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A STUDY ON THE EFFECTS OF THERAPEUTIC LISTENING ON THE SOCIAL AND FUNCTIONAL BEHAVIOR OF PRESCHOOL CHILDREN WITH AUTISM SPECTRUM DISORDER

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Occupational Therapy at Virginia Commonwealth University

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Abstract

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Auditory sensory differences and sensitivities are often mentioned by parents of children with Autism Spectrum Disorder (ASD), and in research involving children with ASD. Addressing these auditory processing differences is the goal of various auditory treatment techniques, but current research does not yield a body of evidence in support of auditory therapy as a treatment for children with ASD. This study is a single-subject study, repeated across two subjects, to investigate the effect of the Therapeutic Listening program on the social engagement and self-care skills of preschool-aged children with ASD. Both social engagement and self-care skills increased with for both subjects in this study. Also, parental stress associated with the mothers' relationship to their child with ASD decreased. These outcomes indicate the Therapeutic Listening program can be a useful modality in the treatment of children with ASD; one that may improve the communication and function of the child and create an environment within the family that decreases maternal stress.

Chapter 1: Introduction

According to the DSM-IV-TR, features of Autism Spectrum Disorders (ASDs) fall into three categories; qualitative impairments in social interaction, qualitative impairments in communication, and restrictive or repetitive interests and activities and/or stereotypic behavior patterns (APA, 2000). These problems with communication, social interaction and behavior can impact a child with ASD's ability to remain engaged in activities of daily living, such as self-care, learning and play. Some therapists and clinicians link this lack of engagement, in part, to auditory processing differences in children with ASD (Russo, Zecker, Trommer, Chen, & Kraus, 2009; Dunn, Gomes, & Gravel, 2007; Alacantara, Weisblatt, Moore, & Bolton, 2004; Boddaert, Chabane, Belin, et al., 2004; Seigal & Blades, 2003). Because practitioners recognize that auditory processing affects the behavior and function of children with ASD (Dunn, Gomes, & Gravel, 2008; Bigler, Mortensen, Neeley, et al., 2007; Groen, Orsouw, Huurne, et al., 2009; Boddaert et al., 2004), a variety of auditory stimulation techniques are used clinically to attempt to address the problem of auditory processing difficulties (Sinha, Silove, Wheeler, & Williams, 2006; Thompson & Andrews, 2000). Unfortunately there is limited scientific evidence regarding whether these individual methods are effective in increasing daily function of children with ASD (Sinha et al, 2006; Dawson & Watling, 2000; American Academy of Pediatrics, 1998). This study provides information on the effects of a structured auditory sensory-stimulation program on the social and functional behavior of two preschool age children with ASD.

Autism and Auditory Processing

"Today, it is estimated that one in every 110 children is diagnosed with autism, making it more common than childhood cancer, juvenile diabetes and pediatric AIDS combined. An estimated 1.5 million individuals in the U.S. and tens of millions worldwide are affected by autism. Government statistics suggest the prevalence rate of autism is increasing 10-17 percent annually" (AutismSpeaks, 2011). ASDs include: Autism, Asperger's Syndrome, Pervasive Developmental Disorder (PDD), Childhood Disintegrative Disorder and Rett Syndrome (National Institute of Child Health and Human Services, 2009).

The DSM-IV-TR outlines 12 symptoms of ASD (the child having to present with at least six of them for diagnosis) clustered into three categories: impairments in socialization, impairments in reciprocal communication, and restrictive or repetitive behavior patterns (APA, 2000). In their landmark summary of autism screening and diagnosis, Filipek, et al. (1999) expanded on the DSM criteria, citing specific behaviors clinicians might encounter. Examples included: problems maintaining joint attention and social engagement, communication deficits, most notably language comprehension and expression deficits, lack of spontaneous and imaginative play, and strong adherence to specific non-functional routines. In addition to this list of behavioral hallmarks of ASD, researchers are currently exploring the difficulty children with ASD have in shifting attention (Watson, Patten, Baranek, Poe, Boyd, Frueler, & Lorenzi, in press; Van Hecke, Lamb, Lebow, et al., 2009; Landry & Bryson, 2004) and lack of orientation to social stimuli (e.g. hand clapping and name calling) versus non-social stimuli (e.g. musical toys and doorbells) (Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998).

It has been theorized that children with ASD have sensory processing problems. "[T]he child with autism shows many of the symptoms of poor sensory processing that are seen in other

children with sensory integrative problems…" (Ayres, 1977/2005, p. 127). Children with ASD demonstrate patterns of not attending to certain stimuli, and/or over-reacting or under-reacting to stimuli (Watson et al., in press; Liss, Saulnier, Fein, & Kinsbourne, 2006, Landry & Bryson, 2004; Wainwright & Bryson, 1996). Therefore their behavioral responses to sensation are not typical. An exceptional percentage of the population of children with ASD have some form of sensory processing problems, auditory filtering problems represent a significant proportion of these sensory processing difficulties (Hitoglou, Ververi, Antoniadis, & Zafeiriou, 2010, Chang, 2009; Ashburner, Ziviani, & Rodger, 2008; Tomchek & Dunn, 2007, Adamson, O'Hare, & Graham, 2006). Minshew and Williams (2007) and Tecchio, Benassi, Zappasodi, et al. (2003) theorize that a child with ASD may not associate a stimulus with a previous experience; in essence, every experience is brand new to the child. This may affect their auditory processing, not allowing them to recognize changes in vocal pitch and timing that communicate verbal meaning, or to associate facial expression with vocal tone, thus inhibiting language development (Siegal & Blades, 2003; Ceponiene, Lepisto, Shestakova, et al., 2003).

Recent research has strongly highlighted the differences in auditory processing in people with ASD. Studies have indicated that children with ASD have auditory sensitivity and filtering problems (Russo, Zecker, Trommer, Chen, & Kraus, 2009; Adamson, O'Hare & Graham, 2006; Alcantara, Weisblatt, Moore, & Bolton, 2004) and trouble with auditory discrimination of sounds (Dunn, Gomes, & Gravel, 2007, Ceponiene et al., 2003). There is evidence of differences in the neurological processing of sound. A recent study indicated, through magnetic resonance imaging, that children with ASD have activation of the language centers in the frontal and temporal regions when listening to music, but not as much when stimulated by speech, when compared to neurotypical controls (Lai, 2010). Other studies suggest that children with ASD use

atypical parts of their brains to process sounds (Hitoglou, Ververi, Antoniadis, & Zafeiriou, 2010; Bigler et al. 2007, Boddeart et al., 2004). Children with ASD may also experience differences in the timing of processing of sounds, making speech difficult to understand (Groen et al., 2009). These auditory difficulties may affect their ability to communicate effectively and process auditory social cues, such as tone of voice, pragmatics, and emotional emphasis.

In the 1950s, Dr. Alfred Tomatis, a French otolaryngologist, began using electronically modulated sound to rehabilitate the ear and the voice while working with two distinct groups; opera singers who had lost their ability to produce certain tones, and factory workers who had lost their hearing in some frequency ranges (Thompson & Andrews, 2000; Madaule, 1993). His view of the auditory system suggested that the ear could be exercised to hear better (Thompson & Andrews, 2000). In the years since, there have been theories proposed regarding listening as an active event that contributes significantly to brain development, not just something to which one is exposed. From Tomatis's theories and work, several music- and sound- based auditory treatment programs have developed in an attempt to treat the auditory processing deficits in people with a variety of psychological and physical diagnoses, including ASD (Frick & Young, 2009; Thompson & Andrews, 2000; Steinbach, 1994; Madaule, 1993).

Some auditory treatment methods are delivered using specialized equipment in a clinical setting (such as Auditory Integration Training® (AIT)) and other treatments are delivered via specially-engineered compact-discs that can be listened to through high-quality headphones in the home (such as Therapeutic Listening® (TL)).

Each program attempts to address deficits in environmental awareness, body awareness and communication by providing stimulation to the physical and neurological structures of the ear. Theoretically, this enhances sound awareness to affect environmental awareness; sound

discrimination and sound processing to improve speech processing; and alertness and modulation of brain activity to increased body awareness. These techniques use electronically-filtered sounds and music to emphasize various frequencies and encourage the muscles of the ear to control the dampening mechanisms to better receive the sound. In theory, this is believed to: attune physical and neurological structures of the ear and brain to frequencies and harmonics that have been disregarded (e.g. one who does not attend to another person's vocal pitch), desensitize the ear to frequencies one finds unbearable (e.g. one who has auditory defensiveness), and/or to increase the ear and brain's awareness of sound localization, thus increasing one's environmental awareness (Frick & Young, 2009; Thompson & Andrews, 2000; Madaule, 1993).

Research has been done since 2008 by Dr. Stephen Porges and colleagues at the University of Illinois Chicago and the University of Maryland involving the effect of electronically modulated sound on the nervous system and communication in children with autism. His explanation, as posted on the website for The Listening Project, most succinctly illustrates the theory of the effect of sound therapy on communication skills:

> "First, the area of the brainstem that regulates the heart … also regulates the muscles of the head including those of the face, middle ear, mouth, larynx, and pharynx. When we studied the general function of these muscles, we realized that collectively these muscles provide an integrated ***Social Engagement System*** that controls looking, listening, vocalizing, and facial gesturing…Second, the middle ear muscles play an important role in extracting human voice from our complex acoustic environment. When the neural tone to the middle ear muscles is low, the middle ear structures do not actively filter out the low frequency sounds that dominate the acoustic environment of our modern industrial world and do not amplify the frequencies associated with human voice. This difficulty in "listening" to human voice might occur even in an individual who has normal "hearing" (i.e., normal function of the cochlea, the auditory nerve, and the brain areas processing acoustic information). Third, the neural regulation of the middle ear muscles is linked to the neural regulation of the other muscles of the face, which control facial expression and vocal intonation. Thus, stimulation improving neural regulation of the middle ear muscles should integrate and stimulate the neural regulation of facial expression, looking, listening, and vocalizing" (Porges, 2010).

While Porges eloquently outlines the purported effect of auditory therapy on communication and social skills, the effect of sound on physical coordination, sequencing and functional skills is less well-understood. Frick (2009) postulates that attuning the ear through sound therapy allows: a child to be more firmly aware of their position in space and because the vestibular system has been alerted by lower frequency sound; an increased awareness of a child's spatiotemporal environment because of better understanding of how sound waves reflect off nearby surfaces; and an improved orienting response-- a combination of sensing, locating and attending to salient features of the environment. All of these effects may be a result of auditory intervention and may allow an increase in functional participation in a child's daily environment.

Statement of the Problem

AIT has been studied most prolifically, but reviews of its effectiveness as a treatment for ASD have been unsupportive (Sinha et al., 2006; Dawson & Watling, 2000; American Academy of Pediatrics, 1998). AIT can be grouped with other auditory treatment methods based on the same theoretical ear- and brain-development principles; however, there are significant differences between it and other forms of auditory intervention. Most notably, AIT and TL (the treatment format to be used in this study) vary in treatment duration, method of treatment delivery (and therefore ease of use, as TL is a home-based treatment), and program structure (TL being adaptable to the needs of the child). These differences in treatment methods warrant further research into the possibility of their effectiveness as treatment for ASD in children.

In their 2004 paper on Autism and PDD, noted autism experts Volkmar, Lord, Bailey, Schultz, and Klin stated that, "[a] major concern is the large, and possibly growing, gap between what science can show us is effective, on one hand, and what treatments parents will actually

pursue" (p.21). Tomatis experts Thompson and Andrews (2000) state that, "[since] Dr. Tomatis opened this field in the mid 20th century, no fewer than a dozen offshoot and related systems of training have been developed. Though each new system of treatment makes claims of effectiveness, no research exists to substantiate their claims… Research is desperately needed in this area" (p.174). Advised by clinicians, parents continue to pursue auditory treatment methods, evidenced by the fact that over 10,000 practitioners have received training in one method alone, TL (Frick & Young, 2009, back cover).

Purpose of the Study

The purpose of this study was to begin to address the dearth of research on a popular auditory-processing treatment for children with ASD, Therapeutic Listening® (TL). This study examined the effects of the TL program of auditory treatment on the social behavior and daily routine participation of preschool-aged children with ASD.

Chapter 2: Literature Review

While there is still some disagreement regarding the number of children in the United States with ASD, there is considerable evidence that ASD is impacting the lives of more and more families in this country (Kogan, Strickland, Blumberg, Singh, Perrin, & van Dyck, 2008). The behaviors of children with ASD can clearly impact the functioning of a child and have considerable effect on the functioning of the child's family unit (Davis & Carter, 2008; Hastings, Kovshoff, Ward, Espinosa, Brown & Remington, 2006; Lecavalier, Leone, & Wiltz, 2006).

Some behaviors associated with ASD can take a toll on family dynamics and increase stress for parents (Diamant, 2011; Bagby, 2009; Davis & Carter, 2008; Lecavalier, Leone, & Wiltz, 2006). Such behaviors include inappropriate eye contact (either avoidance of or excessively seeking eye contact), lack of reciprocation in play, problems with expressive or receptive communication (both verbal and non-verbal), inappropriate use of toys, excessive adherence to routine (throwing temper tantrums if deviation from routine occurs), and repetitive physical movements (such as hand-flapping or rocking). Others patterns of behavior that impact the child's function and role within their family have also been identified. These include lack of orientation to social cues (Dawson et al., 1998), lack of orientation to familiar voices, such as a mother's (Van Hecke et al., 2009), and overfocused attention (Boyd, McBee, Holtzclaw, Baranek, & Bodfish, 2009; Liss, Saulnier, Fein, & Kinsbourne, 2006, Landry & Bryson 2004).

Many of the behaviors exhibited by children with ASD may relate to how those children process sensory input. Children with ASD often over-react to touch, sound, or movement

(Adamson, O'Hare, & Graham, 2006). Some selectively focus on certain stimuli to the exclusion of the world around them; for example, spinning an item on a tabletop repeatedly to focus on the visual stimulation as opposed to attempting to figure out the appropriate use of that item (Liss, Saulnier, Fein, & Kinsbourne, 2006, Landry & Bryson 2004). These sensory proclivities can often impair the social, self-care and play behaviors of children affected by ASD (Ashburner, Ziviani, & Rodger, 2008; Bar-Shalita, Vatine, & Parush, 2008). Correlations have been found in children with ASD (n=28) between auditory filtering and attention to cognitive tasks, indicating that learning through play can be impaired by poor auditory filtering (Ashburner, Ziviani, & Rodger, 2008). Other researchers have drawn conclusions relating to auditory sensory impairment and cognitive and language development (Russo et al, 2009; Ceponiene et al, 2003).

Auditory Treatment: A Review of the Literature

Some of the behaviors exhibited by children with ASD appear to be related to those children's sensory function, and these differences in sensory processing can affect development. In fact, Siegal and Blades (2003) state that "specific impairments can give rise to a number of 'downstream' developmental effects that might appear as more general deficits. "In our view, one key gatekeeper for later development involves the auditory processing through which children normally encounter language" (p.387). With so many indicators of differences in auditory processing among children with ASD, it is evident why practitioners have turned to treatment of the auditory system as a treatment for ASD.

In his treatment of people with hearing loss and vocalization problems, auditory-treatment pioneer Dr. Alfred Tomatis, developed two maxims regarding the rehabilitation of the ear and voice: one can only reproduce vocally what one is capable of hearing, and one can develop additional listening skills through participation in auditory activities that enhance the

ear's ability to select certain frequencies of sound (Thompson & Andrews, 2000). His view of the auditory system indicated that the cochlea and vestibule received vibration though bone conduction in the skull, and the muscles and ligaments of the middle ear were designed, not to conduct sound waves, but to disperse the force in the endolymph of the cochlea and vestibule. The stapedius and tensor tympani muscles in the middle ear attenuate the vibrations of the bones that conduct sound in the middle ear to allow the ear to focus or enhance a desired frequency by dampening reception of undesired frequencies. This mechanism may explain our ability to hear the voice of a familiar person in a noisy room. In essence, the ear could be exercised to hear better (Thompson & Andrews, 2000).

Four methods of auditory treatment are mentioned in the scientific literature: Auditory Integration Training® (AIT), The Tomatis Method®, Therapeutic Listening® (TL), and the Listening Program® (TLP). Another available form of auditory treatment from Integrated Listening Systems® is based on the same principles as the four methods listed previously, but has not been subjected to peer-reviewed scrutiny; the only studies available for review are published on the website for Integrated Listening Systems. A few of the differences in these methods are highlighted in Table 1 and include home-based versus clinically-based treatment, duration of intervention, and the potential use of bone-conduction of sound. These methods use CD- or computer-recorded music that has been electronically filtered to stimulate elements of middle ear muscle development (e.g., attenuation of the tensor tympani muscle to better filter background noise) or increase in speed of processing. Clinicians who use certain auditory treatment methods are also instructed in addressing the qualities inherent in the music as tools to enhance the listener's auditory awareness, e.g. rhythm and emotional tone, to entrain the listener's ear for these things in speech (Frick & Young, 2009). For example, in training for TL,

Table 1

Brief Comparison of Prominent Auditory Treatment Techniques

Method	Mode of Delivery	Frequency of Treatment	Duration of Treatment
Tomatis	Performed in clinic using electronically modified music and sounds delivered through headphones, and incorporating microphones for vocal feedback. May involve bone-conducted sound.	Two hours each day.	Progressive blocks of 10 to 15 days, each block incorporating a new element of the program, for a total of 40-60 days.
Auditory Integration Training® (AIT)	Performed in clinic using electronically modified music and sounds delivered through headphones. May involve bone-conducted sound.	Twice a day for 30 minutes each session.	10-20 days.
The Listening Program® (TLP)	Home-based treatment of electronically-modified music delivered via CD or MP3 player; music choice guided by trained therapist. May involve bone-conducted sound.	One to two times per day (15-30 minute sessions) for five days, followed by a two-day break.	Duration of treatment decided by trained therapist, based on individual case and in collaboration with client.
Therapeutic Listening® (TL)	Home-based treatment of electronically-modified music delivered via CD; music choice guided by trained therapist. Does not involve bone-conducted sound.	Twice a day for 20-30 minutes each session. Sessions separated by at least three hours.	Duration of treatment decided by trained therapist, based on individual case and in collaboration with client. A typical duration of treatment is between two and six months.

the call-and-response motif of a Mozart sonata is suggested to enhance back-and-forth interaction during conversation; the emotionality of a simple song with lyrics may strengthen the meaning of the words for the listener.

Auditory Integration Training® (AIT) has been involved in a sufficient number of studies such that two reviews of AIT's effectiveness have been published (Sinha, Silove, Wheeler, & Williams, 2009; Dawson & Watling, 2000). In neither of these reviews were the authors able to

conclude that AIT is an effective method of treatment for children with ASD. Further, Sinha et al. cited concerns regarding the substantial costs of AIT to families of children with ASD (around $2000). The American Academy of Pediatrics (1998) has also concluded that AIT has not been shown to be effective as a treatment for ASD and should be used in research protocols only until its effectiveness could be established.

In the six randomized-controlled clinical trials examined by Sinha et al., each used the ten-day protocol of AIT treatment, but a variety of outcome measures; from measures of behavior (e.g., Aberrant Behavior Checklist), to measures of listening response (e.g. Fisher Auditory Processing Checklist). Thus meta analysis was not possible. Three of the six studies reviewed demonstrated improvements on the same measure, the Aberrant Behavior Checklist, but the review's authors point out that the Aberrant Behavior Checklist is of questionable validity. None of the other various measures used indicated consistent positive results of AIT. The authors concluded that there is not sufficient evidence to support the use of AIT.

Children with ASD vary greatly in the presentation and severity of symptoms and it is likely that they would best benefit from intervention tailored more specifically to their needs. It is possible that the conceptual foundation upon which AIT is based is valid; that audition is central to brain development, that children with ASD have auditory problems that can be addressed, and that electronically modified music is a potential treatment for those problems. However, the method of delivery of auditory intervention may make the intervention ineffective for some children. For instance, one might question the ten-day protocol, asking if such a short duration of treatment can create the neural changes necessary for sensory and behavior change. In addition to examining duration, there may be a need for an auditory intervention that is fluid to allow adjustment to the child's needs.

A study of the Tomatis method involved a much longer treatment duration than AIT (90 days), but the results only encompassed changes in language, not behavior. Children with ASD (n=11) were enrolled in a randomized, double-blind, cross-over comparing the effects of the Tomatis method versus a music placebo on receptive and expressive language (Corbett, Shickman, & Ferrer, 2007). No improvement in either area was noted following treatment; potential behavioral changes were not addressed. The authors raise the possibility that the small sample size may have contributed to the lack of difference between the groups. They also indicate that, although the groups were randomly assigned, the treatment group did have lower cognitive scores at baseline.

Occupational therapists (OTs) have been treating children with sensory processing issues, including children with ASD, for many years (Ayres, 1977/2005; Bundy & Murray, 2002). While OTs may choose a variety of treatment approaches to help increase the functional abilities of children with ASD, common approaches include sensorimotor, sensory stimulation and sensory integration therapy. Only recently has the attention of the OT community turned to the addition of auditory stimulation as part of a sensory-based program. Dawson and Watling's 2000 review of auditory, visual and motor treatment interventions in autism cites only AIT as an auditory treatment, reaching the same conclusion as Sinha et al; that the research on AIT is not supportive of the use of AIT as a treatment for ASD in children. Case-Smith and Arbesman (2008) mention auditory treatment in their review of interventions for autism of relevance to OT; citing the inconclusive research on AIT, and the lack of research regarding TL.

The Listening Program is an auditory intervention that, like TL, is delivered in the child's natural environment through CD-based music and headphones. Although similar to TL, a notable difference is the fluidity of the TL program, as opposed to the pre-designated protocol of The

Listening Program. A case study involving the use of the Listening Program© in the treatment of a five-year-old boy with PDD-NOS (Nwora & Gee, 2009) reported the subject had improvements in behavior and sensory problems, most notably in tolerance and appropriate response to sound. After a 20-week, home-administered program, improvements were noted on the non-norm-referenced Listening Checklist, and the norm-referenced Sensory Profile (Dunn, 1999), in the areas of auditory, touch and oral-sensory processing. Case studies do not rise to the level of rigor and control as do RCT designed studies, and the results of this study are best viewed as tentative. Further, it is recognized that results of case-studies are not intended to be generalizable.

TL, as developed by Frick, was intended as an auditory therapy technique for use in a wider program of sensory integration or sensory stimulation, not necessarily as a free-standing treatment in and of itself, although it can be used without other sensory interventions (Frick 2002; Frick & Young, 2009). A case report of an 18-year-old student with ASD who, although non-verbal, communicated through a keyboard to tell of his sensory experiences and limitations, provides an example of TL as part of a comprehensive treatment program for ASD (Shoerner, Kinnealey, & Koenig, 2008). Although his program of intervention was vast and extensive in duration (over four years), his gains in functional skills and physical skills, and decreases in sensory sensitivity, may be attributed to a sensory based treatment program, of which TL was a part.

Another example of TL in the literature is the 2007 study of 10 children with sensory processing problems and visual motor delays (Hall & Case-Smith, 2007). An AB study design was applied; phase A being a four-week "sensory diet", a program of sensory-based interventions on a specific schedule, and phase B being the addition of TL to the sensory diet for

another eight weeks. The results indicated that children who participated in the program had increases in visual-motor skills and significant decreases in sensory problems as measured by the Sensory Profile (Dunn, 1999). Although this study did not involve children with ASD, children with ASD often have sensory problems (Tomchek & Dunn, 2007) and coordination difficulties (Dzuik, Larson, Aposta, Mahone, Denckla, & Mostofsky, 2007). It is feasible, therefore, that children with ASD who have sensory and coordination difficulties may receive the same benefits from TL treatment.

In the most-recently published study on TL, fifteen pre-school-aged children participated in a program of school-based TL in a pretest-posttest design that resulted in language, social skills, and motor skills (Bayzk, Cimino, Hayes, Goodman, & Farrell, 2011). The children were also receiving various other, school-based therapies and received TL one to two times per day, for 6 weeks to five months (depending on the needs of the child). The children had significant increases in performance on the following measures: Peabody Developmental Motor Scales-2nd edition (Folio & Fewell, 2000), Draw-a-Person (Naglieri, 1988), Developmental Test of Visual Motor Integration (Beery & Buktenica, 1997), the Social Skills Rating System (Gresham & Elliot, 1990), and the Preschool Language Scale-3 (Zimmerman, Steiner, & Pond, 1991). This study is relevant to the current study in that the population is similar in age, but the Bayzk study involved children of varying diagnoses (four participants had ASD).

There remains to be a study published on the use of TL involving children with ASD only. With as many as 10,000 therapists trained in the use of TL (Frick & Young, 2009, back cover), there are potentially thousands of children with ASD being treated with TL right now. Some verification of the effectiveness and benefits of this treatment, if any, will help

practitioners and parents make a more informed decision regarding TL as a potential treatment for a child with ASD.

The literature on various auditory interventions (summarized in Table 2) lacks consistency in measures, subjects studied and approaches to auditory treatment that limits comparisons. On the whole the mixture of positive results, but lack of consistent change indicate that further research is warranted. While AIT may be the most documented approach in the literature, it is the approach of the most limited duration, it is one of two that must be performed in the clinic setting, and it is one of two that does not involve the direct participation of the parents. Therapeutic Listening®, while based on the same principles as AIT, allows for fluidity in approach that can accommodate for the great variety of symptoms and problems in the ASD population and allows the child to be in a comfortable, familiar environment (perhaps facilitating effectiveness of treatment). Those gains seen only minimally in AIT treatment might be increased if these changes are implemented through Therapeutic Listening®. Table 2, below, summarizes the available literature and highlights the differences between previous studies of auditory treatment programs, and what is proposed in this study.

Table 2

Summary of Auditory Treatment Studies

Author and Date	Study type	Type of intervention	Findings	Problems/Applicability to this Study
Bettison (1996)	RCT, n=80	AIT for treatment group, non-modified music over headphones for control group	Improvement in both groups, no significant between-group differences	Only ten days of treatment. Indicates that auditory input may not need to be electronically modified to be beneficial. Measures obtained 3 and 12 months post-treatment. Wider and older age range of subjects than for proposed study

Table 2 continued

Author and Date	Study type	Type of intervention	Findings	Problems/Applicability to this Study
Edelson, Arin, Bauman, Lukas, Rudy, Sholar, & Rimland (1999)	Double-blind RCT, n=19	AIT for treatment group, non-modified music over headphones for control group	Increases on Aberrant Behavior Checklist. Participants' caregivers indicated increases in social skills and comprehension	10-20 days of treatment, in clinical setting, wider and older age range of subjects than for proposed study.
Mudford, Cross, Breen, & Cullen (2000)	Cross-over experimental design, n=16	AIT for treatment group, non-functional headphones with music via speakers for control condition	Results did not indicate change in any measure for either group	Short (10-day) treatment time, crossover design may have confused subjects. Wider and older age range of subjects than for proposed study.
Corbett, Shickman, and Ferrer (2008)	Crossover RCT, n=11	Tomatis Method®	No significant difference between treatment and control group in language skills	Tomatis therapy consists of blocks of treatment, total of 45 days of treatment. Outcomes only included language skills.
Nwora and Gee (2009)	Single case-study, AB design	The Listening Program® (TLP)	Significant improvement in sensory processing, receptive/expressive listening and language, motor skills, and behavioral adjustment	TLP is very similar to program to be used in this study. Longer treatment length (20 weeks). Subject is child with ASD.
Hall and Case-Smith (2007)	Non-parallel, Repeated single-subject, ABC design, n=10	Sensory Diet for four weeks, the addition of Therapeutic Listening® (TL) for eight weeks.	Significant improvement in auditory processing and behaviors associated with sensory processing, handwriting, and visual perception	Used same auditory program to be used in this study (TL). Subjects were older (5 – 10 years old), and were not limited to those with ASD.
Bayzk, Cimino, Hayes, Goodman and Farrell (2011)	Pretest-postest, n=15	TL in addition to on-going therapies for preschool children of varying diagnoses	Increases in visual motor skills, language development, and behavior	Similar age group and intervention as this study, not specific to children with ASD only and of varying length of intervention.

In a commentary in the *Journal of Autism and Developmental Disorders*, Goldstein (2000) claimed that there was no evidence in the literature to support the use of AIT, and therefore is should be abandoned as a treatment for ASD to leave science free to pursue other treatments that might be demonstrated to be effective. A very impassioned response in favor of auditory treatment intervention was authored by auditory treatment and autism experts Edelson, Rimland, and the notable Temple Grandin (2000). It is evident that those who have faith in auditory treatment methods were not prepared to abandon them. However, the need for more information is also clear; specifically, data regarding a method of auditory training that is more consistently effective for children with ASD.

While AIT has been the most prolifically-researched method of auditory treatment, it has not been shown to be effective as a treatment for children with ASD. This study proposes to explore the use of a system of auditory treatment, TL, that is more easily incorporated into the lives of children and families, allows time for neurological change through daily exposure to therapy over longer duration of treatment, and has the flexibility to conform to the needs and behaviors of the children it is intended to treat.

Chapter 3: Methodology

Three subjects were recruited individually from the surrounding community through contact with physician's offices, Early Childhood Intervention Services, and local pediatric therapy clinics. After confirming each child's diagnosis of ASD, the child's mother met with the therapists for pre-intervention testing and an interview to establish treatment goals. The children then participated in 16 weeks of TL, tracked in participation and goal-related performance by their mothers. After 16 weeks, each child participated in post-treatment testing.

Study Design

This study used a single-subject AB research design, repeated across three subjects to increase external validity. Length of baseline data collection varied from one to three weeks. A multiple-baseline design was chosen to help control for threats to internal validity, such as inconsistencies in parents' or therapists' measurements, and to better establish any change as attributable to treatment intervention (Zhan & Ottenbacher, 2001). A multiple baseline design is appropriate when behavior may not return to baseline during a withdrawal period (Backman, Harris, Chisholm, & Monette, 1997), or when withdrawal of treatment is not appropriate (Rapoff & Stark, 2007). A withdrawal ABA design would not have been appropriate due to the assumed cumulative nature of the therapy being used and an uncertainty regarding maintenance of any gains from TL treatment.

Clinical Researcher

Robin Abbott, OTR/L, was the treating therapist for all three children. She has been an occupational therapist for 13 years; working almost exclusively with children for six years. She has been using TL in clinical treatment for five years. She was instructed in administration and structure of the TL program through a three-day course called "Listening with the Whole Body", and a second course entitled "Advanced Listening with the Whole Body". This training is provided by Vital Links, Inc., a company owned by the TL's developers, Ron and Sheila Frick.

Intervention

TL is a compact-disc-based program of electronically-modified music delivered through high-quality headphones in two 30-minute sessions each day. The equipment allows the child to move throughout their environment almost completely unencumbered (see Figure 1). Each CD is chosen for the child for a period of two weeks. This two-week period can be altered based on the child's behavior, their response to previous CDs in the program (if any) and their observed response to the CD chosen for the two-week period. The CD's treatment effect is attributed to the qualities inherent in different types of music (such as tempo and instrument choice), as well as changes in electronic modification of the music.

TL was chosen for a variety of reasons. It is a home-based program, allowing for and encouraging the parents' knowledge of and participation in assessing the program. It is the least expensive, most adaptable auditory intervention program available. It involves the use of perforated headphones that allow the child to continue to interact with their environment and continue their daily activities while receiving therapy. Practitioners who have been trained in TL use the child's behavior and responses to guide the need for certain sounds to be added to their program. It is emphasized in the training that a great deal of the structure of each child's program

Figure 1. TL equipment. This photo displays CD player pouch, Sennheiser 500-A headphones and a sample of CDs (not pictured, a portable, commercially-available CD player). Photo: Robin Abbott

depends on the child's response to the treatment and the therapist's clinical decision-making process. Like any other therapy process, both the client and the therapist have an effect on the course of treatment.

"Therapeutic Listening programs are not formulaic, and cannot be mapped out at the beginning of therapy. Instead, they are more like a dialogue between therapist and client where the programs are based on general guidelines and how the client responds to each CD" (Frick & Young, 2009, p. 129). An example of the flexibility of the TL approach may be the following: a child who has trouble locating sounds around in their immediate environment, as evidenced by being overly-distracted by common environmental sounds or by constant need for verification of sounds (e.g. the child who persistently asks "What was that?" in response to a dog barking outside or the air-conditioning starting up) may respond best to a CD that incorporates sounds recorded binaurally (using dual microphones) in a natural setting, so that variance in sound

proximity and surrounding location can be enhanced. Should the child listen to a CD with these elements (and there are several in the TL library) and respond well (less distractable, etc.) it may be time to work on the next auditory problem, such as attending to verbal directions in a busy environment through a CD that incorporates electronic enhancement of the frequencies of speech, allowing the child's ear greater opportunity to isolate speech frequencies from background sounds within the music. These clinical decisions are discussed at length during the TL training, but like any other therapy technique, the therapist's experience and knowledge will influence clinical decisions that are made.

The lack of specific direction in the TL program is tempered by the suggestions of the program's designers to classify children according to three "profiles", and use the child's profile to suggest treatment options. Frick and Young provide a "map" of CD categories to proceed through in progression of TL treatment for each profile. The profiles are, as outlined by Frick and Young:

- Profile 1: Severe sensory defensiveness or severe regulatory issues, including behaviors such as being dependent on caregiver for basic regulation (such as sleep/wake cycles), poor eye contact, and being challenged by transitions.
- Profile 2: Mild to moderate sensory defensiveness and regulatory or core issues that have subtle impact on function, including behaviors such as reactivity to textures, picky eating, and coordination problems.
- Profile 3: Mild sensory defensiveness and/or subtle regulatory issues that have been compensated for or have resolved, including behaviors such as difficulty organizing space and items, fluctuating emotional tone, and postural activation that lacks coordination and refinement.

Specific treatment length is not suggested in TL training, and the TL program can be stopped and re-started or used periodically for maintenance of gains after the program has been completed (Frick & Young, 2009). This flexibility, while clinically advantageous, means that documented guidelines for treatment are not available during rigorous experimental investigation. Therefore, the two-week-per-CD recommendation was adhered to whenever appropriate and a pre-determined treatment length of 16 weeks was decided. This length of treatment is based on Frick's (2002) statement that treatment can range anywhere from two to six months. This treatment duration allows treatment to be brief, reducing the potential for gains to be attributable to maturation alone (Morgan & Morgan, 2009), while still allowing time for treatment effects to occur.

During the first listening session with a therapist, each child was provided opportunities to adjust to listening to the headphones; a new experience for all three participants. All three children adapted easily to listening within the first session. Parents were trained in use of the TL equipment, the proper environment for listening (i.e., no TV or video game use, but play is allowed), and how to monitor their child during TL sessions.

Parent, child and therapist met weekly to plan the continuation of the program, assess the child's response to the CD chosen and address any issues that arose for the child and their family regarding TL. During these weekly meetings, the children were outfitted with the headphones and engaged in play or daily activities (such as eating lunch), and they were observed by the therapist. If they displayed behaviors that indicated listening to that particular CD was a problem, the CD might be changed or the therapist may suggest something to make listening times more enjoyable for the child (such as playing with a preferred toy without siblings nearby). Parents shared their reflections of whether their child liked the current CD, how he/she was interacting

overall, and volunteered brief verbal assessments of the child's performance on GAS goals. The next CD in the child's sequence may have been tried (if it was due) and the child's response to the new CD was observed.

Subjects

Three children, between the ages of 30 and 54 months at the time treatment began, with a diagnosis of ASD were selected based on convenience. This age range was chosen for multiple reasons.

- Treatment with Therapeutic Listening® is contraindicated before the age of 24 months (Frick & Young, 2009).
- The diagnosis of ASD is most stable if made after the age of 30 months (Chararska, Klin, Paul, and Volkmar, 2007; Turner & Stone, 2007).
- The age range was capped to avoid school-age children and eliminate the possibility of new behavioral treatment methods being introduced in the classroom setting.
- Clinically, the author has noticed the greatest improvement among younger children participating in auditory treatment.

Subjects were recruited through flyers placed in pediatrians' offices, and though word-of-mouth contact with local pediatric nurses, early childhood intervention offices and local outpatient pediatric therapy providers. Criteria for inclusion in the study were:

- Current confirmed diagnosis of ASD (including Autism, Asperger's Syndrome, Rett Syndrome, PDD-NOS and Childhood Disintegrative Disorder) from a psychologist or psychiatrist who has administered the Autism Diagnostic Observation Schedule (ADOS) (Lord, Rutter, DiLavore,and Risi, 1999) or the Autism Diagnostic Interview- Revised (ADI-R) (Lord, Rutter, and LeCoteur, 1994),

- The child's function considered impaired based on a standardized measure of pediatric function, e.g. the Bayley II (Bayley, 2006), Mullen Scales of Early Learning (Mullen, 1995), Vineland Adaptive Behavior Scales (Sparrow, Cicchetti, & Balla, 2005); the child's scores must have fallen below one standard deviation in at least one functional area; such as communication, daily living skills, motor skills or interpersonal relations.
- Parents or caregivers with a clear understanding of the English language and physically capable of carrying out home treatment per therapist's instruction, availability of caregivers and child for therapy sessions weekly.
- Parental/caregiver consent to video-record portions of the child's daily activities for data analysis.

Conditions which excluded children from the study were:

- Comorbid neurological conditions, such as cerebral palsy,
- Comorbid mental health disorders, currently requiring medication of treatment,
- Any condition which would make the child unavailable for regular therapy sessions,
- Plans of the parents to institute any major life change for the child, such as starting pre-school or moving, during the course of the study.
- Per parent report via record log, lack of participation in listening sessions for three consecutive days in two consecutive weeks disqualifies a child from this study. Parents were not made aware of this limitation on participation prior to the study to increase the accuracy of their reporting. They were informed that "lack of consistent use of headphones on the prescribed schedule may disqualify your child from this study".
- Inability of the child to tolerate headphones and Therapeutic Listening® after four separate therapy sessions have been attempted to establish program.

Research Question and Hypotheses

The overall research goal was to understand if Therapeutic Listening® (TL) is effective in increasing the social engagement and participation in activities of daily living (ADL) for children with ASD and its effect on the lives of the children's family. This query was broken into three hypotheses, with specific measures to address each.

Hypothesis 1: Completion of a 16-week program of TL will result in an increase in the occurrence of socially-engaged behaviors.

Three measures were used to measure change in the children's social function; Goal-Attainment Scaling, the Childhood Autism Rating Scale, and the Social Function Subscale of the Pediatric Evaluation of Disability Inventory.

Goal Attainment Scaling.

Goal Attainment Scaling (GAS) is a method of outcome measurement that has been in use in a variety of health settings for many years (McLaren & Rodger, 2003). It allows for goals specific to each patient or client, with a method of measurement that can be applied across subjects (Donnelly & Carswell, 2002). Mailloux, May-Benson, Summers, et al. (2007) found GAS to be an effective method for measuring progress in children with sensory integration disorders, and children with ASD often have similar sensory issues that affect their function.

In a systematic review of GAS in rehabilitation, Hurn, Kneebone, and Cropley (2006) found evidence in support of high congruent validity of GAS methods with other, standardized measures and high inter-rater and test-retest reliability of GAS methods. Mailloux et al. (2007) reflected the value of GAS to the families of children; the families felt as though their specific needs were being addressed. Despite the idiosyncratic nature of GAS goals, King et al. (2000) found a significant strength of GAS to be its sensitivity to change in performance.

King et al. (2000) state the drawbacks of GAS to be goal bias (goals set to be easily achievable) and rater bias (crediting the subject with a better performance than was displayed). The former problem was addressed by the collaborative nature of GAS goal-setting for this study. Specifically, the mothers were able to state at the outset what level of performance increase would impact their daily lives. Through the one-, two-, or three-week baseline period, it could be established that the goals they set were not being met through current methods employed by the family.

In the original proposal for this study, the latter problem, rater bias, was to be addressed through video review of each of the skills measured by the GAS. The videos were to be shown to an independent reviewer in a random order at the conclusion of all treatment. However, it was not possible to video-record many of the goals set; as some were toileting goals and it did not seem appropriate to record these, and some goals were set across the span of an entire day, thus not possible to record.

In this study, mothers were the recorders of GAS scores. Research has indicated that parents of children with sensory sensitivities can describe their child's sensory issues by describing their response to sensory input. Because many children with ASD are affected by sensory sensitivities or seek out specific sensory experiences (Chang, 2009; Tomchek & Dunn, 2007; Adamson, O'Hare, & Graham, 2006), parents often couch their child's behavior in terms of their sensory processing (Diamant, 2011; Bagby, 2009; Dickie, Baranek, Schulty, Watson, & McComish, 2009). In describing their children's sensory experiences as being "good" (associated with calming or "centering") or "bad" (associated with pain, stress or fear), parents of preschoolers with ASD (n=66) were able to associate specific sensory inputs with behaviors in their child. For example, a mother would be able to predict her child covering his ears in response to a plane

flying overhead. Those associations would, conceivably, allow them to anticipate how they child would react to certain stimuli, and be accurate reporters of change regarding their child's sensory experiences.

While there are a variety of different scales that have been used in GAS measures, in comparing functional measures in pediatric research, Cusick, McIntyre, Noval, Lannin and Lowe (2006) found a seven-point Likert-scale, to be the most sensitive to change, and that outcome informs this study.

Goal Attainment Scaling (GAS) was the most frequent measure obtained throughout the duration of the study, and served as a primary measure of treatment effectiveness. Week-long GAS measures were taken before treatment to establish baseline, for one week every four weeks during treatment to establish trends in the data, and for the final week of treatment. Daily GAS scores were not collected continuously throughout the study because this was felt to be an undue burden on the participating families.

According to Backman et al. (1997), a single-subject research design is defined by first establishing a baseline of function through at least three separate measurement sessions and continuing to take data at periodic intervals during the treatment period. GAS was the measure through which these criteria are met. Backman et al. also suggests that the person recording data be completely independent of treatment and unaware of the goals of treatment. This approach was not feasible for this study.

During the initial pre-treatment interviews with the mothers, two goals regarding social interaction and two goals regarding participation in ADLs were established for each child, according to problems the child is currently experiencing and what would be age-appropriate. The interview for establishing GAS goals followed a protocol established by Mailloux, et al.

(2007, see Appendix B). An example of a behavior addressed by a social interaction goal might be: "C. will take our hand and lead us to what he wants or gesture, but he won't use the word for it, even though he has used the word before" From this information, mother and therapist worked together to establish a gradient of measurement regarding these goals; improvements may be that C. uses signs for the item with prompting, and a decrease in social function may be the C. becomes agitated when asked to give the sign or word for an item.

Childhood Autism Rating Scale.

The Childhood Autism Rating Scale (CARS) (Schopler, Reichler, and Renner, 1988) is an observation-based, norm-referenced assessment that measures the severity of ASD symptoms by scoring a child on a four-point scale in 15 areas that include listening response, body use, verbal communication and adaptation to change. There are five measurements on the CARS that relate directly to social skills and communication: Relationships with People, Imitative Behavior (motoric and verbal), Auditory Responsiveness, Verbal Communication, and Non-verbal Communication. These measures can be used to assess an increase in social engagement. The CARS criteria are correlated with the criteria for diagnosis in DSM-IV (Perry, Condillac, Freeman, Dunn-Geier, & Belair, 2005), and it can be surmised that an improvement in CARS scores reflects a lessening of severity of ASD symptoms.

The CARS has inter-rater reliability estimates from .71 to .94 (Matson, Smiroldo, and Hastings, 1998), and a test-retest stability between 73% and 88% (Rellini, Tortolani, Trillo, Carbone, & Montecchi, 2004). It uses both clinical observation and parent information to obtain a score. Perry et al. (2005) cite that the CARS has been used in previous research studies (decreasing CARS score indicating a positive response to treatment) and that the CARS can be used as an assessment of ongoing treatment effectiveness.

The CARS was administered before and after treatment by an occupational therapist (OT) who has completed training in administration of the CARS. This OT was not involved in treatment and was not aware of other measures (such as GAS goals) that treatment was intended to affect.

Pediatric Evaluation of Disability Inventory.

The Pediatric Evaluation of Disability Inventory (PEDI) (Haley, Coster, Ludlow, Haltiwanger, & Andrellos, 1992) is a parent-report, therapist-scored interview-format evaluation of a child's performance in functional skills (self care, mobility and social function), while also measuring the level of caregiver assistance and the nature of the child's environment and modifications necessary. It is designed for children between the ages of 6 months and 7.5 years. Inter-rater reliability has been established as good, between .68 and .99 (Berg, Jahnsen, Froslie, & Hussain, 2004; Nichols & Case-Smith, 1996). The PEDI has also been found to correlate well with the subscale scores of the Peabody Developmental Motor Scales (Nichols & Case-Smith, 1996), indicating reasonable construct validity. The PEDI has not been used with children with ASD in a published study, but it has been used to assess recovery in children with brain injury and function in children central auditory processing disorder (Flood, Dumas, & Haley, 2005; Dumas, Haley, Ludlow, & Rabin, 2002).

For each functional skill area (197 total), the child is given a score of 0 (unable) or 1 (capable). The authors of the PEDI define a score of 1 as "capable in most situations". Those specific skill areas are grouped to reflect a rating on a scale of performance (from 0 to 5) for a specific task that reflects the level of assistance necessary and modifications necessary for completion of the task.

The social skill area of the PEDI was compared pre- and post-treatment with the two social function GAS goals and was used to help assess construct validity of GAS measures. The overall scores on the PEDI were also used as a pre- and post-intervention measurement to assess program effectiveness.

Hypothesis 2: Completion of a 16-week program of TL will result in an increase in participation in and/or decreased resistance to two routine tasks that contribute to his/her life role and that the child's family has indicated are problematic.

Two measures were used to assess change in the children's participation in daily routines and life roles; GAS and the PEDI.

Goal Attainment Scaling.

During the initial pre-treatment interviews with the mothers, two goals regarding social interaction and two goals regarding participation in ADLs were established for each child. Just as regarding the social interaction of the child (above), the goals regarding their participation in daily routines and activities were tracked through GAS methods. For example, a behavior a mother might mention that could be addressed by a participation-in-daily-routines goal might be: "J. does not like to have his teeth brushed and will push our hand away when we try to brush his teeth" From this information, mother and therapist worked together to establish a gradient of measurement regarding these goals, just as was formulated for the social-interaction goals.

Pediatric Evaluation of Disability Inventory.

The sections of the PEDI that relate directly to the daily routines or tasks addressed by the two GAS goals were used to verify functional improvement in these areas through direct score comparison pre-/post-test. The overall scores on the PEDI were also used as a pre- and post-intervention measurement to assess program effectiveness.

Hypothesis 3: Increases by the child with ASD in daily participation and function within the family, resulting from TL treatment, will positively affect parental stress.

The Parenting Stress Index was the measure used to assess the change in parenting stress related to changes in their child's behavior that may have resulted from their participation in the TL program. A Likert-scale post-treatment survey was used to gather information on the parents' opinions regarding change in their child and the ease of use and value of the TL program.

Parenting Stress Index.

Parents of children with ASD are often affected by stress levels that correlate with the severity of the child's autism and/or the child's behavior (Lecavalier, Leone, & Wiltz, 2006; Davis & Carter, 2008; Tobing & Glenwick, 2002). The Parenting Stress Index – Short Form or PSI/SF (Abidin, 1995) has been used as a measure of parenting stress in several studies of families with children with ASD (Davis, 2008; Lecavalier, 2006; Freeman, Perry, & Factor, 1991).

The PSI/SF was not available for this study, but the Parenting Stress Index-Long Form (PSI) was, and it was used in replacement for the PSI-SF. The PSI is a 120-item self-scoring questionnaire with A Child domain (which quantifies the child's adaptability, mood, demandingness, etc.) and a Parent domain (which quantifies the parent's health, spousal support, feelings of isolation, etc.). Parenting stress as measured by the PSI/SF has been correlated scores with the CARS-P, (form of the CARS completed by parents) indicating that as autism severity increases, parenting stress increases as well (Tobing & Glenwick, 2002). This study measured both scores on the CARS and the PSI to establish effectiveness of treatment, and also to corroborate others' research regarding the behavior of children with ASD and parenting stress through correlational analysis.

Program Evaluation.

In addition to these pre- and post-treatment measures of child and parent, a Likert-scale survey was completed by each child's mother to examine the ease of administration of the treatment program, their perception of the child's progress and the overall value to them of the treatment protocol (see Appendix C). This was used to assess the ease of replication of this treatment for other families, the families' perceptions of the benefits of this treatment, and whether or not this treatment created an undue burden on the participating families. This information may be useful in further studies of this treatment.

Data Analysis

GAS measurements.

During the study, week-long GAS goal data was recorded by the parent each day of weeks 4, 8, 12, and 16, for each of the four goals. Those measurements and the baseline measurements were subjected to visual analysis of scores and calculations of effect size for each GAS goal. This approach subjected the data to the advantages of both visual analysis, which it is intuitively understood, and statistical analysis, which can produce more consistent results across data sets and allow for more uniform comparison. Given the small data set and variability in performance and behavior in children with ASD (Dickie, Baranek, Schultz, Watson & McComish, 2009; Adamson, O'Hare & Graham, 2006), this method tolerated the potential variability in performance, while allowing for intuitive conclusions from the data.

PEDI, CARS and PSI.

The PEDI, CARS and the PSI were administered as pre-/post- tests only to limit the potential effects of multiple testing; total scores as well as scores for each individual functional area were assessed. Additionally, four functional areas of the PEDI, and five items of the CARS were examined individually due to their relationship to the areas addressed by GAS goals. The PSI scores pre- and post treatment were compared, looking at Child Domain, Parent Domain and overall Life Stress.

Data and Safety Monitoring

Participants were identified by letter coding. The key linking these codes to demographic data and any video recordings taken during the study were kept in a secure and locked location in the home of the principal investigator. However, it is recognized that with only 3 participants absolute confidentiality was difficult to insure. Computerized data for this study was kept on the personal computer of the principal investigator, and the files were password protected. Non-computerized data, such as assessment forms and parent surveys, were stored under the subjects' initial code and kept in a file in the home of the principal investigator, away from any demographic data.

Informed consent.

The mother of each child was presented with informed consent forms, explained the contents of those forms, explained the potential benefits and potential harms of TL treatment, made to understand their right to be present for each interaction of the researcher with their child, the right to withdraw their child from the study at any time, and the right to contact the Virginia Commonwealth Office of Research at any time. All parents signed the consent forms.

Chapter 4: Results

Recruitment of the three subjects for this study occurred in November 2010 and the baseline periods began simultaneously for all three subjects, thus staggering the start of TL therapy by one week for each successive subject. Two of the mothers chose to have the weekly meetings in their home, and one mother chose to meet with the researcher in the clinic. In no case was the clinical researcher a treating therapist for the child; all three children had been receiving, and continued to receive, speech, occupational, and physical therapy throughout this study.

Each of the children began the study with a pre-treatment evaluation in the clinical researcher's clinic; which was a new environment to one of the subjects, AE. This evaluation included administration of the CARS, PEDI, and PSI evaluations. Goals were set for GAS measurements, in conjunction with the children's mothers, based on what was discussed during administration of the evaluations and what was observed in the clinic. For example, ZJ's mother was asked what changes in her child would make a difference in her life, she responded that she would appreciate it if her child would stop removing his diaper to urinate on the floor. Improvement of this behavior became a GAS goal.

One week after the pre-treatment evaluations, the clinical researcher met with each child's mother to explain the GAS goal-tracking procedures and each mother was instructed to monitor each goal daily for a period of one, two or three weeks. After this baseline data-gathering period, treatment began for each child.

Pre-Treatment Evaluations

Subject #1: AE.

AE is a four-year-old boy (48 months at onset of study) who was diagnosed with Autism at three years of age using the ADOS assessment. He lives with his mother, father, and younger sister. His mother stays home full-time to care for him and his sister. During this study he did not attend pre-school, but continued to participate in occupational therapy, physical therapy, and speech therapy for 45 minute sessions, twice a week. His baseline data-collection period was three weeks in length. At initial evaluation, AE had a small vocabulary of functional words, but did not use them consistently and seemed to lose the ability to speak when he was upset. He was unable to answer direct questions and was obsessed with trains, repeating the word over and over. His motor skills were adequate to complete daily tasks, but he needed close supervision and physical assistance to stay on task and orient items correctly, especially during dressing.

His mother indicated that her primary concern was AE's inability to wait to have his needs met, resulting in him grabbing items from his sister, stress-creating whining, and tantrums at least once each day. His mother was also frustrated by his inability to help himself by following verbal cues. For example, if he wanted a drink, he could indicate this by saying "cup", but was not able to follow verbal cues to retrieve his full cup from the table for a drink. AE's mother also felt that he should be toileting independently, at least regarding bladder continence; he needed help with his clothing and did not communicate a need to go or head to the bathroom independently. GAS goals were constructed to address four of her concerns as outlined in Table 3.

Table 3

AE's GAS Goals 1-4

Scale	Level of Performance	Daily Outcome
Goal #1: AE will ask or gesture for an item from his sister, as opposed to just grabbing it, at least once per day.		
-3	Much worse than expected	AE becomes aggressive toward most others
-2	Regression	AE seeks to hit his sister without provocation
-1	*Level at onset of treatment	AE snatches items from his sister and/or hits her
0	Expected level	AE asks or gestures for an item/need once
1	Better than expected	AE asks or gestures for an item repeatedly
2	Much better than expected	AE requests Mom's interventionto get what he needs
3	Above all expectations	AE asks for item from sister, demonstrates a skill or participates in interactive play with his sister consistently.
Goal #2: AE will wait for one minute, patiently, to have his needs met.		
-3	Much worse than expected	AE becomes aggressive when waiting
-2	Regression	AE has tantrums when waiting for his needs to be met
-1	*Level at onset of treatment	AE asks, then whines and cues persistently until his needs are met
0	Expected level	AE waits for one minute for his needs to be met
1	Better than expected	AE waits for 2-3 minutes for his needs to be met.
2	Much better than expected	AE waits for several minutes before transition to having his needs met.
3	Above all expectations	AE waits for things that occur later in the day (i.e. "we can have a drink when we get home from the park")
Goal #3: AE will find a desired object in a room with no more than one verbal cue.		
-3	Much worse than expected	AE has a tantrum despite maximum assistance to find an object
-2	Regression	AE requires physical assistance to find a desired item that is in sight
-1	*Level at onset of treatment	AE needs visual cues (pointing near to object) to find an item he would like
0	Expected level	AE finds objects in sight when needed with 1-2 verbal cues
1	Better than expected	AE finds an object with verbal cues from a distance ("your shoes are on your bed")
2	Much better than expected	AE finds an object in another room when requested ("go get your shoes from the hallway")

Table 3 continued

Scale	Level of Performance	Daily Outcome
3	Above all expectations	AE finds objects needed for a task independenty (i.e. getting his clothes after a bath)
Goal #4: AE will use the toilet when prompted, with help to adjust his clothing.		
-3	Much worse than expected	AE has multiple accidents each day
-2	Regression	AE has one accident per day
-1	Level at onset of treatment	AE needs prompting, encouragement and physical assistance to use the toilet
0	Expected level	AE toilets independently, with minimal assistance with clothing
1	Better than expected	AE reports to mom that he must use the toilet, then completes the task
2	Much better than expected	AE reports to mom that he has used the toilet independently
3	Above all expectations	AE rises during the night to toilet independently

*"Level at Onset of Treatment" reflects level of performance as reported by mother at pre-treatment evaluation. Child's actual performance during baseline period may have varied from this pre-designated level.

AE's baseline function.

AE's pre-treatment CARS evaluation test scores indicated that he had mild-moderate autism (score=32). He fell greater than two standard deviations below the mean in functional skills of self-care, mobility and social function on the PEDI, and greater than two standard deviations below the mean in caregiver assistance for self-care and social function on the PEDI. He scored at the 50th percentile for caregiver-assistance in mobility on the PEDI. His mother's responses on the PSI placed her above the 85th percentile for stress in all areas of the Child Domain, and in the 22nd percentile for stress in the Parent Domain, with a Total Stress level above the 90th percentile , and a Life Stress score of 9 (65th percentile).

During the baseline period, AE's scores regarding his GAS goals were fairly consistently at -1 for each goal, which is defined as "level at onset of treatment" in the GAS scoring rubric,

indicating that his performance was consistently at this level without intervention, varying only occasionally.

Subject #2: ZJ.

ZJ was 49 months of age at the onset of this study. He was diagnosed with Pervasive Developmental Disorder, a sub-type of ASD, at three years of age using the ADOS assessment. He lives with his mother, father, and two younger brothers. His mother stays home full-time to care for him and his brothers. He attends pre-school three mornings a week. He participates in occupational therapy, physical therapy, and speech therapy for 30 minute sessions, twice a week. During his initial assessment he was disconnected, could not sit for tasks for more than one minute (including meals) and attempted to spin almost all objects given to him. He did not engage with people in his environments and actively moved away when someone attempted to engage him. He required hand-over-hand assistance to complete a simple shape-sorter activity with his mother. He was non-verbal and did not attempt to communicate in any way other than resistance, but his mother reported that he was capable of using signs when he wanted an item, with prompting.

His mother indicated that her primary concerns were ZJ's need to remove his diaper and urinate on the floor, desire to only eat one food at each meal (even if he liked the other foods presented), inability to communicate his needs through words or consistently through signs, and lack of engagement with toys (he preferred to spin toys as opposed to playing with them) and people during play. GAS goals were constructed to address these concerns as outlined in Table 4.

Table 4

ZJ's GAS Goals 1-4

Scale	Level of Performance	Daily Outcome
Goal #1: ZJ will use 1-2 signs or picture-exchange cards to express himself without prompting.		
-3	Much worse than expected	ZJ becomes upset when encouraged or prompted to use his signs or picture exchange cards
-2	Regression	ZJ does not use signs or picture exchange cards to obtain what he needs
-1	*Level at onset of treatment	ZJ uses 1-2 signs or picture exchange cards with prompting
0	Expected level	ZJ uses 1-2 signs or picture exchange cards without prompting
1	Better than expected	ZJ uses 2-3 signs or picture exchange cards without prompting
2	Much better than expected	ZJ uses single words without prompting
3	Above all expectations	ZJ uses two-word phrases to express himself
Goal #2: ZJ will imitate play interaction with mom at least once during daily play session.		
-3	Much worse than expected	ZJ becomes upset with attempts to engage him
-2	Regression	ZJ avoids all others during play
-1	*Level at onset of treatment	ZJ tolerates others during play, but does not imitate interaction
0	Expected level	ZJ imitates mom once during play session
1	Better than expected	ZJ imitates mom consistently during play session
2	Much better than expected	ZJ imitates regular play routine without prompting and initiates a new interaction during play session
3	Above all expectations	ZJ regularly imitates mom during play session
Goal #3: ZJ will urinate in his diaper instead of on the floor.		
-3	Much worse than expected	ZJ removes his diaper and urinates in multiple areas
-2	Regression	ZJ removes his diaper without informing mom and urinates on the floor
-1	*Level at onset of treatment	ZJ asks that his diaper be removed but then urinates on the floor
0	Expected level	ZJ urinates in his diaper each time
1	Better than expected	ZJ urinates in the toilet at least once that day
2	Much better than expected	ZJ consistently uses the toilet several times a day
3	Above all expectations	ZJ consistently uses the toilet several times per day

Table 4 continued

Scale	Level of Performance	Daily Outcome
Goal #4: ZJ will eat more than one food he likes during a meal.		
-3	Much worse than expected	ZJ refuses foods he has previously liked at meals
-2	Regression	ZJ must be encouraged to eat foods he likes at meals
-1	Level at onset of treatment	ZJ eats only one food at each meal, even if multiple foods he likes are served
0	Expected level	ZJ eats all foods presented, provided they are foods he likes
1	Better than expected	ZJ tries one bite of a new food during a meal
2	Much better than expected	ZJ eats one new food in its entirety when presented
3	Above all expectations	ZJ consistently tolerates new foods

*"Level at Onset of Treatment" reflects level of performance as reported by mother at pre-treatment evaluation. Child's actual performance during baseline period may have varied from this pre-designated level.

ZJ's baseline function.

ZJ's pre-treatment CARS scores indicated that he had severe autism (score=48). His scores on the PEDI were greater than two standard deviations below the mean in functional skills of self-care, mobility and social function, and greater than two standard deviations below the mean in caregiver assistance for self-care and social function. He scored at the 45th percentile for caregiver-assistance in mobility on the PEDI. His mother's responses on the PSI placed her above the 85th percentile for stress in all areas of the Child Domain, and above the 85th percentile in four of the seven areas of stress in the Parent Domain, with scores above the 70th percentile in the remaining three areas of that domain. She reported a Total Stress level above the 99th percentile, and a Life Stress score of 7 (55th percentile).

During the two-week baseline period, ZJ's scores regarding his GAS goals were much less consistent than those of AE, varying from -3 to +1 within his two-week baseline period. This

indicates that his performance was not consistent before intervention, but his mother was unable to assess any factors that contributed to this variability.

Subject #3: CW

CW was diagnosed with ASD at age three through the ADOS, and she was 42 months at the onset of this study. She lives with her mother and father (though her father is often away). She has a twin sister who has not been diagnosed with any developmental disorder and older brother who has also been diagnosed with ASD. She does not attend preschool and her mother stays with her full-time. She attended occupational therapy, physical therapy, and speech therapy before and during the study. At her initial evaluation, she sat and played purposefully with a ball-and-hammer toy while her mother provided information, but her mother said that she does not sit to play with toys at home. Her mother reported that she tears paper or toys and carries the pieces of what she is tearing around with her. Her mother reported that she is constantly on the move, often climbing onto dressers and cabinets, and she has difficulty with all transitions, dropping to the floor in resistance.

Her mother was concerned that, although CW will use words when prompted with her therapists, CW does not use them at home. She was also concerned about the frequency and intensity of CW's tantrums. She had between five and ten tantrums each day, most often during transitions and when an item needed to be taken from her. Her mother was also frustrated by the messes she makes when she eats and that she often climbs to dangerous heights on many surfaces in the house. CW's goals are outlined in Table 5.

During the one-week baseline period, CW's scores for GAS goals #1 and #4 were consistent at the -1 level, but varied between 0 and +1 for goals #2 and #3. This indicates that

either the baseline level for the goals were improperly set, or that CW would have improved in these areas without treatment.

Table 5

CW's GAS goals

Scale	Level of Performance	Daily Outcome
Goal #1: CW will use one word phrases with prompting to express needs.		
-3	Much worse than expected	CW uses no gestures or words to express needs and tantrums uncontrollably because needs aren't being met
-2	Regression	CW uses gestures inconsistently and words not at all
-1	*Level at onset of treatment	CW uses one word phrases inconsistently and not always to express ideas/needs.
0	Expected level	CW uses one word phrases consistently with prompting to express needs
1	Better than expected	CW uses one word phrases consistently with prompting to express needs
2	Much better than expected	CW uses 2-3 word phrases consistently to express herself
3	Above all expectations	CW uses full sentences to express herself
Goal #2: CW will have 1-2 tantrums per day and/or be redirectable from tantrums.		
-3	Much worse than expected	CW has consistent tantrums of longer duration throughout the day
-2	Regression	CW tantrums more tha n 10 times per day or tantrums are of increased intensity/duration
-1	*Level at onset of treatment	CW tantrums 10 times per day over predictable interactions (i.e. taking an item away from her)
0	Expected level	CW has 1-2 tantrums of normal duration
1	Better than expected	CW has 1-2 tantrums per day, but they are shorter or she can be redirected
2	Much better than expected	CW completes a day without a tantrum
3	Above all expectations	CW completes three days without a tantrum
Goal #3: CW will not climb on furniture in a dangerous manner more than 1-2 times per day.		
-3	Much worse than expected	CW climbs to dangerous heights more than 10 times per day and tantrums when redirected
-2	Regression	CW climbs to dangerous heights more than 10 times per day
-1	*Level at onset of treatment	CW climbs to dangerous heights and must be pulled down 10 times per day
0	Expected level	CW climbs to dangerous heights 1-2 times per day and comes down with verbal cues
1	Better than expected	ZJ urinates in the toilet at least once that day
2	Much better than expected	CW does not climb to dangerous heights when asked not to
3	Above all expectations	CW climbs appropriately (i.e. at playground) but refrains independently at home

Table 5 continued

Scale	Level of Performance	Daily Outcome
Goal #4: CW will eat finger foods without making a significant mess.		
-3	Much worse than expected	CW intentionally makes a mess with food and does not take in enough to sate hunger
-2	Regression	CW intentionally makes a mess with food after eating enough to sate hunger
-1	Level at onset of treatment	CW unintentionally makes a significant mess while eating and a greater mess after eating enough to meet her needs
0	Expected level	CW eats finger foods without a significant mess
1	Better than expected	CW eats finger foods without a significant mess and occasionally uses utensils
2	Much better than expected	CW eats with utensils consistently with cues
3	Above all expectations	CW eats with utensils independently when appropriate

*"Level at Onset of Treatment" reflects level of performance as reported by mother at pre-treatment evaluation. Child's actual performance during baseline period may have varied from this pre-designated level.

CW's baseline function.

CW's pre-treatment CARS scores indicated that she had severe autism (score=53). Her scores on the PEDI were greater than two standard deviations below the mean in functional skills of self-care and social function, and greater than two standard deviations below the mean in caregiver assistance for self-care and social function. She scored at the 30th percentile in functional skills for mobility, and the 45th percentile for caregiver-assistance in mobility on the PEDI. Her mother's responses on the PSI placed her above the 99th percentile for stress in all areas of the Child Domain except Hyperactivity, and around the 50th percentile in five of the seven areas of stress in the Parent Domain, with scores below the 30th percentile in the remaining two areas of that domain. She reported a Total Stress level above the 90th percentile, and a Life Stress score of 14 (85th percentile).

Treatment

AE's listening program.

The information provided by AE's mother and through observation of AE indicated that he:

- had poor awareness of his environment and seemed to "drown out" his auditory environment through constant humming or singing;
- was overly sensitive to noises: he was a light sleeper, easily disturbed by sound and he often covered his ears to noises;
- had a fear of noisy appliances and did not attend to novel auditory stimuli in the environment.

These issues, according to TL theory, indicate an inability to localize sound in his environment. In addition, AE did not have a large range of emotional expression and seemed unable to interpret the emotional content of others' speech, offering little response when his mother was upset with him or when she was encouraging to him. According to TL theory, AE may not have been able to recognize the variances in speech pattern and inflection that indicate emotional content of speech. AE's behavior indicated that he was a Profile 2, and the characteristics and map of that profile, as provided by Frick & Young (2009) guided his treatment.

AE was taken through a series of 10 discs (see Table 6). Generally children will use a single disc for 2 weeks time. However for AE discs were changed at the one-week mark four times (once due to a malfunctioning CD, once because AE objected to listening throughout the week when it had not been a problem before, once because the desired effect of the CD was not produced, and once because the desired behavioral change was achieved very rapidly).

Table 6

AE's Listening Program CDs

Week of Treatment	Name of CD	Treatment notes/Observations/ Reflections from mother
Week 1	Disc Ease 4	*Reason for disc choice*: Enhancement of AE's environmental and spatial awareness. *Reflections/observations*: Consistently whiny when listening to certain sounds on CD; disc changed after first week, due to CD malfunction.
Week 2	Peach Jamz Modified	*Reason for disc choice*: Enhancement of speech awareness and emotional range. *Reflections/observations*: Mom reports AE is "less moody" and "more willing to look for things".
Week4	Nature Pop Modified	*Reason for disc choice*: To address listening skills not completed by Disc Ease 4 (it is a similar disc) and to increase spatial organization for dressing. *Reflections/observations*: Mom reports AE dressed himself independently, but the clothing was on backwards, and that he is more cooperative (week 3) and has begun finding items he wants on his own.
Week 5	Grape Jamz Modified	*Reason for disc choice*: To decrease his need for tactile and proprioceptive sensory stimulation and increase his core tone and awareness; possibly help relieve constipation. *Reflections/observations:* Mom reports a "rough week" with tantrums, therefore disc changed after only one week. AE is constipated and has begun tearing paper if he finds it.
Week 7	Strawberry Jamz Modified	*Reason for disc choice:* To increase communication and connection. *Reflections/observations:* Mom reports AE is talking more this week with more eye contact, but not responding to the word "no" consistently. Mom reports that he is toileting independently and staying dry for long periods. Some difficulty with clear speech, now notable because he is speaking more.

Table 6 continued

Week of Treatment	Name of CD	Treatment notes/Observations/Reflections from mother
Week 9	Nature Pop-Spatially Enhanced	*Reason for disc choice*: Chose this disc to encourage scanning environment based on sounds; this was expected to enhance ocular-motor skills. *Reflections/observations:* Still not locating objects in crowded environment (like messy playroom) and becoming frustrated. Mom reports he is starting to recognize where they are going in the car and anticipate direction by telling her when to turn.
Week 11	Vivaldi for Modulation	*Reason for disc choice*: Chose this disc to enhance his processing of speech when background noise is present. *Reflections/observations*: AE still having problems understanding verbal directions.
Week 12	Mozart Strings #1	*Reason for disc choice*: Changed to this disc early because previous disc did not seem to affect his ability to perceive salient auditory information in the environment. *Reflections/observations:* No noticeable change in behavior.
Week 14	Gregorian Chants	*Reason for disc choice*: Observed AE in constant motion and climbing up to heights often. Chose this disc to offer low-frequency sound to provide grounding and physical center. *Reflections/observations:* He responded by whining and asking to have headphones off. Mother was consistent in putting them back on.
Week 15	Apricot Jamz-Modified	*Reason for disc choice*: Chose to change discs because time was short, behavior had improved and wanted to address attention, arousal and expression; to allow him to reflect engagement with activity for sustained period. *Reflections/observations*: AE calmer upon observation. Mom reports he asked a question in a whole sentence.

As AE continued through his program, he averaged two 20-30 minute listening sessions per day, missing no more than two days in a row at three periods throughout the 16 weeks. His

mother noted in his log book that he "seems a little less moody/less tantrums", "more cooperative", "looks for cup", "puts shirt and pants on by himself", and "had a BM three days in a row" (constipation was an ongoing issue for AE). Negatively, his mother would note when a disc seemed to make him "whine more", "ripping paper", and "more upset". These phrases helped the therapist adjust his program accordingly; for example, deciding with the therapist that she is willing to keep replacing headphones on AE when he has persistently complained about a disc to try to work through the problem, or noticing that a disc made no change in his behavior.

ZJ's listening program.

The information provided by ZJ's mother and through observation of ZJ indicated that he:

- had poor spatial and safety awareness, climbing on counters and furniture;
- had little connection with his environment, and did not initiate communication with others;
- mouthed objects to determine their qualities and touched all the objects in a new environment; he" makes a circuit" of any new area;
- had an obsession with spinning objects for visual stimulation that interfered with his proper use of the objects.

TL theory indicates that ZJ's need to mouth objects and his routine of making a circuit of new areas indicates that he has poor spatial awareness or anticipation of how objects might feel based on how sound reflects off of the objects and walls of his environment. It is the author's experience that children who spin objects or visually stimulate (or "stim", in the parlance of the autism community) themselves with patterns excessively have little depth perception; the object they use to stim is not really an object, but a two-dimensional pattern in space that they

manipulate. This is substantiated clinically by multiple observations in which a child who has been difficult to engage because of persistent visual self-stimulation ceases to stim as much and begins to use objects in a purposeful way a course of listening to a disc designed to enhance depth perception and awareness ("Nature Sounds" and other discs in the collection). ZJ's behavior suggested that he was a Profile 1, and the characteristics and map of that profile, as provided by Frick & Young (2009) guided his treatment.

ZJ was taken through a series of 10 discs (see Table 7), changing discs at the one-week mark four times (twice because he continued to object to listening throughout the week when it had not been a problem before, once because the chosen disc did not appear to have the intended effect, and once because he responded so quickly to what the disc was intended to elicit).

Table 7

ZJ's Listening Program CDs

Week of Treatment	Name of CD	Treatment notes/Observations/ Reflections from mother
Week 1	Disc Ease 2	*Reason for Disc Choice:* Disc Ease 3 is recommended for children who seem particularly disconnected from their environment. *Reflections/observations:* Although he did not display an orienting response (i.e., quieting, soft focus of the eyes) to Disc Ease 2 he sat to look at a book while listening, which was a new behavior for him.
Week 2	Disc Ease 3	*Reason for Disc Choice:* Disc Ease 3 is recommended for children who seem particularly disconnected from their environment. *Reflections/observations:* He did not display an orienting response (i.e., quieting, soft focus of the eyes) to Disc Ease 2 after one week of listening.
Week4	Mozart for Modulation	*Reason for Disc Choice:* Chosen to help ZJ regulate his attention. *Reflections/observations:* He had been constantly wandering his surroundings, flitting from one item to another. Mom reports picking up toys more.

Table 7 continued

Week of Treatment	Name of CD	Treatment notes/Observations/ Reflections from mother
Week 6	Apricot Jamz Modified	*Reason for Disc Choice:* Chosen to support arousal and encourage communication. Disc has low bass tones for providing a sensation of internal awareness, mixed with higher frequencies to emphasize communication. *Reflections/observations:* Mom reports ZJ tries to help care for baby brother and hugged his younger brother.
Week 8	Nature Pop-spatially enhanced	*Reason for Disc Choice:* To enhance his auditory awareness of distance and allow him to assess the space farther from him without having to go over to "check it out". *Reflections/observations:* Mom reported ZJ was running off from her in public places (a new behavior).
Week 9	Grape Jamz	*Reason for Disc Choice:* Chose to move on to this CD early to enhance his motor coordination. *Reflections/observations:* Mom reflected that his running off had decreased during the last week (an assumed response to the previous CD), and he is climbing on counters less.
Week 11	Disc Ease 4	*Reason for Disc Choice:* Chosen because he continues to lack a connection to others and his environment. *Reflections/observations:* Whining while listening, but mother agrees to continue with this disc.
Week 12	Nature Sounds	*Reason for Disc Choice:* Changed previous disc early because whining persisted throughout the week therefore it could not be effective. *Reflections/observations:* continued to persistently whine with TL through the week, whining prevented him hearing/responding to contents of disc. Mom reports climbing more.
Week 13	Razberry Jamz Modified	*Reason for Disc Choice:* Chosen to encourage verbal communication and connection with others. Rejected initial choice of Strawberry Jamz (possibly because it features a woman singing). *Reflections/observations:* Mom reports he is more engaged with others and making sounds that sound more like words.
Week 15	Strawberry Jamz Modified	*Reflections/observations:* Mom reports that he is very affectionate this week, and the "makes him more social".*Reason for Disc Choice:* Able to tolerate this CD at trial last week, but it was the preferred treatment choice.

As he continued through his program, he averaged almost two 20-30 minute listening sessions per day, although there were two three-day gaps in which the CD player was not working. ZJ's mother noted in his log book that he "tried to help brother", "hugged his brother", "less climbing on furniture", "eating better", and "making sounds more like words". Negatively, his mother would note when a disc seemed to make him "run away more (while out in public places)", "whining more", and "more active". His program was adjusted to address any issues (such as running off) so that they resolved and his mother reflected to therapist by the end of his program that he was not climbing on the furniture inappropriately much at all.

It should be noted that, at the termination of the program, when the equipment was returned, the clinical researcher began to use ZJ's CD player that ZJ had used for 9 weeks of the program, and discovered that the player would "cut out" after 5-10 minutes of use. Sometimes it would resume, and sometimes it would need to be restarted. This particular CD player was replaced by one of higher quality that had become available at Week 13, but the original CD player that may have been malfunctioning was used during Week 3-12. ZJ's mother states that she never noticed it stopping when ZJ used it, but she never placed it on her ears at the end of the session. It is possible that ZJ did not get full treatments each day of the intervention due to the possibility of equipment problems.

CW's listening program.

The information provided by CW's mother and observations of her indicated that she:

- hummed constantly;
- required minimal amount of sleep, only sleeping about 5-6 hours total each night and waking often;
- liked to arrange objects in her environment and became upset when someone moved

them;

- needed physical cues to understand verbal directions.

When CW's behaviors were viewed through the lens of TL theory, it they indicated that she had poor environmental awareness (arranging items so that she could find them again, perhaps because scanning her environment was too difficult). She had poor modulation rhythms and was sensitive to noise, such that it interrupted her sleep often. And she had poor speech processing, as evidenced by her inability to follow verbal directions.

Unfortunately, CW only participated in this study for four weeks. At that time, the family left town for a family emergency and forgot to take the headphones with them. A family member shipped them through the mail, and during shipping they broke. After repair, which took three weeks, CW continued to listen, but her data could not be used because she had now met one of the exclusion criteria regarding continuous participation in TL. Thus, baseline and 4 week data were collected, but no additional data collection points were feasible. The profiles provided by Frick and Young (2009) indicate that CW was a Profile 1, and that information helped to guided CD choice.

CW's mother wished to continue TL therapy after she was informed that CW could no longer be in the study. She completed 16 weeks of TL, her program being designed by the clinical researcher, although those weeks were not consecutive. The information gathered is anecdotal, but will be presented and included in the Discussion. The CD choices and rationale are listed in Table 8.

Table 8

CW's Listening Program CDs

Week of Treatment	Name of CD	Treatment notes/Observations/ Reflections from mother
Week 1	Disc Ease 1	*Reason for Disc Choice:* Although this disc is not listed in the map for Profile 3, it was chosen to assess its effect on CW's sleep pattern. *Reflections/observations:* Her mother reported that her sleep at night increased from 3 to 7 hours at a stretch.
Week 3	Mozart for Modulation	*Reason for Disc Choice:* To address CW's continuing trouble with transitions and frequent tantrums. *Reflections/observations:* Family left town for three weeks after week 4 of this study, during which CW was not listening as prescribed. **At this point CW exited the study.**
Week7	Disc Ease 1	*Reason for Disc Choice:* Mom requested CW return to Disc Ease 1 because she was no longer sleeping well. *Reflections/observations:* Mom requested that CW continue with TL, although she could not be included in the study.
Week 8	Nature Winds	*Reason for Disc Choice:* This disc was chosen to enhance CW's spatial awareness and address her constant need to climb to heights. *Reflections/observations:* Mom reports she was climbing less, but her sleep was no longer as good.
Week 9	No TL	*Reflections/observations:* At this point, CW chewed through the cord leading from the CD player to the headphones and there was a two-week interruption in therapy while the headphones were sent out for repairs.
Week 11	Grape Jamz	*Reason for Disc Choice:* Disc chosen to enhance CW's body awareness and give her the sense of movement that she constantly seeks. *Reflections/observations:* Mom reported she had ceased climbing by week 11 but still sought out items to hold.
Week 13	Apricot Jamz	*Reason for Disc Choice:* To decrease her need for the proprioceptive and tactile sensations she may be getting from tearing things apart. *Reflections/observations:* CW was beginning to sign more consistently and transitions between environments were becoming easier. She was still tearing apart items within the house.
Week 15	Strawberry Jamz	*Reason for Disc Choice:* This disc was chosen to encourage her self-expression and emotional connection with words. *Reflections/observations:* Mom reports she is tearing up books less, and looking at them instead. CW using more words in therapy, but not at home, per mom's report.

Post-treatment scores and results

Given the quantity of data supplied by the GAS goal recording, it was possible to subject the data to both visual analysis and calculations of effect size. Theoretically, the nature of TL may be cumulative and/or a child's behavior could be dependent on his acquiring multiple listening skills over more than one phase (disc) of his TL program. As demonstrated by visual analysis, some GAS-recorded behaviors in AE or ZJ showed immediate or rapid change, while others showed increased variability during the treatment period, and others developed upward trends through the 16 weeks. Because of these varying responses across goals to TL treatment, three different types of effect size calculations were performed on the data for each goal.

- Mean Shift (d) assigns a number to the magnitude of change observed when a trend in the data may not be discerned visually (e.g., unstable baseline condition or immediate, consistent change during the treatment period compared to the baseline). It is calculated by subtracting the mean of the baseline data from the mean of the treatment data and dividing by the standard deviation of the baseline. All calculations were performed with JMP statistical software.
    - $d = (\bar{X}_B - \bar{X}_A)/S_A$,
    - $\bar{X}_B$ and $\bar{X}_A$ are variable values for the treatment and baseline conditions, respectively
    - S_A is the standard deviation of the variable in the baseline condition.
- Change in Variability (f^2) captures the increase or decrease in the stability of behavior; this is useful when the data to do reflect a change in level of performance or trend. A change in variability may indicate that the child had an increase in the number of "better" performances or a decrease in the number of "poor" performances during the treatment

period. It is calculated by computing the variability during the baseline and treatment periods, then dividing the larger of the two numbers by the smaller. That ratio is then multiplied by the number of data points in the larger variability group, minus one; then divided by the total number of data points in both groups.

  - $F' = S_L^2/S_S^2$
  - S_L^2 is the larger of the variabilities and S_S^2 is the smaller
  - $f^2 = (n_L - 1)F'/(n_L + n_S)$
  - n_L is the number of observations in the larger-variability group and n_S is the number of observations in the smaller-variability group.

- Change in Slope (dr^2) assigns a number to the increase or decrease in trend; it is helpful when visual analysis indicates a trend (e.g., when the effect of treatment appears to be cumulative over time). It is calculated through three mathematical maneuvers. First, a least-squares regression is performed on the entire data set (which assumes no effect of treatment). Then a regression is performed on the baseline and treatment periods separately, in which a coded variable is introduced that sets the value at 0 for observations in the baseline, and 1 for observations in the treatment period (essentially weighting for the trend in data observed through visual analysis). Finally the effect size is calculated by obtaining the difference between the weighted regression and the regression that assumes no treatment effect, then dividing that difference by the inverse of the regression of the weighted regression. To calculate this effect size the following three equations are used:
  - $y_1 = b_0 + b_1T + e$, where y_1 = the dependent variable (GAS score), T = the successive period of observation, b_0 = the initial value of the dependent variable

(baseline recording #1) and b_1 = the slope in the data. Finally, e = the residual of the regression.

- $y_2 = b''_0 + b''_1 T + b''_2 X + b''_3 XT + e$, where X = a dummy-coded variable (X) taking the value of 0 for the baseline period and 1 for the treatment period. When X=0 (the baseline situation), the resulting equation has the same slope as the equation for y_1, but when X=1 (the treatment condition), the resulting slope reflects the trend for the treatment phase of data.
- $dr^2 = (R^2_{y2} - R^2_{y1})/(1 - R^2_{y2})$, in which R^2_{y2} is the coefficient of determination for the equation of y_2 and R^2_{y1} is the coefficient of determination for the equation of y_1.

In a comprehensive analysis of effect size in single-subject research, Komrey and Foster-Johnson (1996) evaluated the variety of opinions on the interpretation of effect sizes and concluded that when d = 0.2, 0.5, and 0.8, the effect values should be considered small, medium and large, respectively; and for f^2 and dr^2, the small, medium and large effects are represented by the values 0.02, 0.15, and .035, respectively. These conclusions informed the analysis of the treatment effect of TL for each goal.

Hypothesis 1: Completion of a 16-week program of TL will result in an increase in the occurrence of socially-engaged behaviors.

Two GAS goals for each child and the CARS captured changes regarding socially-engaged behaviors, communication and social function.

AE's GAS goals #1 (ask for an item from his sister before grabbing it) and #2 (wait for one minute to have his needs met) were related to social function and communication. A visual analysis of AE's performance on Goal #1 (Figure 2) indicates that AE had a very stable baseline

performance, and that his performance trended upward as his program progressed. This is supported by the large effect size calculated from the change in slope (dr^2) and mean shift (d) for Goal #1. For Goal #2, visual analysis indicates little trend (Figure 3), but large effect sizes were calculated from the change in mean (d) and the change in variability (f^2)for Goal #2. A calculation for effect size from change in mean and change in variability for Goal #1 was not possible because the baseline period was stable at -1 with no variability (Table 9).

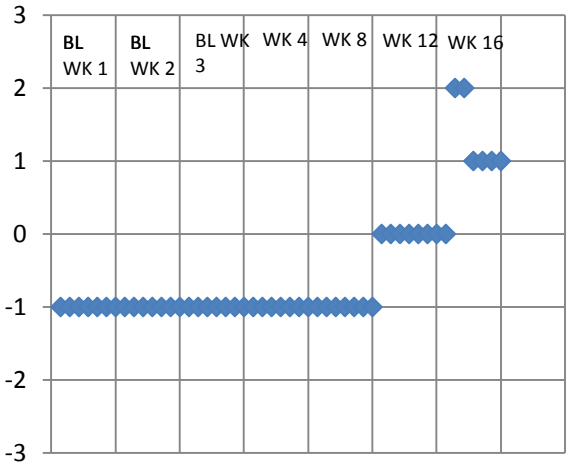

Figure 2. AE scatter-plot of GAS scores for goal 1: Asking or gesturing for items from his sister. BL WK= Baseline week, WK= Week of treatment.

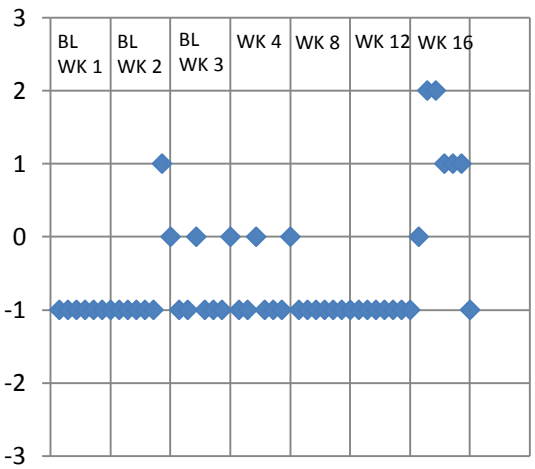

Figure 3. AE scatter-plot of GAS scores for goal 2: Waiting one minute to have his needs met. BL WK= Baseline week, WK= Week of treatment.

For both ZJ's GAS goals #1 (independently use picture cards or gestures to communicate need 1-2 times each day) and #2 (imitate mom during play once each day) ZJ was performing for several days during the Baseline period at 0, or level of performance expected during treatment (Figures 4 and 5). This may be an indication that the GAS goals for these skills were not written to accurately capture his baseline performance or that his mother did not fully understand the nature of recording ZJ's actual performance.

Table 9

Analysis of Treatment Effect Sizes, AE Goals #1 and #2

Treatment Effect Mean Shift (*d*)					
	Baseline mean	Baseline Standard deviation	Treatment mean	Treatment Standard deviation	*d*
Goal #1	-1.00	0.00	-0.21	0.96	--
Goal #2	-0.76	0.54	-0.43	0.96	0.62
Treatment effect for change in slope (dr^2)					
		Regression assuming no trend	Regression of treatment period (trend present)		dr^2
Goal #1		0.63	0.80		0.82
Goal #2		0.31	0.33		0.04
Treatment Effect Change in Variability (f^2)					
		Variability of Baseline	Variability of Treatment	F'	f^2
Goal #1		0.00	0.92	--	--
Goal #2		0.29	0.92	3.17	1.75

Both goals were related to social function and communication. A visual analysis of the data graphed in Figure 4 indicates little change in mean or trend of the data; and the effect size calculations reveal only a small to medium increase in mean change treatment effect (*d*), but a large change in variability (f^2)(Table 10). ZJ's scatter plot regarding imitation in play indicate a positive trend and mean shift; the effect size calculation support this and also indicate a decrease in variability (f^2) illustrating an increasingly stable, positive response to treatment.

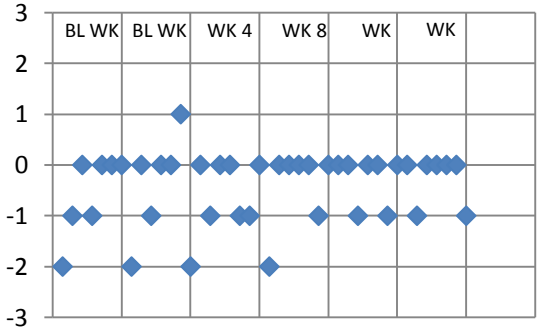

Figure 4. ZJ's scatter-plot of GAS scores, goal: using picture cards or gestures. BL WK= Baseline week, WK= Week of treatment.

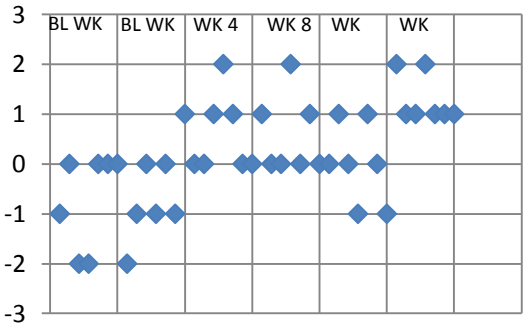

Figure 5. ZJ's scatter-plot of GAS scores, goal: imitating during play with mom. BL WK= Baseline week, WK= Week of treatment.

Table 10

Analysis of Treatment Effect Sizes, ZJ Goals #1 and #2

Treatment Effect Mean Shift (*d*)					
	Baseline mean	Baseline Standard deviation	Treatment mean	Treatment Standard deviation	*d*
Goal #1	-0.73	1.01	-0.36	0.56	0.37
Goal #2	-0.82	1.17	0.11	0.42	1.10
Treatment Effect Change in Variability (f^2)					
		Variability of Baseline	Variability of Treatment	F'	f^2
Goal #1		1.02	0.31	3.26	0.84
Goal #2		1.16	0.85	1.39	0.36
Treatment effect for change in slope (dr^2)					
		Regression assuming no trend	Regression of treatment period (trend present)	dr^2	
Goal #1		0.08	0.11	0.04	
Goal #2		0.39	0.42	0.05	

Although the outcomes of CW's TL program cannot be included in an analysis of the effectiveness of TL over a 16-week program, it would appear from the data gathered in the first four weeks of treatment that TL had a positive impact on her behavior regarding communicating her needs using words consistently, but may have had a negative impact on her tantrums during that time (Figures 6 and 7). There may have been an error in setting or recording the CW's baseline function for this goal, as her scores in the baseline section are not consistently -1.

The other measurement intended to capture change in communication and social function was the CARS. AE's scores pre-treatment and post-treatment on the CARS remained unchanged (32 before and 32 after).

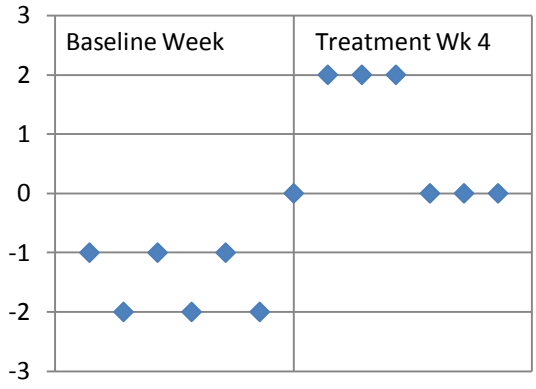

Figure 6. CW's scatter-plot of GAS scores, goal: using one word phrases to have needs met.

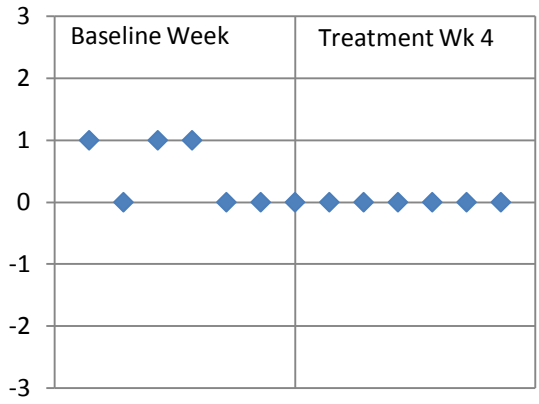

Figure 7. CW's scatter-plot of GAS scores, goal: having only 1-2 tantrums per day.

For AE, the largest improvement in a single test section was in Listening Response (a change from 3 pre-treatment to 1.5 post-treatment, 1 being normal response). Five of the CARS test items directly relate to communication and social function, and AE's scores on those items are listed in Table 11.

Table 11

AE's CARS scores by test section that relate directly to communication and social function

Scoring Item	Score before treatment	Score after treatment	Assessor's comments
Relating to People	1.5	2.5	Before: doesn't attend when called. After: delayed response to name
Imitation	2.5	2	
Listening Response	3	1.5	After: inconsistent response to name.
Verbal Communication	3	3	
Nonverbal Communication	2	2.5	

ZJ's scores pre-treatment and post-treatment on the CARS relative to social communication decreased (48 before and 41.5 after), indicating a lessening on the severity of autism-related behaviors. The scores of the 5 areas directly related to communication and social skills either remained the same or demonstrated improvement, indicated by lower scores (Table 12).

Table 12

ZJ's CARS scores by test section that relate directly to communication and social function

Scoring Item	Score before treatment	Score after treatment	Assessor's comments
Relating to People	4	2.5	Before: solitary play only. After: Took therapist's hand to ask for help with shape sorter
Imitation	4	3.5	Before: no imitation. After: MaxA for ball toss with another boy
Listening Response	3	2	
Verbal Communication	4	4	After: Using Picture Exchange System, not verbal
Nonverbal Communication	3	3	

Hypothesis 2: Completion of a 16-week program of TL will result in an increase in participation in and/or decreased resistance to two routine tasks that contribute to his/her life role and that the child's family has indicated are problematic.

Two GAS goals for each child and the PEDI were the measures used to capture changes regarding participation in daily routines and life roles.

AE's GAS goals #3 (finding desired objects in a room with no more than one verbal cue) and #4 (toileting independently when prompted) were related to routine tasks within his life role. Here, a visual analysis (Figure 8) indicates variable performance for Goal #3, with little change

in trend in the data, but an increase in the number of "expected level" (0) performances. This is supported by calculations indicating a medium effect size for Mean Shift (*d*) and medium to large Change in Variability (dr^2) (Table 13). For Goal #4 (Figure 9), a positive mean shift is evident, and effect size analysis indicates a large treatment effect for mean shift (*d*).

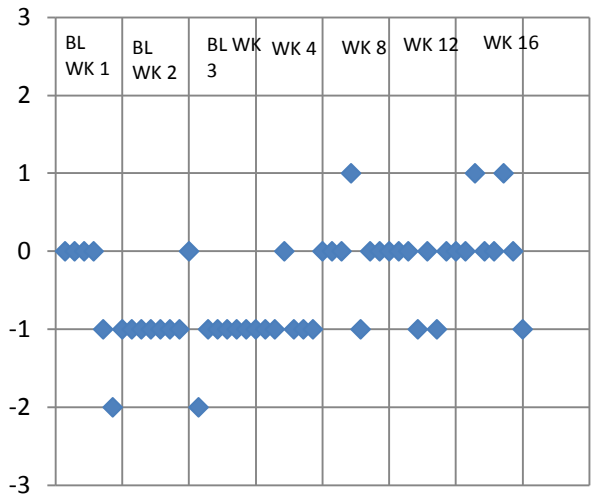

Figure 8. AE scatter-plot of GAS scores, goal: finding objects in a room with one verbal cue. BL WK= Baseline week, WK= Week of treatment.

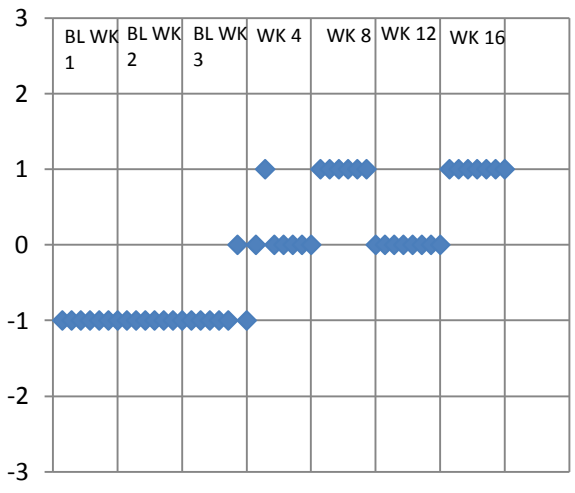

Figure 9. AE scatter-plot of GAS scores, goal: toileting independently when prompted. BL WK= Baseline week, WK= Week of treatment.

ZJ's GAS goals #3 (urinating without taking off his diaper and urinating on the floor) and #4 (eating more than one food at each meal) were related to routine tasks within his life role. A visual analysis of the data graphed in Figure 10 below shows ZJ's improvement with no longer removing his diaper, and a large effect size of mean shift (*d*) and large change in variability (f^2) were calculated. Regarding eating more than one food at each meal, ZJ's scatter-plot of scores is variable (Figure 11), but effect size analysis indicates a medium treatment effect for mean shift (*d*) and a small to medium decrease in variability (f^2), indicating a increase in level of performance and stability of performance.

Table 13

Analysis of Treatment Effect Sizes, AE Goals #3 and #4

Treatment Effect Mean Shift (*d*)

	Baseline mean	Baseline Standard deviation	Treatment mean	Treatment Standard deviation	*d*
Goal #3	-0.86	0.57	-0.14	0.65	1.25
Goal #4	-0.95	0.22	0.50	0.51	6.66

Treatment Effect Change in Variability (f^2)

	Variability of Baseline	Variability of Treatment	F'	f^2
Goal #3	0.33	0.42	1.29	0.71
Goal #4	0.04	0.26	5.44	3.00

Treatment effect for change in slope (dr^2)

	Regression assuming no trend	Regression of treatment period (trend present)	dr^2
Goal #3	0.29	0.45	0.28
Goal #4	0.79	0.79	0.00

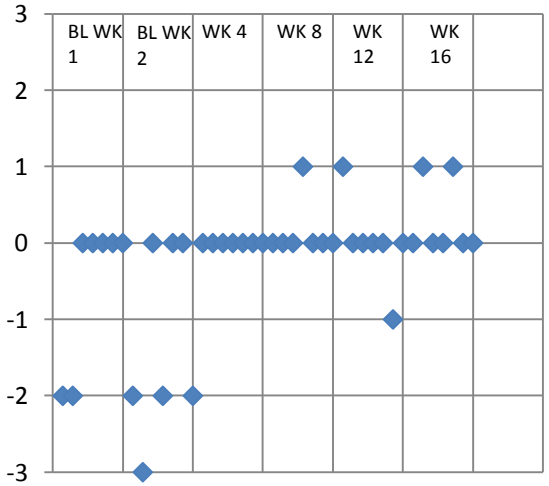

Figure 10. ZJ's scatter-plot of GAS scores, goal: no longer urinating on the floor. BL WK= Baseline week, WK= Week of treatment

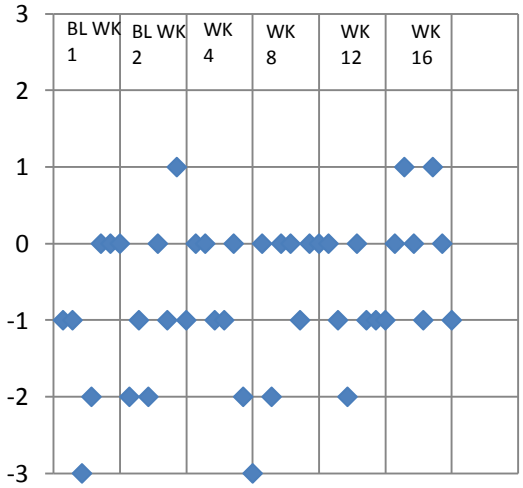

Figure 11. ZJ's scatter-plot of GAS scores, goal: eating more than one food at each meal. BL WK= Baseline week, WK= Week of treatment

Again here, for both goals, ZJ was performing for several days during the Baseline period at the 0, or Expected Level of performance for the treatment period. It is unknown why the baseline period recordings did not agree with the level of performance his mother indicated at the initial evaluation.

Table 14

Analysis of Treatment Effect Sizes, ZJ Goals #3 and #4

Treatment Effect Mean Shift (*d*)					
	Baseline mean	Baseline Standard deviation	Treatment mean	Treatment Standard deviation	*d*
Goal #3	-1.18	1.16	0.11	0.42	1.10
Goal #4	-1.18	1.08	-0.57	0.92	0.57
Treatment Effect Change in Variability (f^2)					
		Variability of Baseline	Variability of Treatment	F'	f^2
Goal #3		1.36	0.17	7.87	2.02
Goal #4		1.16	0.85	1.37	0.35
Treatment effect for change in slope (dr^2)					
		Regression assuming no trend	Regression of treatment period (trend present)	dr^2	
Goal #3		0.42	0.42	0.00	
Goal #4		0.15	0.19	0.05	

From the limited data available on CW's progress related to her GAS goals, it would appear that TL had a positive impact on her behavior regarding eating without making a mess during weeks 1-4 (Figure 12). There may have been an error in setting or recording the CW's baseline function for the goal regarding climbing on the furniture (Figure 13), as her scores in the baseline section are not consistently -1. It should be noted that, anecdotally, her mother reported that she had ceased climbing on the furniture at all by week 16 of her listening program.

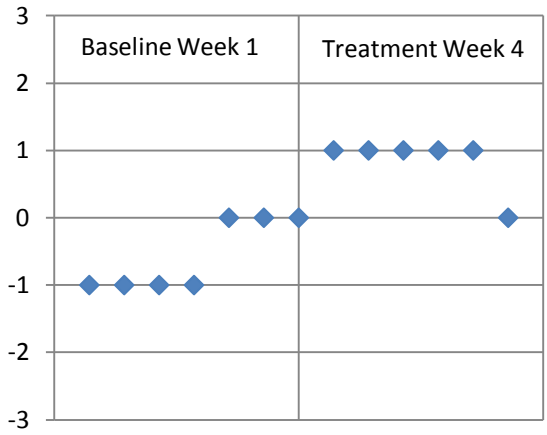

Figure 12. CW's scatter-plot of GAS scores, goal: eating without making a significant mess

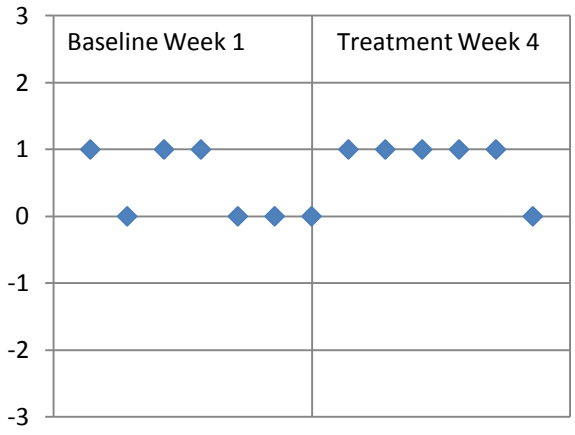

Figure 13. CW's scatter-plot of GAS scores, goal: not climbing on furniture more than 1-2 x/day

The other measurement intended to capture change in participation in daily tasks and routines was the PEDI. The scores on the PEDI are standardized and normed, and a score of 50 indicates the average for that age group.

AE's post-treatment scores on the PEDI indicated that he needed less assistance in self-care and social skills, particularly in regard to caregiver assistance (Table 15). This may be a reflection of increased verbal-direction processing. His mother was able to ask him to complete a task, and he was able to cooperate, as opposed to having the entire task completed for him. However, his scores regarding "caregiver assistance with mobility" increased, perhaps a reflection of his increased activity level requiring his mother to intervene because he was falling more often or running off without permission. Excessive activity is a common theme in the post-test results for AE.

Table 15

AE's PEDI scores by test section

DOMAIN	Before Treatment	After Treatment
Self-Care (functional skills)	<10	20
Mobility (functional skills)	28	28
Social Function (functional skills)	<10	<10
Self-Care (caregiver assistance)	<10	36
Mobility (caregiver assistance)	50	44
Social Function (caregiver assistance)	23	40

The post-treatment scores for ZJ on the PEDI remained almost completely unchanged from pre-treatment levels (Table 16), with the exception of a slight decrease in the amount of caregiver assistance needed for social function and self-care. This change in the level of assistance needed is likely a result of his increased ability to use the Picture Exchange Communication System (reported anecdotally by mother and speech therapist) to have his needs met.

Table 16

ZJ's PEDI scores by test section

DOMAIN	Before Treatment	After Treatment
Self-Care (functional skills)	<10	<10
Mobility (functional skills)	25	28
Social Function (functional skills)	<10	<10
Self-Care (caregiver assistance)	<10	12
Mobility (caregiver assistance)	44	44
Social Function (caregiver assistance)	15	21

Hypothesis 3: Increases by the child with ASD in daily participation and function within the family, resulting from TL treatment, will positively affect parental stress.

AE's mother's stress increased in regard to his Hyperactivity/Distractibility. This increase was off-set by improvements in AE's mother's stress in the categories of Mood (stress related to AE's mood) and Reinforcing Parent (interactions between child and parent producing good feelings for the parent), resulting in an overall score improvement in the Child Domain (Figure 14). AE's mother's PSI profile for the Parent Domain reflected that she perceived greater freedom in her role as a parent (Role Restriction), but rated her overall health as lower; creating zero change in scores (score of 103) for the Parent Domain (Figure 15). The Total Stress score decreased post-treatment (277 to 258), while the Life Stress score (an indicator of the presence of stressors outside the parent-child relationship) rose (9 to 13). This may indicate that, while other aspects of the mother's life had caused additional stress during the treatment, her relationship with her son had improved such that her Total Stress had decreased.

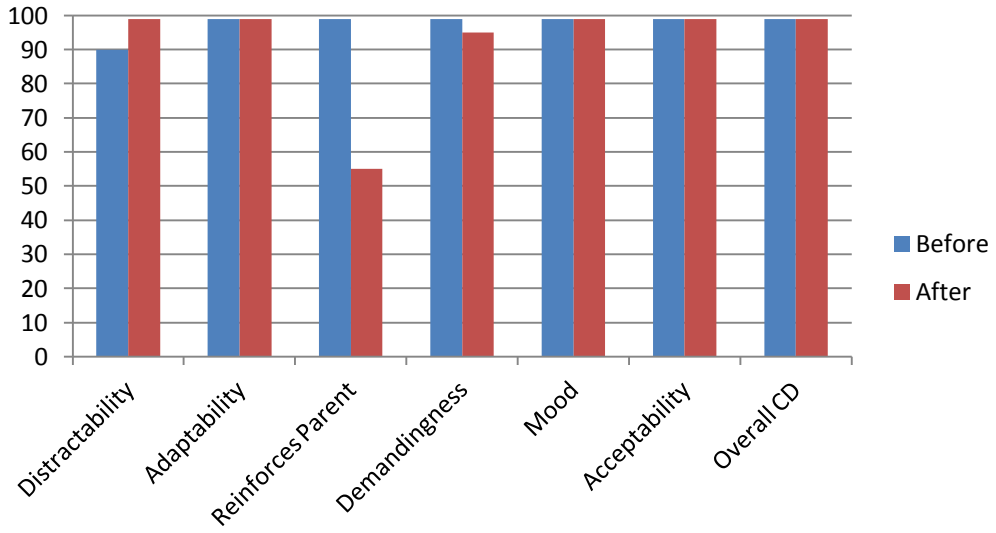

Figure 14. Child Domain, AE's PSI. Percentile rank of scores.

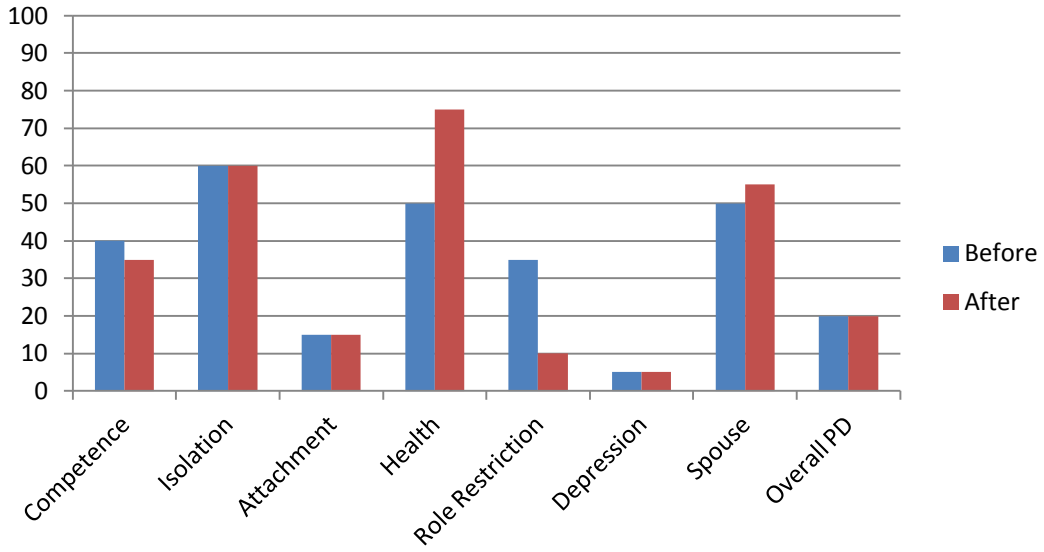

Figure 15. Parent Domain, AE's PSI. Percentile rank of scores.

For ZJ's mother, scores in both the Child and Parent Domains decreased (Figures 16 and 17), with the most notable drops in stress in the Child Domain related to the ZJ's Distractability/Hyperactivity, Mood, and Demandingness. ZJ's mother's stress related to her feelings of Competence as a parent, and Role Restriction improved; and her feelings of depression related to her son improved dramatically. Overall stress related to her relationship with ZJ and parenting decreased from 321 to 271, but still remained above the 90th percentile. Like AE's mother, ZJ's mother's PSI profile also reflected an increase in life stressors outside the parent-child relationship (Life Stress, Figure 18) but a decrease in Overall Stress (Figure 19).

Table 17 details the percentile rank of the score for each item on the PSI given by both mothers. For several scores there was a change of more than 10 percentage points, and in the Parent Domain for ZJ's mother, a change in scores occurred that brought the score within the range of acceptable normal, as defined by Abidin (1995) based on normative sampling.

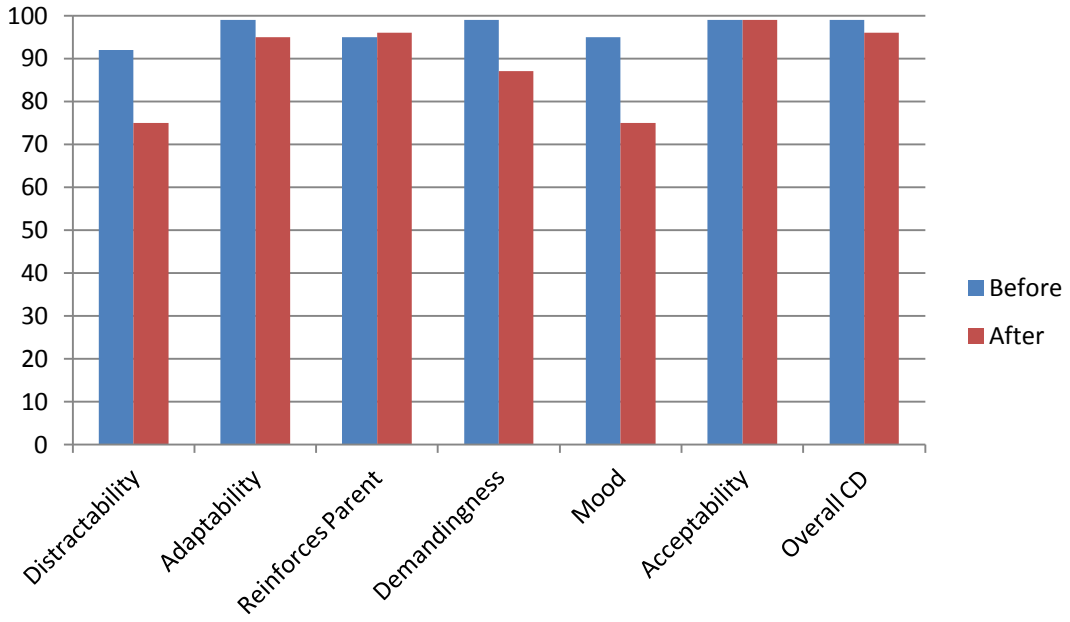

Figure 16. Child Domain, ZJ's PSI. Percentile rank of scores.

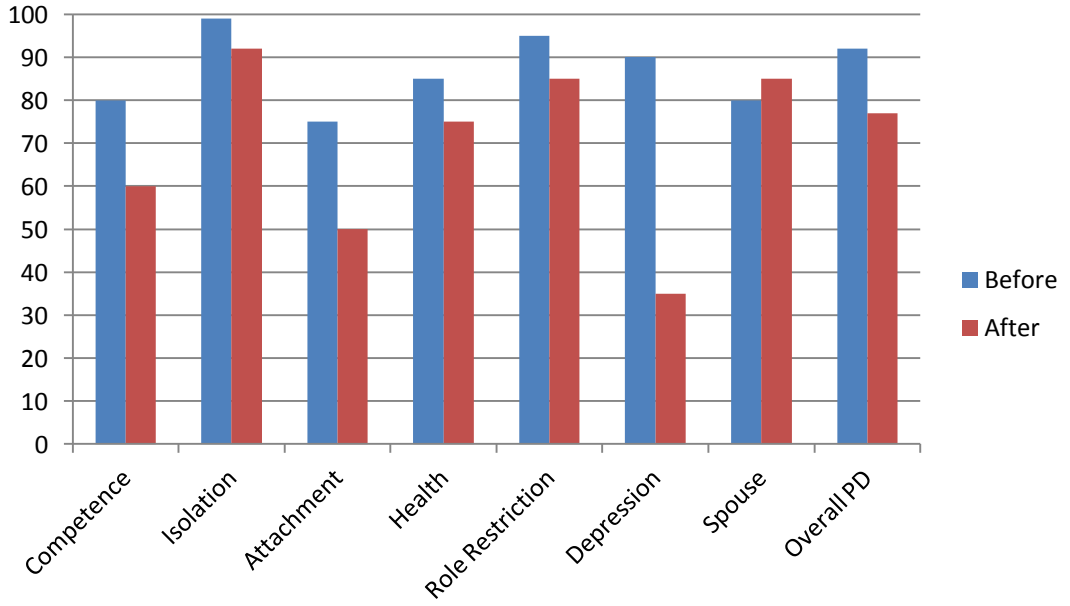

Figure 17. Parent Domain ZJ's PSI. Percentile rank of scores.

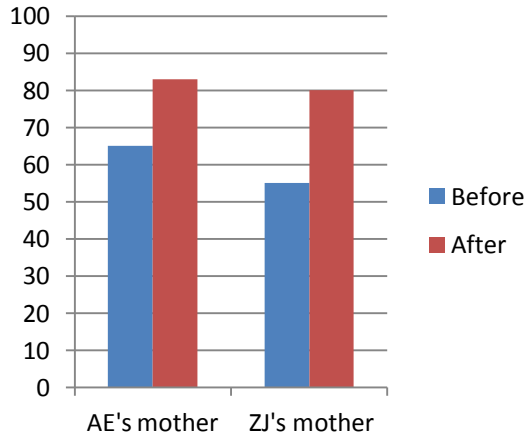

Figure 19: Life Stress, PSI. Percentile Rank of scores.

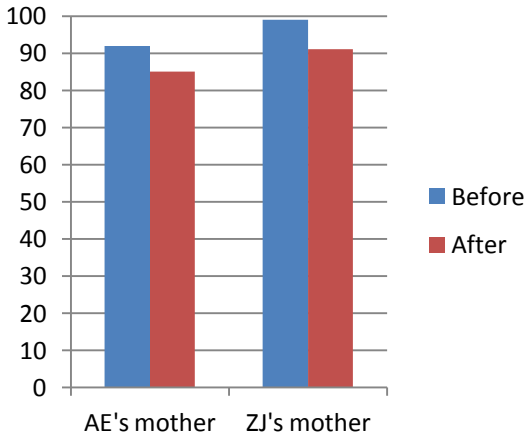

Figure 20: Overall Stress, PSI. Percentile rank of scores

Table 17

Mother's PSI scores reflected by percentile rank

	AE		ZJ	
	Percentile rank BEFORE	Percentile rank AFTER	Percentile rank BEFORE	Percentile rank AFTER
Child Domain				
Distractability/Hyperactivity	90	99+	92	*75
Adaptability	99+	99+	99+	95
Reinforces Parent	99+	**55	95	96
Demandingness	99+	95	99+	*87
Mood	99+	99+	97	*75
Acceptability	99+	99+	99+	99+
Overall Child Domain	99+	99+	99+	96
Parent Domain				
Competence	40	35	80	*60
Isolation	60	60	99+	92
Attachment	15	15	75	*50
Health	50	*75	85	*75
Role Restriction	35	*10	95	*85
Depression	<5	5	90	**35
Spouse	50	55	80	85
Overall Parent Domain	20	20	92	**77
Overall Stress				
Total Stress	92	85	99+	91
Life Stress	65	*85	55	*80

* indicates scores the changed more than 10 percentage points between Pre- and post-testing.
** indicates scores that dropped into the range of normal post-treatment.

Parent Program Post-Treatment Survey.

AE's mother rated the overall value of the TL program very highly; strongly agreeing with all statements regarding the program's effect on her child and strongly agreeing with all statement relating to "ease of use" of the program, She strongly agreed that AE was more independent in self-care, but was neutral on whether caring for him had become easier (perhaps due to the increase in hyperactivity and demandingness indicated on the Child Domain section of the PSI); she "agreed" that daily routines took less time at the end of 16 weeks of treatment than they had before treatment (Table 18).

AE's mother "strongly agreed" that her son's social skills had improved after treatment, with the exception that she was neutral on his being "calmer than he was four months ago". The results of AE's mother's responses on both the PSI and the Post-treatment Survey indicate that the TL program was not overly burdensome to use, that she considered the program worth her time and effort.

Table 18

AE, Results of Post-treatment Parent Survey Regarding Therapeutic Listening®

Statement of Evaluation	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
OVERALL VALUE					
TL was effective for my child					X
TL made a difference within our family					X
I appreciate the TL program					X
I would like to see my child continue TL					X
I would recommend TL to another parent with a child like mine					X
EASE OF USE					
TL was easy to use everyday					X
TL required an excess amount of my time	X				
I was able to follow the TL program with Minimal Effort					X
The TL program added stress to my life	X				

Table 18 continued

Statement of Evaluation	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
EFFECT ON DAILY ACTIVITIES					
In the last four months, my child has gained skills that help him take care of himself.					X
My child can do things he couldn't four months ago					X
Caring for my child has become easier in the last four months			X		
Daily routines take less time than they did four months ago				X	
SOCIAL SKILLS					
My child communicates better than he did four months ago					X
My child is more engaged than he was four months ago					X
My child is calmer than he was four months ago			X		
My child can better make his needs know than four months ago					X
My child can participate in activities with others better than he could four months ago					X

ZJ's mother agreed with all statements regarding the program's effect on her child and strongly agreed with the statement that she would recommend TL to another parent with a child like hers. She agreed that the use of the TL program was not stressful and required minimal effort. She was overall neutral regarding statements that the program allowed ZJ to become more independent in self-care. ZJ's mother agreed that ZJ was calmer and more engaged than before treatment, but was neutral regarding any increase in his communication skills (Table 19).

Comprehensively, this study shows that all three children showed behavioral gains, either in social skills, daily life role participation, or both. The two parents who completed the program within the study reported changes in stress level. These promising results suggest that further research is warranted.

Table 19

ZJ, Results of Post-treatment Parent Survey Regarding Therapeutic Listening®

Statement of Evaluation	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
OVERALL VALUE					
TL was effective for my child				X	
TL made a difference within our family				X	
I appreciate the TL program				X	
I would like to see my child continue TL				X	
I would recommend TL to another parent with a child like mine					X
EASE OF USE					
TL was easy to use everyday			X		
TL required an excess amount of my time		X			
I was able to follow the TL program with Minimal Effort				X	
The TL program added stress to my life		X			
EFFECT ON DAILY ACTIVITIES					
In the last four months, my child has gained skills that help him take care of himself.			X		
My child can do things he couldn't four months ago				X	
Caring for my child has become easier in the last four months				X	
Daily routines take less time than they did four months ago			X		
SOCIAL SKILLS					
My child communicates better than he did four months ago			X		
My child is more engaged than he was four months ago				X	
My child is calmer than he was four months ago				X	
My child can better make his needs know than four months ago			X		
My child can participate in activities with others better than he could four months ago				X	

CHAPTER 5: Discussion

There are many common observations of behaviors related to lack of communication, lack of orientation to or hypersensitivity to sound in children with ASD; there is also research from a variety of fields on differences in auditory processing in children with ASD. These facts help explain the continued interest in auditory treatment methods for these children. There are many methods of auditory treatment available, but few have been subject to study within the community of children with ASD. This study sought to examine the social and functional effects of one of the methods available, Therapeutic Listening®, in the absence of any additions or changes to the occupational, speech and physical therapy already being received by three subjects.

While TL is not intended to be used as a stand-alone treatment (Frick & Young, 2009), this study focuses strictly on the effect of TL in the absence of conjunctive therapies suggested by its designers to more clearly establish what treatment effects can be derived from TL treatment alone. Hopefully, future research can incorporate sensory-based and vestibular interventions, such as Ayres Sensory Integration® and Astronaut Training©, allowing a study of the comprehensive approach to the treatment of ASD that is practiced in clinics around the world (Frick &Young, 2009).

Summary of Findings

While the nature of this study does not allow for a direct causal link between the use of TL and improvements in the children's function and parental stress, clear improvements were seen in all three subjects. All three subjects exhibited gains in socially-acceptable behaviors and communication. AE and ZJ made gains in their GAS goals reflecting participation in daily routines.

Mothers of AE, ZJ, and CW (who participated in only a portion of the study) reflected that they valued the TL program and felt it was beneficial for their child. The most consistently positive outcome in the case of both AE and ZJ was the reduction of parent-child interaction related stress post-treatment. Both mothers reported less stress related to their child with ASD, and some of the individual items in the Child Domain section were decreased enough to fall within normal limits. This contrasts greatly with the pre-test scores in the Child Domain which were all well above typical limits for all parents. For mothers of AE and ZJ, whose children completed the study, their stress related to their life independent of their children increased, but their overall level of stress decreased. These decreases in stress experienced by the mothers are positive indications that the changes in the child's behavior elicited by TL allowed for less-stressful child-parent interactions and improved the child-parent dynamic.

Special notes on AE.

The most substantial gains were made by AE, who exhibited gains in all four of his GAS goals. His scores on the PEDI improved, particularly in reference to the amount to caregiver assistance needed. His scores on the CARS did not change overall because gains made in the area of listening response were offset by an increase in his activity level. At the beginning of treatment, AE was obsessed with trains and his focus was poor for any other task. After TL

treatment, he had a broader range of interests and engaged with toys other than trains, bringing the researcher drawing toys and dolls during our weekly sessions. This newfound interest in the items around him appeared to create a situation in AE became distracted by novel items. As he was drawn to explore items in his environment his activity increased. It is possible this newly developed distractibility could have been addressed had his TL program progressed beyond the 16th week, as refining attention is a common focus of TL intervention.

During the baseline period, AE had some functional vocabulary and his arousal level was appropriate in some situations. However, before treatment, he was ineffective at meeting his own needs, reverting to whining for assistance. Using the theoretical base of the TL program (Frick & Young, 2009), his behaviors were interpreted to indicate that he lacked the ability to search his surroundings due to poor spatial and temporal awareness. Within the first weeks of treatment two discs were chosen to address these deficits (Disc Ease 4 and Nature Pop-Modified). As his awareness of his surrounding space improved, he became more adept at understanding his position in a situation, such that if he asked for or his cup, his mother would point to it some distance away and he could follow this gesture to retrieve it. As his program progressed, other discs were added to enhance his ability to understand verbal communication; AE gained skill in meeting his needs with verbal prompts.

Special notes on ZJ.

When ZJ entered the study, he was very disconnected from the world; he did not respond to his name or activity within a room and he focused intently on spinning objects repetitively (cups, toys, coins, etc.). He was non-verbal and required maximum assistance with all daily tasks. During the first part of ZJ's course of therapy, he tolerated the headphones with minimal assistance, but he displayed none of the typical cues that he was hearing the music (e.g., a

quieting of movement, a momentarily unfocused gaze, or tapping to a beat). There is a possibility that, because he had not been attending to information in the environment, the TL music was initially simply incorporated into the background that he had been ignoring for most of his life. The first discs in ZJ's sequence were chosen to break through his resistance to being engaged by his surroundings (Disc Ease 2 and 3). Engagement took longer than is typically expected with the TL program. It is possible there was a threshold of experience with the music through headphones that had to be reached before he could begin to listen to the content of the music. Only after a lengthy period of time, perhaps allowing threshold to be reached, was ZJ able to demonstrate that he had gained listening skills, incorporating these skills into his daily life.

Since the study ended, ZJ has continued TL therapy and has begun adjunct vestibular and sensory integration therapy with the clinical researcher who supervised his participation in the study. He has used his first word ("eat"), can complete simple puzzles independently and remains seated for up to 15 minutes during tasks in the clinic without needing cues to maintain attention. He no longer spins objects persistently, and often uses them for their intended purpose without cueing. These improvements suggest that a longer course of TL intervention and a more comprehensive course of treatment were needed to achieve functional improvements.

CW: Anecdotal evidence.

As noted in results, CW was unable to participate in the program sufficiently to include her data in this analysis and interpretation. None-the-less, she too exhibited changes that are potentially attributable to TL. Initially CW was also disconnected from her surroundings, but unlike ZJ who became engrossed in visual stimuli to distract himself from the world, CW was constantly seeking vestibular and tactile stimulation. She would climb to heights, persistently rub items she held and become upset if they were taken away, and tore books, toys and furniture

apart. Although measurements throughout the 16 weeks were not possible, anecdotal evidence from her mother indicated that CW became calmer, more engaged and communicative, and ceased climbing to heights. It was observed by the clinical researcher that she was no longer as upset by transitions into, between, and home from therapy. Most interestingly, CW's modulation of her arousal level was improved such that she began sleeping through the night. Her mother had not mentioned poor sleep habits in the initial interview, and as such improvements in sleep behavior were not included in her GAS goals. Perhaps this was due to the fact that lack of sleep was such a long-standing problem that CW's mother did not think TL could affect it. However, CW's mother noticed the change in CW's sleep patterns very soon after treatment began and attributed the change to her participation in TL. This was verified by CW's return to broken sleep patterns in the absence of TL.

Relationship to Previous Research

The most-frequently studied alternative method of auditory treatment, AIT, has shown inconsistent results for children with ASD, such that three reviews of its effectiveness (Sinha etal., 2009; Dawson & Watling, 2000; American Academy of Pediatrics, 1998) found it could not be recommended as a treatment for ASD. It was hypothesized in the current study that TL, being of longer duration and more adaptable to the child's natural environment, would produce more consistent results in regard to children with ASD's communication, social skills and overall function. The results of this study indicate that TL treatment created an opportunity for unique gains in communication and daily participation for three children with ASD. All three mothers involved in this study reflected their belief in the value of TL treatment and indicated their child made appreciable gains due to TL. In addition, TL has other features that make it a potentially

better choice than other forms of auditory intervention: affordability and adaptability for families using the program.

The results of this study support the work of Hall & Case-Smith (2007), who studied the use of TL in children with sensory processing disorders and visual-motor delays, and Nwora & Gee (2009) who studied the effects of the Therapeutic Listening Program® (TLP), a program similar to TL in theory, flexibility of approach to treatment, and treatment length. Both of these studies found that their respective auditory treatment programs positively affected auditory processing, reflected in increases in behavior such as following verbal directions or reacting when asked to stop a negative behavior. All three subjects involved in the current study demonstrated improved auditory processing, as reflected in increased communication (CW's use of words/signs consistently, AE's asking for items from his sister) and ZJ's increased engagement and situational awareness (increase in play participation and imitation), as well as improved scores in the Listening Response section of the CARS for both children who completed post-treatment testing.

The only published study of TL involving preschool age children found accelerated rates of development in fine motor, gross motor, verbal communication and non-verbal communication (Bayzk et al., 2010). While measures of fine and gross motor development were not used here, measures of communication did improve (GAS goals related to communication and CARS scores regarding communication and relating to people).

The data on listening programs other than AIT is limited. And the information that is available is at the lowest levels of evidence; this includes the current study. Thus, while this study offers some support for the clinical use of TL with children with ASD, more research is needed. Further, TL was used in this study without specific combination with other therapies,

and this is not the ideal approach. Frick and Young (2009) state that "using sound for enhanced sensory input is a powerful sensory integration modality" (p. 43) and go on throughout their book and in training classes for TL practitioners, to emphasize the need to pair TL with interventions involving vestibular input, core musculature awareness, breath exercises and other sensory inputs. However, the improvements produced through the use of TL in conjunction with unknown speech therapy, occupational therapy and physical therapy interventions provide initial tentative support for the role of TL in a program of treatment for children with ASD. Because the types of other interventions in therapies for the children were not known, it remains to be seen if TL would be more effective as part of an overall sensory integration approach.

Parenting stress involved in caring for children with ASD has been found to be higher than parenting stress involved in parenting children with other special needs or for parenting children without special needs (Mori, Ujiie, Smith, & Howlin, 2009; Davis & Carter, 2008; Hastings et al., 2005). The scores reported by all three mothers support these conclusions. Studies have also drawn correlations between severity of impairment in the child with ASD and parental stress (Lecavalier, Leone, & Wiltz, 2006; Tobing & Glenwick, 2002). Tobing and Glenwick divided children (N=31) by diagnosis of ASD or PDD-NOS. They found the mean score on the CARS to be 35.2 in the ASD group, close to the score (both pre- and post-treatment) for AE, also diagnosed with ASD. The mean PSI score in this group of mothers was 274, close to the Overall Stress score obtained by AE's mother's. Tobing and Glenwick found the mean CARS score for PDD-NOS to be 25.6, much lower than that found pre-treatment in the current study for ZJ (48), indicating that the severity of autism (or PDD-NOS in this case) was more severe for ZJ. In parallel with this, ZJ's mother's Total Stress score (pre-treatment) on the PSI was much higher (321) than the mean reported by Tobing and Glenwick of 252. Thus the

findings in the current study are very consistent with those reported in the literature: parental stress is high for parents of children diagnosed on the autism spectrum, and the degree of stress parallels the severity of autistic behaviors. Interestingly, in the current study, the post-treatment results reflect both increases in the children's social communication and life role function on the CARS, and decreases in parenting stress related to the child. While the overall CARS score for AE did not change, these specific areas did change; ZJs overall CARS scores decreased following the study. The post-treatment decrease in PSI scores related to interacting with the child, paralleling the changes in autism severity noted, suggests that TL could have an impact not just on the child, but also on the parent.; this agrees with previous research.

Lessons Learned and Study Limitations

Hindsight is 20/20; and viewing this study in retrospect, several themes emerge. The use of a single-subject research design yielded a wealth of information, that was, at times, unwieldy, but contained information that may not have been possible to gather in a study involving a larger number of subjects. The equipment problems experienced by one of the subjects that resulted in her exclusion from the study hindered the broader range of data that may have been available. And the results of this study offer the opportunity to reflect in the positives and negatives of collaborative research involving the parents of children with ASD.

A single-subject research design (SSRD) was chosen for this study to best capture the individual changes unique to each of the children participating. The criteria for SSRD outlined by Backman, Harris, Chisholm and Monnette (1997) were met in this study. Because of the almost complete absence of previous research on children with ASD and TL therapy, it was not possible to predict with accuracy what measures would be most likely to reflect the changes that might occur in the children's behavior as a result of TL. Therefore, greater concentration on a

few individual children was likely to yield a greater wealth of information (Rapoff & Stark, 2008; Zhan & Ottenbacher, 2000).

The depth of information made possible by the SSRD allowed a multi-faceted study of not only the child's improvement, but the impact on the family (in this study, the mother). This aspect of the study yielded the most consistent result between the two subjects that completed post-treatment testing, changes noted in the PSI. It is interesting that the responses of both mothers were similar and indicate that TL had a positive effect on their family dynamics. According to Backman et al., "[if] a clinically significant change occurs as a result of the intervention, then the study must be replicated…to accumulate evidence to strengthen external validity" (p. 1145). The consistency of positive responses between the two subjects is an indicator that examination of perceived parental stress should be a measure in future research on TL, either as a primary focus of data collection or as an adjunct to data regarding the child's behavior and performance.

Although parents did not report any difficulty in the administration of the TL program, the possible equipment problems experienced by ZJ, and the fact that CW was not able to complete the study, highlight a problem with TL's home-based treatment that must be addressed in future studies. Vital Sounds (the company that produces TL) has begun offering the music program loaded onto computer chips that are played on a digital music player, which can be mounted out of the child's way on top of the headphones. This addresses issues with the wires experienced by CW and also eliminates "skipping" and dysfunction created when a CD is scratched or otherwise damaged. This is a necessary adaptation that will potentially make the administration of TL treatment more consistent and less susceptible to equipment malfunctions.

A unique aspect of this study was the collaborative nature of the data-gathering, though

GAS scores. While the PEDI provided an objective measure of the daily function of the child, GAS was more subjective. Previous research indicates that items on the PEDI do not encompass all the daily interactions and functions a child might participate in that have value to the family or the child. Both GAS and PEDI measures may be needed to be inclusive of valuable treatment goals (Steenbeek, Gorter, Ketelaar, Galama, & Lindeman, 2011). The use of multiple outcome evaluation tools that combine objective measurement with family-/client-centered methods of goal-setting and data-collection was a valuable facet of this study.

While measures of parental stress and the parent-completed rating of the program were subjective measures intended to capture stress created or relieved by the use of TL for the mother and child, GAS scoring was intended to be an objective measure of the child's performance. As originally conceived, GAS measurements were to be validated by additional observers of the child's behavior through video-reviewed performances. This was not possible due to the nature of the GAS goals chosen by the parents; goals addressing issues of a personal nature or requiring the child's overall performance for the day to be assessed. Because the parents' assessment of their child's performance was not validated by another source, it cannot be deemed reliable and may have been influenced by rater-bias (as outlined by King et al., 2000). However, GAS measurement allowed a catalog of the parent's belief that their child's performance changed or remained the same, and therefore it has value to the collaborative research process.

Parent-participation allowed the parents to reflect on the value of this program in their lives and the lives of their children. The benefit of GAS goals was discussed earlier. Both the PSI post-treatment assessment and parental rating of the program in the post-treatment survey indicate the TL treatment created opportunities for the mothers to build more communicative and less-stressful relationships with their child. With so many treatment options and combinations of

treatments currently available to treat ASD, parents can find themselves overwhelmed with choices and unsure of how to evaluate a treatment program's effectiveness for their child. This type of cooperative research may be important to parents assessing the wide variety of ASD treatment options and help them become better consumers of treatment for ASD. If a treatment is not creating an opportunity for the child to build a better bond with the family, participate more in the family's life or create better feelings for the parents of that child, then is there a benefit in that treatment? This may be a question researchers should consider when designing future research regarding ASD treatment.

Directions for Future Research

Although all three children were diagnosed with some form of ASD, each began the treatment at a different level of function and presented differently. These differences in initial presentation of course influenced outcomes. Differences in presentation and behavior of children with ASD should be taken into account when estimating how long TL treatment might need to continue to be effective. Bayzk (2010) used a variable treatment length of TL, from 6 to 20 weeks, allowing the attainment of goals to determine at which point treatment was considered to be completed. This may be more appropriate, as opposed to the uniform treatment length chosen for this study, given the variability among children with ASD and in outcome goals.

It may also be beneficial to segment subjects in future studies by types of behaviors (such as agitation, non-compliance, or social withdrawal). The Aberrant Behavior Checklist, used in many of the AIT studies, and the Sensory Profile, often used in research with children with ASD, are both measures capable of discriminating groups of children based on their behaviors (Karabekirolgu & Aman, 2008; Dunn, 1999). Perhaps these or similar measures used to classify

children with ASD will create an opportunity to refine prediction of treatment sequence, length of treatment and expected gains.

The PSI was a measure that allowed an aspect of ASD treatment other than the child's performance to be studied; one that can be overlooked in clinical treatment—the effect of ASD treatment on the family dynamic. This was very valuable information in assessing the value of TL therapy and the results paralleled those obtained from the study-designed Post-treatment Survey. However, the PSI was constructed involving parents of the general population, with a wide variety of children and circumstances. Previous research on parenting stress and ASD has noted that the levels of stress reported on the PSI in parents of children with ASD often far exceed the norm (Tobing & Glenwick, 2002, Abidin, 1995). The Autism Parenting Stress Index (Silva & Schalock, 2011), currently in development, takes the unique situations involved in parenting a child with ASD into account, and will be scaled for this population. It may be more sensitive to change in parenting stress. In future research, The Autism Parenting Stress Index may be a better choice to capture the data related to whether any ASD treatment has a positive impact on the family's relationship.

While the results found here indicate overall positive changes for these children participating in TL while receiving other, unconnected therapies, it was never intended to be a stand-alone treatment (Frick & Young, 2009). TL was designed to support a program of sensory-based treatment and to be used in support of therapeutic activities, including vestibular activities, postural and breath activities, and movement activities (Frick & Young, 2009). However, the complexity of multi-faceted programs is difficult to investigate. Before a comprehensive program of ASD treatment that involves TL as one aspect, could be studied it was important to examine TL as a singular form of treatment. This study provides some evidence that even alone

TL can be shown to have some effectiveness. Future studies could compare TL alone to TL linked with other sensory-based therapies, consistent with TL theory.

This study adds to our current understanding of listening programs in general, and TL more specifically. Findings in this single-subject study suggest that the TL program has definite, although somewhat limited, potential as a stand-alone treatment for children with ASD. However, the nature of SSRD does not allow for generalization to the population of children with ASD, but a larger study of TL is warranted by the positive results seen here.

A study regarding a comprehensive, controlled program of TL, vestibular and sensory integration treatment may result in more profound and robust outcomes. A structured study of a complete OT intervention program utilizing a sound-based treatment like TL would also be a logical progression of the work done here.

This study is a beginning step in evaluating TL as a treatment tool in addressing the needs of children with ASD. While the results are encouraging, the dropout of the third subject and equipment difficulties are problems that could be avoided in future research. The outcomes of this study indicate a positive effect of TL for children with ASD in social skills, daily functional skills and listening response. This work can be added to the forming foundation of research into TL as a treatment modality for children with ASD.

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Vita

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