	Difference, Tomatis – Non-Tomatis (95% CI)	*P*	Difference, Tomatis – Non-Tomatis (95% CI)	*P*
Attention Quotient				
Full Scale (FSAQ)	14.1 (-6.4, 34.6)	0.2	15.0 (-4.2, 34.2)	0.12
Auditory (AAQ)	17.0 (-2.9, 36.9)	0.09	18.2 (-0.5, 36.9)	0.06
Visual (VAQ)	8.5 (-10.1, 27.0)	0.4	8.9 (-8.4, 26.2)	0.3
Coding (standard scores)	1.9 (0.1, 3.6)	0.04	1.9 (0.2, 3.6)	0.03
TOWRE				
Sight Word Efficiency	4.3 (-6.5, 15.0)	0.4	5.8 (-4.5, 16.2)	0.3
Phonemic Decoding Efficiency	7.3 (-3.1, 17.7)	0.2	8.9 (-1.1, 18.9)	0.08
CTOPP (composite scores)	8.2 (1.2, 15.3)	0.02	7.6 (1.0, 14.3)	0.03
BASC-II				
Attention Problems	-5.0 (-9.9, -0.1)	0.045	-4.0 (-8.9, 0.8)	0.10
Behavioral Symptoms	-5.9 (-10.8, -1.1)	0.02	-4.7 (-9.6, 0.2)	0.06

Neurophysiological Measures (qEEG)

It was decided to limit the neurophysiological analysis to the three midline recording sites: Fz, Cz and Pz (Figure 2).

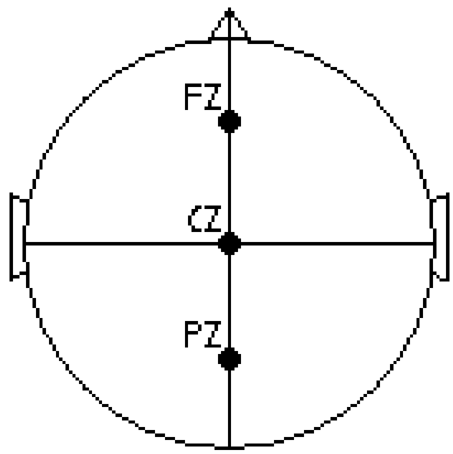
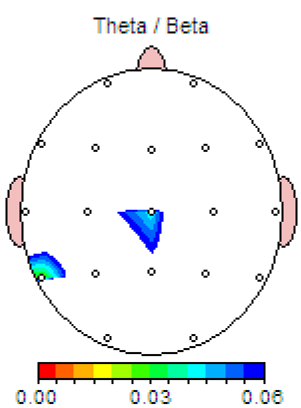


Figure 2. Scalp distribution of central recording-sites

This approach enhanced the odds of having muscle tension-free raw EEG data for each participant, as the qEEG recordings exhibited continuous muscle contraction contamination in multiple cases at some frontal, temporal and occipital scalp recording sites. Recording protocols for individuals with ADD at central sites (Cz) have been used previously (Ackerman, Dykman, Oglesby, & Newton, 1994; Janzen, Graap, Stephanson, & Marshall, 1995), or for instance when working with neurofeeback protocols (Monastra et al., 2005). As shown in Table 12 and illustrated in the right side of the spectral map (Figure 3), during the recording, the Tomatis group exhibited statistically significant pre- to posttest changes ($p < 0.04$) in the theta/beta-ratio at Cz and nearing significance ($p < 0.04$) at Pz. The ratios were calculated using absolute power values. The specific bands widths used for the analysis were as follows: delta 1-3Hz, theta 3-7Hz, alpha 7-12Hz, and beta 12-18Hz. Paradoxically, however, the changes exhibited by the Tomatis group showed a significant increase in the theta/beta ratio and the theta/gamma ratio posttreatment, when comparing each participant's pre- and posttreatment recordings. On the other hand, the non-Tomatis group did not show significant changes in any of the EEG frequency band ratios. Those results are illustrated in Table 13 and on the right side of the spectral map depicted in Figure 3.

Table 12 *FFT Paired t tests, Two Tailed, Tomatis Group (p Values)*										
Midline Recording Sites	Δ/θ	Δ/α	Δ/β	Δ/Γ	θ/α	θ/β	θ/Γ	α/β	α/Γ	β/Γ
Fz –	0.36	0.44	0.78	0.70	0.08	0.54	0.68	0.26	0.25	0.88
Cz	0.13	0.90	0.68	0.15	0.13	**0.04**	0.01	0.82	0.49	0.32
Pz	0.12	0.72	0.71	0.45	0.25	**0.06**	0.03	0.82	0.90	0.60

Tomatis Group



Non-Tomatis Group

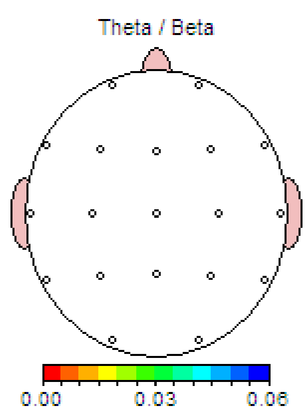


Figure 3. Spectral brain-maps: FFT Power Ratio Group t-test (p-Values)

Table 13

FFT Paired t tests, Two Tailed, Non-Tomatis Group (p Values)

Midline Recording Sites	Δ/θ	Δ/α	Δ/β	Δ/Γ	θ/α	θ/β	θ/Γ	α/β	α/Γ	β/Γ
Fz	0.79	0.59	0.77	0.64	0.63	0.99	0.66	0.70	0.49	0.38
Cz	0.75	0.18	0.40	0.50	0.18	0.37	0.45	0.63	0.64	0.82
Pz	0.281	0.135	0.27	0.98	0.36	0.87	0.49	0.54	0.25	0.07

Comparisons of the individual EEGs with the normative database allowed further analysis and individual characterizations. Individual peak alpha frequencies over the midline recording sites, as well as *z*-scored FFT maps for each frequency band and *z*-scored FFT Relative Power maps were plotted and qualitatively analyzed. The scope was to identify or categorize each participant's ADD neuro-physiological signature according to neurophysiological research (Clarke et al., 2001a; Clarke et al., 2001b; Kropotov 2009; Lubar, 1991; Satterfield et al., 1972). In the Tomatis group, eight participants were categorized in the third subgroup as they exhibited hyperarousal; four participants were categorized in the second subgroup given the maturation lag in their EEG profile; and two participants exhibited hypoarousal and were categorized in the first subgroup. One participant in the Tomatis group did not show any of the ADD electrophysiological evidence (evaluated EEG descriptors fell within "normal" range). It is noteworthy that not all participants fell perfectly into a specific category, some of them exhibiting characteristics of other subtypes as well. In the non-Tomatis group, eight out of the ten participants exhibited the hyperaroused qEEG profile. The supplemental file compiles the following data for each participant: age, gender, pre- and posttest peak alpha frequencies over the midline and *z*-scored theta/beta ratio, including the ADD subgroups described in Table 2.

Chapter V Discussion

This researcher has spent nearly two decades in clinical practice offering the Tomatis Method, and clinically documenting its power; still, the need to examine it in a more rigorous fashion became evident. In particular, the need to explore the Tomatis Method's effects on the cognition, behavior and attention of children diagnosed with ADD, together with the need to investigate the underlying brain physiology for the changes observed, led to this research study.

There is a clinical and scientific need to examine the effects of the Tomatis Method on neurophysiology, cognition, and behavior in children with ADD. To address the above clinical and scientific interests, this dissertation used a quasi-experimental between group and controlled research design to examine the early effects of the Tomatis Method of sound stimulation. To account for the early effects of the Tomatis Method, the intervention consisted of only the first of three phases. In this study, 25 children ages 7-13 years old diagnosed with ADD were evaluated and assigned to two groups: a Tomatis intervention group and a non-Tomatis group who did not receive the Tomatis sound stimulation. The Tomatis group did not receive medication for ADD, while the non-Tomatis group was stabilized on ADD medication prior to and throughout this research study.

Given the challenges in meeting the proposed numbers of participants, especially in the non-Tomatis group, a randomized selection of participants was not possible. While aware of the internal validity limitation posed by lack of randomization, any children ages 7-13 diagnosed with ADD from the greater Seattle area who met the selection criteria were invited to participate.

As stated above, this research explored the effects of the first phase of the Tomatis method on specific cognitive functions and on behavior and attention as captured through standardized neuropsychological measures. In order to explore the neurophysiologic basis underlying the above-mentioned effects, non-invasive EEG recordings during rest with eyes open, and their quantitative analyses (qEEG) were obtained.

To my knowledge, this research study is the first to investigate early effects of the Tomatis Method. The need for research into the early effects is important for multiple reasons. The first phase of the Tomatis Method is comprised of 30 hours of Tomatis sound stimulation distributed in daily 2-hour increments (Mo. to Fri.) for 15 days. As previously stated, in my experience, the first phase of the program yields important changes in the children's TLT results, as well as in their behavior. Phase One is almost twice as long as each of the following two phases, each of which last eight days (two-hour sessions). Phases Two and Three are shorter since they follow the major perceptual training and development that was set in motion during Phase One. Given the clinical changes I have observed after the first phase of the Tomatis program throughout my career, including parental feedback, this early part of the Tomatis intervention lends itself to scientific inquiry.

Furthermore, the first phase allows for a more robust research design when controlling for the confounding variables associated with other treatments that children with ADD typically receive concomitantly. In the attempt to help their children, and often prior to medicating them, parents may access a variety of interventions available to children with ADD. These interventions include and are not limited to: tutoring, coaching, psychotherapy, social groups, speech and language therapy, occupational therapy and nutritional services. Many children receive concomitantly at least one, and often two or three interventions. In my experience, parents do everything possible in order to ensure their child's academic success and promote emotional and social regulation skills. Most interventions occur on a weekly basis and can extend over years. All previous peer-reviewed research reported findings that were based either on the completion of the Tomatis Method program in its entirety, or were based on an extended Tomatis sound stimulation program with additional treatment hours. For instance, Ross-Swain (2007) used 90 hours and Gilmor (1984) used 100 hours of Tomatis sound stimulation treatment in their research. Given the assimilation time (i.e., breaks in intervention) between each sound stimulation phase, the Tomatis Method basic program in its entirety lasts approximately 4 months and consists of 62 hours of listening. As with many diagnoses which impact a child's ability to learn and function socially at home and in school, families with children with ADD often feel overwhelmed and may seek more than one professional's expertise.

Clinical experience suggests that the effects resulting from completion of all three phases of the Tomatis Method are greater and more powerful than those effects experienced solely in the first phase. However, these effects are more challenging to extract and interpret perhaps because of the above-mentioned confounding variables or concomitant interventions.

Processing Speed

As hypothesized, when compared with results of the non-Tomatis group, the experimental group results showed a statistically significant increase in processing speed as measured in the Coding subtest from the WISC-IV. More specifically, increases were evident in the areas of perceptual (visual) and grapho-motor processing speed, as measured by the Coding subtest, which also requires sustained attention paired with adaptation to novel learning. Clinically speaking, the increase in processing speed that occurred between pre- and posttesting in the experimental group averaged 2.3 standard score points, equaling more than 2/3 of a standard deviation or 66.6% of a standard deviation improvement after only three weeks of Tomatis sound stimulation treatment. A practice effect resulting from the repeated use of the same measurement tool (i.e., the Coding subtest) could have played a role in the more favorable outcome of the posttest results and needs to be mentioned. Nevertheless, the control group was equally exposed to this practice effect, since they were asked to use the same Coding subtest form in the pretest and the posttest that followed three weeks later. Assuming that the non-Tomatis group benefited equally from any practice effect, because their improvement was a negligible 0.1 standard score points, it is likely that the practice effect was not the main cause for the significant improvement exhibited by the experimental group. The non-Tomatis group was stabilized on ADD medication and their processing speed performance remained in the "average" range, and was stable, showing almost no change. Therefore, these findings confirm our hypothesis that the first phase of the Tomatis Method significantly improves visual perceptual and grapho-motor processing speed, which requires sustained attention and adaptation. These findings were statistically supported at a 99% confidence interval. Rourke and Russell (1982) reported improved hand-eye coordination in their experimental group after completing the Tomatis Method treatment. Grapho-motor processing requires hand-eye coordination; thus, our findings corroborate previous perceptual research. Shams et al. (2001) found that sound alters temporal aspects of visual perception. They compared VEPs with and without sound stimulus in their research, concluding that when a single flash is presented at the same time with two auditory signals, the person perceives the single visual input as two inputs, or two flashes. In addition, these researchers showed that sound also influences the perception of vision in motion, thus suggesting that visual cortical processing is tightly connected to multimodal processing. Given that the Tomatis Method intervention is exclusively an auditory-based treatment and the noted processing speed improvements in the present research were in the visual perceptual domain, the findings of this study point to the existence of sensory integrative processes assumed by Tomatis' explanatory model and supported by the above researchers.

According to Weiler, Bernstein, Bellinger and Waber (2002), children with ADD who were categorized as inattentive exhibit a diminished visual processing speed. In their research studies, the authors found that children with reading disabilities performed poorly on written language but not on processing speed tests. Conversely, children with ADD performed exactly the opposite to those with reading disabilities on the Coding and the Symbol Search subtests of the WISC-IV, which measure processing speed using visual and visual motor skills. These authors also used a computerized measure, the Visual Filtering task, to investigate visual information processing in children with ADD when compared to children with reading disability. Their findings led to the same conclusion suggesting that temporal-related processing in children with ADD is slower than in those with reading challenges (Weiler et al., 2002). Those empirical findings that attempt to explain the moment-by-moment functioning of individuals diagnosed with attention issues also emphasize how challenges in temporal processing of information can negatively impact these individuals (Toplak, Dockstader, & Tannock, 2006). The lack of an appropriate reaction time as required by activities of daily life can be a serious obstacle. Deficits in attention result in either an impulsivity with too hasty a reaction time, or in a response time that is too slow. Without appropriate temporal-processing, successful functioning does not occur with ease. Appropriately timed discrimination and well-timed responsiveness and motor execution all contribute to good cognitive and behavioral functioning, as well as to daily and social adaptation, regardless of whether or not a task requires auditory or visual processing. Therefore, speed of processing was one of the major outcome measures in this study and the results of this research study indicate that the first phase of the Tomatis program significantly improves this aspect of cognitive functioning. Therefore, processing speed was one of the major outcome measures of this study and this research indicates that the first phase of the Tomatis Method significantly improves processing speed.

Phonological Processing

It was hypothesized that phonological awareness will be affected by the first phase of the Tomatis Method. The present results confirmed the hypothesis, as the experimental group exhibited a significant improvement on the composite score of the CTOPP, PACS, when compared to the non-Tomatis group. As a composite score, the PACS encompasses two subtests: Elision and Blending Words. Clinically speaking, the experimental group improved their performance in phonological awareness by an average of eight standard score points upon completion of the first phase of the Tomatis Method sound stimulation program. This increase in performance represents a gain of slightly more than half, or 53%, of a standard deviation. The non-Tomatis group, on the other hand, showed a very slight improvement of only 1 standard score point on average, or 6.6% of a standard deviation. These results point to a large effect size for the experimental group in comparison to the non-Tomatis group.

Breier et al. (2001) suggested that phonological awareness is only slightly less developed in children with ADHD when compared with typically maturing peers. However, these authors also pointed out the existing comorbidity of ADHD and reading disabilities (RD). They noted the considerable challenges in auditory and phonological processing that children who present with both conditions exhibit. Among other measures, the researchers used subtests from the CTOPP and TOWRE to examine the reading and phonological awareness abilities of children with ADHD and RD, as unique conditions or as comorbid conditions, while comparing them with those of typically developing peers. As stated above, phonological awareness was reported to only be slightly less developed in children with ADHD when compared with their peers. In the present study, the improvements we found in children's ability to differentiate and process spoken language after the Tomatis intervention, even if only slightly affected, seemed to facilitate a more continuous and rapid gain of meaning in different situations, such as when asked to listen and follow instructions. This increase in meaning or improved listening in turn increased the children's ability to attend and participate with more ease. Parents observed significantly improved attention and general behavior in their children after Phase One of the Tomatis Method. The parental observation outcomes will be discussed later in this section.

To summarize, these findings suggest that children with ADD who exhibit phonological awareness skills within the "average" range can further improve their listening skills using the Tomatis listening intervention. Furthermore, it can be inferred that children with ADD who also present with RD and have poor phonological awareness skills may considerably benefit from the Tomatis Method. Further research on children with a dual diagnosis of ADD and RD and the effects of the Tomatis Method could be very informative for intervention purposes.

Attention and General Behavior

As predicted, the parents of the children in the experimental group reported a significant reduction in attention problems, including improvement in overall challenging behavior. As evidenced by the BASC-II, parents observed significant changes in their children's attention levels and behavior after completion of the Tomatis sound stimulation intervention. Clinically speaking, the average 6-point decrease in t scores for the experimental group on the Attention Problems scale may be interpreted as a significant improvement in attention as observed by their parents. While the average *t score* on the Attention Problems scale in the pretest fell in the "clinically at risk" range ($t = 66$), the posttest score (average $t = 60$) bordered on the "average" range, which requires a t score of 59. Similarly, the overall challenging behavior measured by the BSI improved significantly from the “clinically at risk” range ($t = 61$) to well into the “average” range with an average t score of 55. Unlike the experimental group, the initial behavior scores on both scales for the non-Tomatis group improved by only 1 t point: Attention Problems ($t = 66$) and BSI ($t = 68$). As a result, the average scores for the non-Tomatis group remained in the “clinically at risk” range. The predicted behavior improvement findings in this thesis are consistent with previous research supporting the effect of the Tomatis Method of sound stimulation on this area of development (Gilmor, 1999).

At the same time, the behavioral findings in the non-Tomatis group seem to suggest that ADD medication to a certain extent helps these children regulate their attention and general behavior. However, parents of the non-Tomatis group rated their children’s attention and general behavior as slightly below the clinical range on the BASC-II, in spite of having their children medically treated for ADD. These findings shed light on the considerable challenges children with ADD and their families must experience relentlessly.

Further research studies are needed on the impact a family experiences once a child has received an ADD diagnosis. While parental observation of their child’s behavior was used in this study, no note of the family’s well-being was taken, nor was it considered how the family’s well-being in turn impacts the child. Although the BASC-II has a teacher form, it was not added to the already large amount of measures used in this research study. A classroom attention and general behavioral observation measure would have been even more edifying with regard to the early effects of the Tomatis Method, considering that these children have challenges performing in school in spite of their average or higher intelligence.

Reading Efficiency

The phonemic decoding efficiency subtest of the TOWRE was administered to assess the visual and auditory processing skills that are essential for reading. According to Kouri et al. (2006), students with poor reading skills rely mainly on context in order to identify written words and do not engage in phonemic decoding. However, when words are not recognized by a child, phonemic decoding skills should be used prior to confirming their analysis of contextual information (Kouri et al., 2006).

In the present study, as predicted, the experimental group showed significant improvements in performance on the phonemic decoding subtest when reading after the first phase of Tomatis intervention. In other words, children who received the Tomatis sound stimulation intervention improved their decoding speed while also maintaining or improving their decoding accuracy.

Processing speed in particular is very important in reading fluency, and the preliminary findings of the present study on the sight word efficiency subtest show a slight improvement in the experimental group when compared to the non-Tomatis group. Although the difference was not statistically significant, these findings suggest that further testing is needed in this area and completion of the Tomatis treatment may be warranted. Therefore, while the results of the phonemic decoding efficiency subtest are significant, and may be suggestive of gains in reading fluency with just the first phase of the Tomatis Method, further treatment may also be required in order to see similar improvements in sight word efficiency.

Attention

In addition to parental observation scales, the IVA-Plus was selected as a measure for attention for a number of reasons. Being a continuous performance test and administered via a computer, this measure eliminates researcher bias and facilitates double-blind conditions desirable for high internal validity of any research. Moreover, the practice effects are considerably small at 3% (Strauss, Spreen, & Sherman, 2006). Additionally, this measure requires not only the "go/no-go" paradigm used by other continuous performance tests, such as the Test of Variables of Attention- Auditory (TOVA-A), but the IVA-Plus also poses a demand on the individual's ability to flexibly engage the auditory and the visual system in a quick and fluid manner while responding to the go/no-go task. This fluidity is achieved through an unpredictable alternation of either auditory or visual signals asking the participants not only to remain alert, but also to be flexible in engaging both sensory systems while only responding to the correct stimulus.

The preliminary results on the IVA-Plus in the present study confirmed the hypothesized improvements in attention for the experimental group. Keeping in mind the complexity of the test, the preliminary results of the IVA-Plus suggest that even though the increase from pre- to posttest in the average performance on the AAQ by 2.5 standard score points for the experimental group may be considered slight, it is nevertheless an important step in the right direction. More importantly, it speaks about the effects of the Tomatis Method in that the non-Tomatis group's performance declined considerably, averaging a loss of -20.1 standard score points when comparing pre- to posttest results. Thus, the difference between the experimental group and the non-Tomatis group averaged 22.6 points with a range of 2.1- 43.1. Although there is a statistically significant difference between the two groups on the AAQ, a number of other aspects must be mentioned when considering clinical relevance. Unlike all of the other measurement tools that were administered and that required a short concentration time, the IVA-Plus lasted 15 minutes, and children might have found it to be drawn out and uninteresting. On such tests, children may choose to disengage if asked to perform such long and seemingly boring tests a second time. Another explanation for the highly fluctuating performances in the posttest of the non-Tomatis group is that while the first-time exposure and novelty kept participants motivated during the pretest, the anticipation of repeating a long and boring test may have resulted in a considerable decrease in the motivation level of some of the participants during the posttest. Therefore, the test-retest reliability coefficient is important to mention in the context of the current findings. According to Strauss et al. (2006), the test-retest reliability coefficient for IVA-Plus is considered adequate (0.70-0.79) for the FSAQ and VAQ while it is considered marginal (0.60-0.69) for the AAQ.

Nevertheless, it should also be considered that both the experimental and the non-Tomatis groups had to repeat the same test after an identical interval period of three to four weeks, and it is evident that the experimental group exhibited a much stronger posttest performance when compared to the non-Tomatis group. Given the complexity and duration of the task, the increase in the average performance of the Tomatis group after only the first phase of the Tomatis Method of sound stimulation supports our hypothesis suggesting positive preliminary clinical findings.

It is important to point out that the children's motivation was not tested, nor was the amount of parental rapport controlled for during this research study. Children in the Tomatis group had considerably more rapport with their parents by participating in the Tomatis program compared to the children in the non-Tomatis group. The parents in the Tomatis group dropped off and picked up their children daily from the Center and thus had additional time with their child during the commute. This increased rapport during their commute in the Tomatis group may have also affected children's performance motivation during the posttest. Therefore, it can be considered another confounding variable which needs to be controlled for in future research.

As presented in the results section, a slight increase in the VAQ performance of the experimental group was recorded, while again, a decrease in performance was noted in the non-Tomatis group. However, the difference between the two groups did not reach statistical significance. The FSAQ, although with marginal statistical significance, presents a similar clinical picture: an increase in performance in the experimental group of 1.8 standard score points and a decrease of -17.1 standard score points for the non-Tomatis group with a -2.5, 40.3 range of difference between the two groups. In summary, the IVA-Plus preliminary findings support the predicted effect of the first phase of the Tomatis Method of sound stimulation on auditory attention and attention in general when given a very complex continuous performance task. Specifically, positive effects were observed when presented with a go/no-go paradigm that placed demands on flexibility while testing both auditory and visual attention over time.

Further support to the hypothesized early effects of the Tomatis Method of sound stimulation was provided by the results of the regression analysis which controlled for age, gender, and gender-age interaction, in addition to an analysis that controlled for gender and age only. In spite of the small sample sizes, this additional analysis made evident to an even greater extent the statistical significance of the discussed findings. As previously stated, it was not possible to include age and gender matching of the experimental and the non-Tomatis groups in the study design of. Neither was it possible to use randomization when selecting research participants. Thus, controlling for the above confounding variables in the statistical analysis is an important aspect in increasing the internal validity of these findings.

It is important to point out that the outcomes of the t-tests were not adjusted for multiple comparisons. While a considerable number of t-tests were applied, there were only three major cognitive domains investigated: processing speed, attention and phonological awareness. Processing speed was captured in the outcomes of the Coding and the TOWRE subtests, while phonological awareness was reflected in the outcomes of the CTOPP subtests. Finally, attention was captured in the IVA Plus performance and in the parental observation on the BASC-II. The triangulation of measures around the major investigated cognitive domains had the scope to reduce the experiment-wise error rate.

Neurophysiology

ADD is a heterogeneous disorder with various subtypes in clinical presentation as well as in neurophysiology. As already described, when analyzing EEG recordings of children diagnosed with ADD, researchers have identified three distinct clusters (Clarke, Barry, McCarthy, Selikowitz, & Brown, 2002).

One subgroup is characterized by cortical hypoarousal, with deficits in relative beta waves across all sites with concomitant increases in relative theta. A second subgroup exhibits a maturation lag and has an EEG profile showing increased relative delta and theta, a decreased relative alpha overall and a decrease in beta mostly at central recording sites. A more recently noted subgroup, the third neurophysiological profile, shows cortical hyperarousal characterized by excess beta activity at the frontal and central sites (Clarke et al., 2001b). A fourth subgroup shows an increase of alpha activity at the posterior, central or frontal sites (Kropotov, 2009).

Preliminary findings. Only one peer-reviewed study previously used pre-treatment and post-treatment recordings associated with qEEG brain-mapping and ERP neurophysiological measures to document the effects of the Tomatis Method of sound stimulation program on brain functioning. Vervoort et al. (2007) used a single case study design when reporting changes in qEEG and ERP recordings before and after the Tomatis Method treatment in four individual cases and correlated changes in the brain's physiology with those exhibited on the TLT. However, the presented children had severe developmental delays and the Tomatis Method intervention used long and intensive sound stimulation protocols. Changes in both the TLT and brain electrophysiological measures were evident given the long Tomatis intervention and the case by case analysis of both EEG and ERPs. According to Vervoort et al. (2007), the changes observed were the results of the Tomatis Method intervention and encompassed maturity in the listening function as captured by the TLT and faster brain activity with increased neurophysiologic inter-hemispheric symmetry in the qEEGs. Furthermore, the changes in the TLT were correlated with those in the EEG and the ERPs. The ERPs suggested better automatic discrimination, (in one case a small amplitude N200 response was recorded and apparent for the first time post Tomatis intervention), and an improved processing ability of meaningful stimuli, (P300 showed larger amplitude in some cases while a small amplitude response was recorded for the first time in one of the cases).

In the present study, statistically significant changes in the qEEG spectral maps were observed in the experimental group when comparing pre- and post-treatment-recordings. These changes were observed for the theta/beta ratio at the midline sites Cz and Pz, with the ratios being larger after the first phase of the Tomatis treatment. This spectral analysis showed no statistically significant change in the non-Tomatis group, as children maintained their intake of ADD medication throughout the research study.

The significant changes, however, noted in the Tomatis group at the midline central and parietal recording sites are paradoxical, since they point to an increase of the theta/beta ratio after the first phase of the Tomatis Method of sound stimulation. This paradoxical preliminary outcome was contrary to expectations, since, in general, attention is correlated with an increase in the faster beta waves rather than in the slower theta waves, particularly over frontal and even central recording sites. Research, however, shows that there is more than one ADD neurophysiological profile in children. Clarke et al. (2001b) suggested that the subgroup of children exhibiting elevated levels of beta activity actually amounted to a smaller percentage of total children with ADD. The children in the subgroup with elevated levels of beta activity had been diagnosed with a combined type ADD. However, not all children with this diagnosis exhibited an identical EEG profile. Thus, the matching of clinical subtypes with certain neurophysiological profiles remains a challenge for clinicians and researchers alike.

In the present study, a further evaluation and thorough description of each and all individual qEEG maps for peak alpha frequencies over the midline recording sites, *z*-scored FFT maps for each frequency band and *z*-scored FFT Relative Power maps led to better characterization of each child in terms of their neurophysiological ADD profile according to the four subgroups described in Table 2**.** In the Tomatis group, eight participants exhibited hyperarousal and were categorized in the third subgroup, four participants exhibited maturation lag and were categorized in the second subgroup, and two participants exhibited hypoarousal and were categorized in the first subgroup. Interestingly enough, one participant in the Tomatis group did not show electrophysiological evidence that allowed characterization as ADD (EEG descriptors evaluated classified the child as "normal"). These findings point to the relative significance of qEEG as a diagnostic or research tool when attempting to use it as a stand-alone measure, since the wide individual variation in electrophysiological descriptors for a supposedly common "diagnosis" is evident even in this small sample. Interesting as well is the observation that in the non-Tomatis group, eight out of the ten participants exhibited the hyperaroused qEEG profile.

Further exploration of the peak alpha frequency values and the *z*-scored theta/beta ratios of the pre- and post-qEEGs for each participant in the Tomatis group were undertaken. The paradoxical changes obtained when using individual raw values, all showing changes toward a higher theta/beta ratio, were not observed to the same extent when using *z*-scored values. The *z*-score values suggest that the theta/beta ratio, although higher for the Tomatis group after training, remained within the average range for all participants. In other words, although the pre-post treatment comparison of the qEEG ratios for the Tomatis group resulted in paradoxical findings, the individual analysis of the pre- and post-qEEGs showed that the changes observed still fell within normal values. This result may serve to explain that the gains in the cognitive, behavioral and attentional domains do not necessarily stand in contradiction with the qEEG outcomes. These findings may also reflect the individual variability in electrophysiological patterns described above for the Tomatis group, which was considerably less homogenous than the non-Tomatis group. This analysis reveals that the initial assumption about expected unidirectional changes (faster brain activity) in brain physiology post Tomatis was too generalized. Instead, formulating a hypothesis that would have taken into consideration the various ADD neurophysiological subtypes would have been more appropriate. These findings will be important to bear in mind when designing further research. For instance, future research might investigate the effects of the Tomatis Method on children with hypoaroused neurophysiological ADD profiles, or with hyperaroused profiles if compared to a medicated group with mostly hyperaroused profiles.

Conclusions

The reviewed body of literature evidenced the need for further investigation into the effects of the Tomatis Method of sound stimulation. By using only the first phase of the Tomatis Method as an intervention modality, this dissertation explored early effects on cognition, attention, behavior, and brain electrophysiology in children with ADD. First phase effects have not previously been presented in scientific peer-reviewed publications. The short duration of intervention used in this research helped to control for other treatments that many children with ADD undergo concurrently, such as occupational therapy, speech and language services, counseling, coaching and tutoring. Moreover, using qEEG recordings in a controlled group design, this research attempted to explore early electrophysiological effects of the Tomatis Method. Finally, this research study was the first one to my knowledge to study Tomatis training effects on children with ADD. Previous research showed effects of the Tomatis Method on children diagnosed with learning disabilities (Rourke and Russell, 1982), autism spectrum disorder (Gerritsen, 2008; Neysmith-Roy, 2001), and children with speech and language or auditory processing challenges (Ross-Swain, 2007); however, this is the first research to focus on the diagnostic category of ADD and children who present with attention challenges.

Using the first phase of the Tomatis Method, significant positive effects were found on processing speed, phonological awareness, and reading phonemic decoding efficiency of those children. Moreover, congruent with the findings of the auditory and full attention quotient continuous performance test, parents reported a significant reduction in attention problems and challenging behaviors. Finally, a significant change in brain physiology was recorded post intervention at the central and parietal midline recording sites. When comparing pre and post-treatment ratios within each group, a statistically significant increase in slow activity at central and parietal midline recording sites in the Tomatis group was observed. Taken in isolation, these are paradoxical neurophysiological findings, since they do not concur with the behavioral gains documented by the other tests carried out in this study. Further characterization of the EEG profiles, however, show the importance of individual variation in this complex analysis and observation. These findings strongly suggest that further research is needed, perhaps investigating more homogeneous groups, a larger sample, comparing eyes closed and eyes opened EEG recordings, or using more electrophysiological tools altogether, such as ERPs while decoding, reading, listening passively and actively, and so forth.

The presented outcomes add to the body of evidence in support of the effects of the Tomatis Method. These highly significant, early effects suggest that the Tomatis Method can be a brief and efficacious intervention and, given further research, can be considered a scientifically proven tool alongside other established evidence-based treatments for children with ADD.

Finally, the outcomes of this research study are in agreement with recent neuroscientific findings that suggest that sound stimulation alone has significant positive effects on cognitive functions such as attention, memory, learning, and language development (Patel, 2006). Kraus and Banai (2007) have also shown that auditory processing, which is a response to our sound milieu, is strongly related to broader cognitive functions beyond language development. The various cognitive and behavioral outcomes in this dissertation are in line with those authors' findings, since by using the Tomatis Method, we used a solely auditory stimulation intervention. Additional vestibular, visual and motor coordination exercises were not used during the sound stimulation sessions, nor did participants receive other interventions during the three weeks of Tomatis training.

Tomatis postulated the central and integrative role of the listening function for the other sensory systems and for optimal brain functioning. Studying the listening function and the effects on behavior, language, interaction and communication, he embedded his method of sound stimulation in the theoretical frame of the field he created: audio-psycho-phonology. In accord with his model, current research suggests that auditory processing is a dynamic process influenced by higher cognitive functioning such as attention, memory, and contextual framework (Kraus & Banai, 2007). Efficient brain functioning is a *sine qua non* condition for optimal cognitive, behavioral, emotional and social functioning. As presented, children with ADD have specific neurophysiological signatures which differ from those of their peers. Therefore, understanding if and how an intervention such as the Tomatis Method can contribute to optimizing brain activity is very worth undertaking. In principle, we expected to find changes in the brain physiology when changes in cognition, behavior and attention occur. At this point, it is important to raise the question whether the quantitative analysis of the EEG alone is sufficient to evaluate such early changes, since auditory and visual ERPs as well as other neuroimaging tools could vastly contribute to future research in characterizing the neurophysiological changes underlying documented changes in behavior, cognition, and attention.

Study limitations. Given the clinical nature of the study, several limitations were inevitable. Recruiting sufficient research participants was challenging and therefore, the initially proposed experimental design with random selection and assignment was abandoned. The final implemented research design inherently reduced the internal validity when compared to a randomized study. The small sample size itself presented another limitation. Another research design limitation was the use of the same pre- and post- measures for comparison when quantifying the effects of the Tomatis Method. Only one test had a form A and a form B available to administer in order to control for training effect.

Furthermore, the comparison group was not a classic control group, such as one which received no treatment or a placebo treatment only. The comparison group was on ADD medication and did not receive any extra daily time with their parents, unlike the experimental group. It is possible that other factors, such as participants' daily exposure to parental interaction on the way to and from the Tomatis intervention sessions, may also have affected the research outcomes.

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Appendix A

Dear Dr____________________

In January 2008, I will begin an experiment as part of my doctoral program in clinical psychology. The experiment has the purpose to investigate possible effects of the Tomatis Method of sound stimulation on brain's physiology and on attention and other cognitive functions, and behavior in children who have been diagnosed with ADHD. I am writing to you to inform you about this opportunity for some of your patients / clients to participate in the project with the possibility to attend to the first and second part of the program at no charge.

Following criteria need to be met:

1) Children ages 7 through 13 will be selected for participation in this study.

3) Children and their parents are required to have English as their primary language.

4) Children must have been either diagnosed by a psychologist or a physician with Attention Deficit Disorder (ADD), according to the DSM IV.

5) Children must not have been previously diagnosed with a neurological (e.g., seizures, head trauma, tumors), or hearing disorder.

6) Children must not be under the influence of any long term mood altering and attention inhibiting medication while participating in the study, and must have been off all stimulant medication for at least two days prior to beginning the study.

If you feel that some of your family could benefit from participating in this study please have them contact us at 206 522-8873 or at lsacarin@sacarin.com asking them to have the e-mail titled “study”.

I would like to thank you in advance for your support, and would like to invite you to contact me if you would like more information about the study.

Sincerely,

Liliana Sacarin

Appendix B

Informed Consent Form

Sacarin Center

5901 Roosevelt Way NE Suite C

Seattle, WA 98105

January 1, 2008

Dear Parents:

As part of my doctoral dissertation we will be initiating a research project in January of next year. The purpose of the research is to determine specific effects of the Tomatis method of sound stimulation on the brain's physiology and on certain cognitive and attentional parameters. Approximately 44 children ages 7-13 will be included in the study, and I would like to have your permission for your child's participation in the research.

There is strong clinical evidence that the Tomatis method of sound stimulation positively influences psychomotor, cognitive, and linguistic skills in children with learning and developmental challenges, as it is used in over 250 centers all over the world. For this and many other reasons, I strongly believe that your child will benefit personally from participation in this project, either during the experimental phase or shortly there after if he or she is selected to be in the control group. The most important benefit of this research is that your child's participation may help the project team identify important strategies in developing health and wellness for children which I hope will lead to more support for children's mental health in both your local and global communities.

Your child's participation in this research is voluntary. If at any time your child feels uncomfortable, they can ask to be excused from the meeting and return at a later time or not return at all. Participants' information will be kept confidentially. If you agree for your child to participate, you will be given a copy of this document and a written summary of the research when the project is completed. In the event that we do further follow-up research in connection with this project, we ask for your permission to contact your child in the future, as a potential research volunteer.

You may contact Liliana Sacarin at any time if you have questions about the research. You can reach her at:

Sacarin Listening Movement and Development center

5901 Roosevelt Way NE Suite C

Seattle, WA 98105

By phone at 206-522-8873, or e-mail at lsacarin@sacarin.com

We want to thank you for your time, consideration, and help in this project.

If you are willing to have your child participate in the study please return the attached permission form to the Sacarin Center.

Again, I greatly appreciate your cooperation in this endeavor. If you have any questions concerning the research please do not hesitate to contact me.

Sincerely,

Liliana Sacarin

I have read the above statement and I herby give permission for

____________________________________ to participate in the research study undertaken at

the Sacarin Center beginning in January 2008.

Date______________________ Parent Signature___________________________

Appendix C

Participant Assent Form

Study Title

Specific Effect of the Tomatis Listening Method on the Brain and on Cognitive and Behavioral Functions

Investigators

Liliana Sacarin, MA (206.522.8873)

I am being asked to help Miss Liliana Sacarin with a project which she calls a "study".

Why is this study being done?

This study is being done in order to better understand how specific methods of sound stimulation affect children's abilities in attention and processing in order to help kids like me, in learning, attention, focus and behavioral control.

If I do the study, what will I have to do?

If I decide to participate in the study, my part in the project will involve going to The Sacarin Center, putting on and listening to headphones for two hours, for 26 days. At three different times during these days, I will spend about an hour meeting with just Liliana in order to answer some questions verbally, as well as answer some of the questions her computer asks me. In these meetings, I will also put on a cap in order to read my brain's activity. This cap will not hurt me and will be of very little, if any, discomfort. I understand that if I miss a part of a class or am not able to participate in the study on certain days, I will have to make up for the time that I missed. I also understand that I may miss a part of my extracurricular activities if the study takes place during those times.

Do I have to be in this study?

I understand that I do not have to participate if I feel uncomfortable about the study and if that is what I decide, no one will treat me badly. I can stop part of the way through and skip the questions I don't want to answer and that will still be OK. I understand that my information and answers will be kept private and that the person who interviews me will not tell anyone what I have said. I also understand that some of my time at the Sacarin Center will be recorded and that too will be kept private as is only for Liliana and her team to review if they have any questions.

What happens after the study?

When the study is all done, I understand that there will be a report written about what was learned. This report will not include my name or say that I was in the study. If I agree to participate, I will be given a copy of this report when it is done, as well as a copy of this paper that I am reading now. If in the future there is another study which is connected with this study, I understand that by signing this paper Liliana and her team are asking my permission to contact me in the future, as someone who might want to participate in the other study.

I understand that I or my parents may contact Liliana Sacarin at anytime with any questions that we may have.

Here is some information that will help us reach her.

Sacarin Listening Movement and Development center

5901 Roosevelt Way NE Suite C

Seattle, WA 98105

By phone at 206-522-8873, or e-mail at lsacarin@sacarin.com

Signing this document means that the research study, including the above information, has been described to me and that I am freely choosing to participate.

I have read the above statement (or have had it read to me) and I understand my rights with regard to participating in this research project.

______I agree to participate in this project

______I do not want to participate in this project.

Student signature/Date

Investigator/Date

Appendix D

Standard Scores and Descriptive Statistical Analysis

Table 14

Processing Speed: Coding Subtest Standard Scores

Group	Tomatis		Control	
Participants	Pretest	Posttest	Pretest	Posttest
1	6	6	6	8
2	3	7	9	8
3	5	8	11	9
4	6	7	8	8
5	9	11	9	7
6	8	10	10	8
7	5	7	6	7
8	7	9	7	10
9	7	9	8	11
10	12	13	12	11
11	4	10		
12	2	5		
13	10	13		
14	8	8		
15	4	7		

Standard Score (SS) is based on mean of 10 and standard deviation of 3.

Table 15

Processing Speed: Coding Descriptive Statistical Analysis

	Tomatis		Control	
Univariate Analysis	Pretest	Posttest	Pretest	Posttest
Average	6.4	8.666667	8.6	8.7
Median	6	8	8.5	8
Standard Deviation	2.720294	2.380476	2.01108	1.494434

Table 16

Phonological Processing: C-TOPP Composite Scores

Group	Tomatis		Control	
Participants	Pretest	Posttest	Pretest	Posttest
1	121	124	109	100
2	79	94	97	100
3	100	118	121	115
4	100	109	76	73
5	94	94	106	112
6	115	118	88	88
7	97	121	103	118
8	103	112	91	100
9	85	100	94	97
10	112	121	112	112
11	88	88		
12	82	82		
13	97	109		
14	103	106		
15	103	103		

Standard Score (SS) is based on a mean of 100 and a standard deviation of 15

Table 17

Phonological Processing: C-TOPP Descriptive Statistical Analysis

	Tomatis		Control	
Univariate Analysis	Pretest	Posttest	Pretest	Posttest
Average	98.6	106.6	99.7	101.5
Median	100	109	100	100
Standard Deviation	11.939131	12.9383152	13.149144	13.7295302

Table 18

Reading Efficiency: TOWRE Standard Scores for Phonemic Decoding Efficient and Sight Word Efficient

Test	Phonemic Decoding Efficient				Sight Word Efficient			
Group	Tomatis		Control		Tomatis		Control	
Participants	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
1	132	130	117.5	97	130	123	99	88
2	77	72	85	86	62	72	86	83
3	83	86	118	130	79	85	102	120
4	88	111	104	102	80	111	95	100
5	94	95	106	100	93	97	102	93
6	93	122	110	98	82	118	116	112
7	127	123	118	101	111	113	113	108
8	107	96	93	89	96	95	94	92
9	105	106	105	105	98	106	87	95
10	119	134	141	135	116	115	121	130
11	92	94			104	109		
12	78	91			88	88		
13	111	103			113	114		
14	93	92			89	95		
15	103	103			109	115		

Standard Score (SS) is based on a mean of 100 and a standard deviation of 15

Table 19

Reading Efficiency: TOWRE Descriptive Statistical Analysis

Test	Phonemic Decoding Efficient				Sight Word Efficient			
	Tomatis		Control		Tomatis		Control	
Univariate Analysis	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Average	100.13	103.87	109.75	104.3	96.67	103.73	101.5	102.1
Median	94	103	108	100.5	96	109	100.5	97.5
Standard Deviation	16.82	17.37	14.61	15.17	17.56	14.41	11.31	14.26

Table 20

Behavioral Observation: BASC-II Standard Scores for Attention Problems and Behavioral Symptoms Index

Test	Attention Problems				Behavioral Symptoms Index			
Group	Tomatis		Control		Tomatis		Control	
Participants	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
1	67	59	61	61	65	55	68	69
2	73	73	61	64	56	57	56	60
3	63	53	69	69	54	54	82	72
4	69	56	64	61	62	50	67	61
5	60	61	73	68	56	56	81	77
6	74	61	66	66	66	59	85	83
7	55	51	72	72	41	41	61	61
8	69	67	71	66	61	52	76	76
9	61	59	72	67	68	55	61	60
10	67	67	51	51	56	53	51	51
11	61	48			58	42		
12	73	73			70	66		
13	66	58			65	57		
14	77	59			76	61		
15	63	60			71	67		

Note: t scores (TS) 60 and above are in the “at risk” range and scores 70 and above are in the “clinical range.”

Table 21

Behavioral Observation: BASC-II Descriptive Statistical Analysis

Test	Attention Problems				Behavioral Symptoms Index			
	Tomatis		Control		Tomatis		Control	
Univariate Analysis	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Average	66.53	60.33	66	64.5	61.67	55	68.8	67
Median	67	59	67.5	66	62	55	67.5	65
Standard Deviation	6.12	7.24	6.94	5.84	8.62	7.22	11.75	9.96

Table 22

Attention: IVA-Plus Standard Scores for Full-Scale Attention and Auditory Attention

Test	Full-Scale Attention				Auditory Attention			
Group	Tomatis		Control		Tomatis		Control	
Participants	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
1	91	76	85	70	88	88	86	63
2	72	78	53	77	54	67	72	87
3	103	105	89	52	92	111	91	46
4	67	82	97	99	68	84	110	109
5	105	108	106	56	104	102	101	52
6	111	126	121	48	117	127	120	46
7	104	96	87	74	107	95	88	80
8	90	78	93	95	84	62	90	88
9	82	86	91	73	64	77	94	81
10	114	100	117	124	112	102	124	123
11	103	111			97	103		
12	86	70			82	62		
13	104	109			95	105		
14	63	83			58	76		
15	82	96			79	78		

Note: Standard Score (SS) is based on a mean of 100 and a standard deviation of 15

Table 23

Attention: IVA-Plus Descriptive Statistical Analysis for Full-Scale Attention and Auditory Attention

Test	Full-scale Attention				Auditory Attention			
	Tomatis		Control		Tomatis		Control	
Univariate Analysis	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
Average	91.8	93.6	93.9	76.8	86.73	89.27	97.6	77.5
Median	91	96	92	73.5	88	88	92.5	80.5
Standard Deviation	16.15	16.12	19.02	23.56	19.5	19.19	16.19	26.09

Table 24

Attention: IVA-Plus Standard Scores for Visual Attention

Group	Tomatis		Control	
Participants	Pretest	Posttest	Pretest	Posttest
1	95	72	86	81
2	91	89	48	74
3	112	98	89	69
4	75	85	86	90
5	106	113	109	67
6	104	123	116	64
7	99	98	88	72
8	99	98	99	102
9	104	97	90	71
10	112	99	108	120
11	108	116		
12	92	81		
13	113	111		
14	78	94		
15	89	112		

Note: Standard Score (SS) is based on a mean of 100 and a standard deviation of 15

Table 25

Attention: IVA-Plus Descriptive Statistical Analysis for Visual Attention

	Tomatis		Control	
Univariate Analysis	Pretest	Posttest	Pretest	Posttest
Average	98.47	99.07	91.9	81
Median	99	98	89.5	73
Standard Deviation	11.82	14.03	18.88	17.96

Appendix E

Individual EEG Analysis

Table 26

Tomatis Group Individual EEG Analysis

Participant	Peak Alpha Frequency		ADD Subgroup		Z Scored FFT Theta/Beta Ratio, SD		Age	Gender
	Pre	Post	Pre	Post	Pre	Post		
1	FZ = 9.35 CZ = 9.41 PZ = 9.45	FZ = 9.37 CZ = 9.46 PZ = 9.40	2 or 3	2 or 3	Normal	Normal	8.11	M
2	FZ = 9.32 CZ = 9.33 PZ = 9.30	FZ = 9.40 CZ = 9.29 PZ = 9.39	3	3	Normal (-1.75 Central, Frontal)	Normal	12.1	F
3	FZ = 9.40 CZ = 9.45 PZ = 9.64	FZ = 9.35 CZ = 9.54 PZ = 9.82	3	Improved in Beta	Normal	Normal	9.5	M
4	FZ = 9.36 CZ = 9.41 PZ = 9.46	FZ = 9.33 CZ = 9.37 PZ = 9.37	2	2 and some 3	Normal	Normal	9.3	M
5	FZ = 9.35 CZ = 9.44 PZ = 9.37	FZ = 9.49 CZ = 9.51 PZ = 9.33	3	3	Normal (– 1 Central, Frontal)	Normal	11.4	F
6	FZ = 9.60 CZ = 9.76 PZ = 9.88	FZ = 9.75 CZ = 9.84 PZ = 9.96	2	2	Normal	Normal	11.8	F
7	FZ = 9.52 CZ = 9.58 PZ = 9.62	FZ = 9.46 CZ = 9.66 PZ = 9.73	3	3	Normal	Normal	12.8	M
8	FZ = 9.33 CZ = 9.56 PZ = 9.86	FZ = 9.34 CZ = 9.44 PZ = 9.61	3	3 and some 2	(-2.5 Parietal, Occipital)	(-2.5 Occipital)	12.3	M
9	FZ = 9.44 CZ = 9.51 PZ = 9.49	FZ = 9.46 CZ = 9.48 PZ = 9.47	2		Normal (+ 1.5 Frontal)	Normal (-1.25 CZ,PZ)	11.11	M
10	FZ = 9.53 CZ = 9.75 PZ = 9.94	FZ = 9.35 CZ = 9.70 PZ = 9.87	3 and some 4	3 and some 4	Normal (– 1 Parietal, Central)	Normal	10.8	F
11	FZ = 9.15 CZ = 8.91 PZ = 8.97	FZ = 9.21 CZ = 8.93 PZ = 9.00	1	1	Normal (-1 at PZ)	Normal (+1.25 Parietal)	8.9	F
12	FZ = 9.03 CZ = 8.99 PZ = 9.06	FZ = 9.23 CZ = 9.00 PZ = 9.15	3	Overall improvement	Normal	Normal	7.7	M
13	FZ = 9.35 CZ = 9.56 PZ = 9.72	FZ = 9.35 CZ = 9.56 PZ = 9.74	3	3 Less post beta	(-2 Posterior – 1.75 PZ, CZ)	Normal (-1.25 Occipital)	12.9	F
14	FZ = 9.43 CZ = 9.43 PZ = 9.55	FZ = 9.53 CZ = 9.39 PZ = 9.40	No ADD	No ADD	Normal	Normal	8.9	F
15	FZ = 9.84 CZ = 9.81	FZ = 9.66 CZ = 9.58	3	3 Improvement	Normal (–1.75 CZ)	Normal (-1 CZ)	9.1	M

	PZ = 9.63	PZ = 9.48		Post Beta				

Table 27

Non-Tomatis Group Individual EEG Analysis

Participant	Peak Alpha Frequency		ADD Subgroup		Z Scored FFT Theta/Beta Ratio, SD		Age	Gender
	Pre	Post	Pre	Post	Pre	Post		
1	FZ = 9.25 CZ = 9.67 PZ = 9.71	FZ = 9.51 CZ = 9.72 PZ = 9.63	3	3	(-1.75 Central, -2.75 Temporal)	Normal	10.4	M
2	FZ = 9.31 CZ = 9.40 PZ = 9.43	FZ = 9.31 CZ = 9.40 PZ = 9.47	3	3	Normal (-1.75 Posterior)	Normal (-1 Parietal)	9.1	M
3	FZ = 9.47 CZ = 9.34 PZ = 9.27	FZ = 9.21 CZ = 9.15 PZ = 9.21	3	3	Normal	Normal	9.0	M
4	FZ = 9.42 CZ = 9.36 PZ = 9.46	FZ = 9.50 CZ = 9.59 PZ = 9.67	3	3	Normal	Normal (-1 CZ, PZ, FZ)	13.7	M
5	FZ = 9.66 CZ = 9.68 PZ = 9.86	FZ = 9.45 CZ = 9.46 PZ = 9.57	3	3	(-2 PZ, CZ)	(-2 PZ, CZ)	13.1	M
6	FZ = 9.88 CZ = 10.09 PZ = 9.88	FZ = 9.44 CZ = 9.93 PZ = 9.48	NO ADD	NO ADD	Normal (-1 CZ)	Normal	12.8	M
7	FZ = 9.35 CZ = 9.32 PZ = 9.50	FZ = 9.32 CZ = 9.16 PZ = 9.27	NO ADD	NO ADD	Normal	Normal	9.0	F
8	FZ = 9.61 CZ = 9.58 PZ = 9.67	FZ = 9.56 CZ = 9.69 PZ = 9.70	3	3	(-2 Temporal)	(-2 Central, Temporal)	12.1	M
9	FZ = 9.26 CZ = 9.20 PZ = 9.29	FZ = 9.30 CZ = 9.05 PZ = 9.06	3	3	Normal (-1 Frontal)	Normal	8.7	M
10	FZ = 9.30 CZ = 9.29 PZ = 9.30	FZ = 9.52 CZ = 9.46 PZ = 9.27	3	3	Normal (-1 CZ)	Normal	10.11	M