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Changes in Auditory Processing After Completing the Listening Program Training

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ABSTRACT

Professionals may recommend listening therapies for people identified with auditory processing problems. A concern arises whether the therapies have evidence supporting changes that occur after completing such training. The authors looked at a large sample of people over a wide age range who completed TLP training. Using each individual as his/her own control, the following study was undertaken. Files of people ranging in age from 5-year to 50-year old for people who had completed TLP training were evaluated. Assessment was completed via results of the SCAN test of auditory processing both before and after completing training. Analyses of changes on the SCAN were computed via paired samples t-tests. Measures found significant improvements with large effect size improvements. Findings support a conclusion that one should expect improvements in auditory processing abilities in people completing TLP training.

Introduction

Many professionals are recommending the use of listening therapies for people they identify having some auditory processing problems. What is interesting is that many of these therapies are being used, but research is limited regarding the success of listening therapies for persons with sensory processing problems including auditory processing difficulties.

One listening therapy that has been used is the Tomatis program (www.tomatis.com). Gilmor (1999; published on-line in 2012) evaluated the effectiveness of the Tomatis Method treatment on children with learning and communication problems. Gilmor completed a meta-analysis looking at findings from five research studies investigating changes (pre- versus post-treatment) on five areas including one area being auditory processing. However, Gilmor's findings showed the smallest effect size for this auditory processing area, which could be due to the measures employed.

A more recent study by Ross-Swain (2007) looked at changes in auditory processing for 41 participants (age range 4 years to 19 years old) after they completed Tomatis Method treatment. Ross-Swain looked at changes in auditory memory, auditory sequencing, following directions, auditory discrimination, and auditory cohesion. Using a comparison of pre- versus post-treatment statistical analyses, significant improvements were found in all areas investigated.

In addition to research looking at improvements in listening/auditory processing abilities after completing Tomatis Method training, other research has been provided investigating a method called The Listening Program (TLP) (www.advancedbrain.com). Vargas and Lucker (2016) investigated studies looking at pre- versus post-TLP treatment using more than just single cases. To strengthen their analyses of the outcomes from TLP, they completed a meta-analysis of these studies with interesting findings. What they did was calculate the effect size of each study that used at least four participants and then looked at the overall findings from studies that used similar pre- and post-therapy measures.

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Interestingly, the studies that looked at changes in auditory processing found very large effect sizes based on outcomes from the SCAN-A test for adolescents and adults (Keith, 1994), and for children, the SCAN-C test (Keith, 1999a).

Effect size looks at improvement in statistical terms based on the number of standard deviations found for the changes measured. Thus, an effect size of 1.00 is a one-standard deviation improvement. An effect size of 0.70 (i.e., 70% of a standard deviation) is considered a large improvement. For the studies that looked at changes in auditory processing based on the SCAN-C test, Jeyes (2013) yielded an effect size of 1.19 based on a sample of 12 children. Butler and Clark (2003) yielded a moderate effect size of 0.51 on a sample of 20 children. Harris' data, combined (2002a, 2002b) also yielded a moderate effect size of 0.56 on a sample of four elementary school children. Additionally, Lawrence and Davies (2003) found a slightly weaker but moderate effect size of 0.49 based on adults tested with the SCAN-A (Keith, 1994). However, when these studies were combined so that a larger sample size was obtained, the effect size for improvements on the same subtests for the SCAN-C and -A combined yielded a value of 0.72 which is a large change. In view of the fact that one study yielded an effect size over one-standard deviation (Jeyes; effect size of 1.19) and used the largest number of participants, it was questioned whether a large and significant change might be seen in a very large sample of participants if the same auditory processing measures were administered to children (SCAN-C) and adults (SCAN-A).

A third listening therapy is one called Integrated Listening Systems (iLS) (www.integratedlistening.com). Evidence-based research has also been completed on this listening therapy (Kaul & Lucker, 2016; Reeves & Lucker, 2017). Findings revealed very significant improvements in auditory processing abilities when iLS was combined with other auditory training programs.

Considering that some evidence of improvements in auditory processing abilities are found following training using a listening therapy, it was felt that a study using a very large sample would provide good support that auditory processing can be improved following the use of a listening therapy, specifically TLP. Thus, the following research study was undertaken. The research questions posed included:

(1) What changes in auditory processing abilities, based on SCAN test results, would occur in a large group of participants after completing TLP training?
(2) Would these changes be related to age?
(3) Would these changes be related to gender?

Results of such investigation would add evidence-based information that TLP can improve auditory processing abilities, which would support the value in using such a listening program with people who are found to have auditory processing disorders. Additionally, positive outcomes would provide the needed evidence-based research identified as missing by various professional associations (American Academy of Audiology, 1993; American Speech-Language-Hearing Association [ASHA], 1994, 2003, 2004; Educational Audiology Association, 1997).

Method

Participants

A file review was conducted on clients who had completed auditory processing testing before and after undergoing TLP training. All clients had undertaken treatment and testing prior to the inception of the current research. Thus, this was a retrospective study using the information of 456 clients from this file review to extract performance data for analyses in the present study. When clients came for training, they were informed that their data may be used in the future as part of a research study. Thus, clients enrolling in the TLP training, or their legal guardians, signed an agreement that they would undergo the pre- and post-training testing and complete the TLP

training, and their test data, and comments they make about the training, might be used in a future research study. The Institutional Review Board of Howard University approved the file review for this study.

The study included 166 males and 290 females ranging in age from 5 years to 50 years with a mean age of 10 years (standard deviation of 8.38 years). All subjects were originally seen by one of the authors (TB) at Links to Learning Center in Australia where they received listening therapy using The Listening Program (www.advancedbrain.com).

All participants or caregivers of the younger participants completed the Listening Checklist from Advanced Brain Technologies. This checklist asks the rater to identify concerns related to listening, language (receptive and expressive), sensory-motor skills, behavioral and social adjustment, level of energy, developmental history, and environmental history. The persons completing this checklist also complete a client history form that included information regarding birth, development, academics (especially for children) and history of any medical evaluations and diagnoses. Factors regularly used at Links to Learning as criteria to identify clients appropriate to receive TLP treatment included: reports of a history of developmental delay, frequent ear infections, observed poor listening skills, unsettled behaviors, problems with social interactions, and language delays. Additionally, each individual had to score below −1 standard deviation on at least one of the subtests of the SCAN test (C for children, Keith, 1999a; A for adolescents and adults, Keith, 1994). These are factors Links to Learning uses on a regular basis to identify appropriate clients to receive TLP treatment. Thus, each individual met the usual criteria used at Links to Learning to receive such treatment and, thus, were not chosen specifically for a research study.

Equipment and materials

The SCAN-C (Keith, 2000) and -A (Keith, 1994) were the tests used to evaluate the auditory processing abilities of all people whose data were used for analyses. These tests are standard measures of auditory processing having four subtests which were used for evaluating pre- and post-therapy auditory processing abilities. The SCAN-C and -A tests were chosen because they are widely used, standardized measures of auditory processing abilities in children, adolescents and adults. Keith (2008) found the SCAN-C to be a valid measure of auditory processing abilities in children with very good test-retest reliability. Then in 2008, Keith identified the validity and reliability of the SCAN-A for use with adolescents and adults.

The four subtests of the SCAN used in the present study included the following. The first subtest is Filtered Words (FW) in which single syllable, prerecorded words are presented to the listener one ear at a time. These words are electronically filtered to distort the phonemes (sounds) in the words. Auditory Figure-Ground (AFG) is the second subtest in which prerecorded, single-syllable words are again presented to each individual ear, but the words are mixed electronically with speech babble as background noise. The third subtest presents prerecorded, single-syllable words with two words presented simultaneously, one word to each ear. This is known as a dichotic listening situation. Since the words "compete" with each other for the brain to process each word, the subtest is known as Competing Words (CW). The last subtest also uses competing auditory messages, but this time the messages are simple sentences. A sentence is presented to each ear, simultaneously, in a dichotic listening mode. In this Competing Sentences (CS) measure, the listener is instructed to repeat only one sentence, from a specific ear with the first half of the test repeating only the sentence heard in the right ear and the second half only the sentence in the left ear.

Individual ear values are summed for each subtest of the SCAN to obtain the raw score for each measure. The norms provided are for scaled scores and percentile ranks for each of the subtests based on chronological age level. Thus, a seven-year-old child's performance would be scored based on the seven-year-old norms. Percentiles above the 16th are considered normal. Thus, deficits were identified when percentiles were below the 16th for each subtest. As stated above, if the participant failed one subtest, then the results were considered an indicator of abnormal auditory processing for

that individual. For the present study, the percentiles for each subtest pre-TLP training and post-TLP training were compared to determine what differences were found after this training was completed.

For testing and TLP training, the individuals wore Sennheiser HDA280 headphones. These are considered "closed headphones" which block out background noise from the environment (see Poulsen & Oakley, 2009). The SCAN tests were administered from a SONY Discman CD player.

Procedures

All subjects whose data were used in the present study were seen for pre- and post-treatment evaluations via the SCAN test in a quiet, distraction-free environment. For children, at least one parent was present throughout the testing to calm the child and allow the child to feel safe. Each person was fitted with the Sennheiser HDA280 headphones, and then the four subtests of the SCAN were administered and scored (by TB). People who were evaluated and were identified as having problems listening based on: at least one measure of the SCAN being below 16th percentile and having identified concerns with listening and auditory processing based on the ratings on the Listening Checklist and from their case history information were identified as candidates to undergo TLP training. The training was completed by the individual participant. For children, parents undertook to monitor their child's treatment. Whether the parent or individual monitored his/her treatment, initial training involved teaching the monitor how to handle the TLP equipment and recordings.

Each participant completed a minimum of two 15-min listening sessions per day, 5 days per week for approximately 10 months. Thus, on average, each participant completed about 100 listening hours of TLP therapy.

All treatments were completed in the individual's home under the individual's self-guidance, for adults, or guidance of the parent or a caregiver for children. Specific listening schedules were developed for each individual participant based on that individual's needs. The general structure for the schedule for listening followed the framework that the developers of TLP recommend (see www.advancedbrain.com). Schedules were modified and customized for each participant depending on the person's age, described difficulties in auditory processing, and presenting behaviors. The schedule was also modified, as needed, accommodating how the person responded to the treatment. In most cases, there was additional time given in the Sensory Integration and Speech and Language zones of TLP training.

Most people began their listening therapy about 1 month after the pre-therapy evaluation was completed. Post-therapy testing was typically completed within 30 days of completion of the segments of TLP used.

Results

Results of the present study based on the retrospective file review included comparison of pre- and post-treatment evaluations for the four subtests of the SCAN including the range of scores as well as the means and standard deviations for each subtest before and after TLP treatment are presented in Table 1. Review of this table indicates that large improvements were seen on the post-treatment test findings compared with the initial test results. To determine whether these differences were significant, One-Way ANOVA was calculated for each of the subtests comparing the values for post-treatment versus the values for pre-treatment for each individual subtest of the SCAN. Table 2 presents the results of these calculations.

Review of Table 2 indicates that for all four subtests of the SCAN, the post-treatment findings were significantly better than the pre-treatment results (p = .000). Thus, the findings from the present study indicate that the listeners made highly significant improvements in their auditory processing abilities based on results of their performance on the four subtests of the SCAN test.

The highly significant findings from the One-Way ANOVA led the researchers to question how much improvement was made on each subtest for the whole group. Such improvement can be

Table 1. Ranges, means, and standard deviations for the pre- and post-TLP training for participants (N = 456) in the present study for each of the four subtests of the SCAN.

Subtest	When Tested	Range	*M*	*SD*
Filtered Words	Pre	0.1–91	21.5	20.58
	Post	2–98	59.3	21.60
Auditory Figure-Ground	Pre	0.1–95	18.1	19.47
	Post	1–98	55.6	22.31
Competing Words	Pre	0.1–84	11.8	17.35
	Post	0.1–99	37.6	26.02
Competing Sentences	Pre	0.1–84	19.4	21.29
	Post	0.1–99	40.6	24.77

Table 2. Results of One-Way ANOVA comparing results post- versus pre-treatment for each of the subtests of the SCAN for the whole group.

Subtest	*F*	*df*	*p*
Filtered Words	739.373	1	.000*
Auditory Figure-Ground	738.613	1	.000*
Competing Words	312.492	1	.000*
Competing Sentences	194.171	1	.000*

*Significant $p < .001$.

calculated using what is known as an effect size measure. Effect size is a statistical analysis that identifies the size of the improvement seen between the pre- and post-treatment tests based on the number of standard deviations difference. An effect size (improvement) of 1.00 means that the difference between the two measures changed by one-standard deviation. Furthermore, an effect size of 0.50 indicates that the difference changed by half a standard deviation. Using Cohen's *d* to calculate the effect size for each of the four subtests of the SCAN, results would indicate how much improvement was made after subjects completed TLP training. A positive value would indicate a higher score post-treatment and a negative finding would indicate a decrease in performance. Effect sizes of .70 or higher are considered large improvements, and those above 1.00 are very large improvements. Table 3 presents results of the Cohen's *d* calculations for the four subtests of the SCAN.

Review of this table indicates a very large improvement in SCAN test results for three of the subtests (Filtered Words, Auditory Figure-Ground, and Competing Words) and a large improvement for the fourth subtest (Competing Sentences). Thus, findings from the present study indicate that one should find significant improvements in auditory processing following TLP training.

One other question asked by the investigators related to the fact that participants in the present study covered a large range in age (from 5 years to 50 years). Thus, a question arose whether the significant improvement found for the whole group for each of the subtests could be due to great improvements in some age groups and no improvements in other age groups. If such were true, comparison of test results on the SCAN based on age would show significant differences. Thus, another One-Way ANOVA was computed for each individual subtest for the pre-treatment findings and the post-treatment findings separately. Such analyses could provide input regarding whether the subtests showed significant differences based on age at the start of training and after training was completed. This One-Way ANOVA compared the various ages with the pre- and post-treatment SCAN test findings for each subtest. Table 4 presents results of these analyses.

Table 3. Results of Cohen's d measures for effect size for each of the four subtests of the SCAN.

Subtest	Effect Size *d*	Magnitude
Filtered Words	1.79	Very Large
Auditory Figure-Ground	1.79	Very Large
Competing Words	1.66	Very Large
Competing Sentences	.91	Large

Table 4. Results of One-Way ANOVA comparing results post- versus pre-treatment for each of the subtests of the SCAN for the factor of age.

Subtest	When Tested	*F*	*df*	*p*
Filtered Words	Pre	1.167	30	.253
	Post	.928	30	.563
Auditory Figure-Ground	Pre	1.379	30	.091
	Post	.973	30	.501
Competing Words	Pre	1.743	27	.013*
	Post	1.622	27	.033*
Competing Sentences	Pre	2.077	28	.001**
	Post	1.255	28	.190

*p < .05; **p < .01.

Review of this table indicates that two of the four measures of the SCAN (Competing Words and Competing Sentences) showed a significant age effect on initial testing, and only one (Competing Words) showed a significant age effect on the post-treatment testing. Thus, TLP training showed no differences in subtest performance after training (post measures) for three of the subtests (FW, AFG, CS) based on comparison by age, and for Competing Sentences, the lack of a significant difference after training indicated that the processing task was found to be much easier for individuals than before TLP training for those age groups for which it was difficult before training. The finding that CW showed a significant difference both before and after training based on age indicates that this is a difficult subtest for some age levels, likely the younger ages. Then, as age increases, the task might become easier.

From one of the author's clinical experiences, it is typical that young children find the competing measures of the SCAN more difficult compared with adolescents and adults. However, the lack of significant age effects after TLP training could indicate that this training improved listening making difficult listening conditions (such as Competing Sentence measures of the SCAN) easier for younger people.

The last question asked regarding changes in SCAN test results related to whether any significant differences might be seen related to gender (male versus female). Research has found that girls tend to have stronger language abilities than boys (Leopold, 2008). Thus, there could be differences in SCAN results between genders since the SCAN measures a linguistic unit (words and simple sentences). To evaluate this factor, another One-Way ANOVA was calculated comparing pre-treatment and for post-treatment findings for each of the subtests of the SCAN and gender. Table 5 presents results of these comparisons.

Review of this table indicates there were no significant differences between males and females in the present study.

Conclusion

Results of the present study answered all three research questions. The first question related to changes in auditory processing after TLP training based on SCAN test results. Analyses of the data from the

TABLE 5. Results of One-Way ANOVA comparing results post- versus pre-treatment for each of the subtests of the SCAN for the factor of gender.

Subtest	When Tested	*F*	*df*	*p*
Filtered Words	Pre	.128	1	.721
	Post	.116	1	.734
Auditory Figure-Ground	Pre	.005	1	.944
	Post	.032	1	.858
Competing Words	Pre	.012	1	.913
	Post	.789	1	.375
Competing Sentences	Pre	1.596	1	.207
	Post	1.129	1	.289

present study indicated that all four areas of auditory processing measured via the SCAN test were significantly improved after TLP training. Further investigation indicated that the auditory processing results after training did not differ based on gender, and for three of the four measures (FW, AFG, and CS), did not differ based on age. Thus, the present study supports a conclusion that one should expect to see improvements in auditory processing abilities in people who complete TLP training when the areas of auditory processing are those related to the factors assessed on the SCAN test.

Many professionals either use or recommend the use of listening therapies for people with whom they work when there are indications that the person has some listening (auditory processing) problems. As discussed earlier in this paper, the question that has been posed since the 1990s is whether changes in auditory processing occur after a person undergoes a listening therapy. The present study supports the conclusion that auditory processing abilities do improve after listeners undergo a listening therapy, specifically TLP.

Whilst the purpose of this study was to evaluate the measurable changes in auditory processing abilities for people who undergo TLP training, the changes that took place in participants' lives after completing the treatment are of equal, or perhaps even greater, importance. For example, observations and reports from those who completed TLP and the children's parents indicated the following. The individuals were observed to be calmer, more settled, having reductions in anxiety, greater confidence and self-esteem, improved social interactions, and better outcomes in reading and spelling abilities as well as improvements in speech and articulation. Some examples are presented below.

Subject 29 is now a happy bubbly child who willingly engages in conversation, has established friendships, loves going to her friend's birthday parties, and her family can now enjoy trips to the supermarket, to their local restaurant or even enjoy holidays together. None of these factors were observed prior to the child completing TLP training.

Subject 42 struggled to read and can now pick up a book, read it, and comprehend what the story is about while taking herself "into another world" based on the story. She can now use her reading skills to expand her knowledge and, when older, comprehend legal documents.

Subject 78 no longer is excluded from activities within his classroom as he was ostracized before TLP training. Previously the school environment was overwhelming resulting in poor behaviors, with the child missing learning opportunities. He now says he enjoys school.

Subject 121 used to get in the parents' car at the end of each school day and have a complete meltdown. The burden of struggling to deal with what the child felt was a bombardment of auditory input completely overwhelmed her. After TLP training, at the end of the day, she hops in the car and happily shares the highlights of her day.

Subject 327 is a 10-year-old boy who used to feel frustrated and angry because he struggled to understand what was going on in his classroom and with his circle of friends at lunchtime. He now confidently joins in and laughs along with their jokes and understands what the teacher presents in class. His parents are very happy to be receiving positive feedback about his learning and behavior after many years of negative feedback. They now feel good about his future, and him becoming independent in the world.

Subject 362 is a 14-year-old boy who was ready to drop out of school since he just didn't "get it," and everything was "too hard." He is now thinking about his future, what he will do when he has completed his schooling, and how much he understands at school, which has become a more positive place for him to attend.

Subject 184 recently enjoyed an afternoon with his family at their local club. The parents were able to sit in the sunshine sharing a drink with friends while their son played happily with other children on the jumpy castle amidst the chaos and noise of all the children having fun. This was something this family had never had the opportunity to experience before TLP training.

Participants may change quantitatively or qualitatively in many ways. Findings from the present study demonstrated the positive changes in how participants are processing auditory information, but there are many changes that we simply cannot measure on standardized tests. We can help

individuals improve how they process what they hear which can positively influence their functioning in school, at work, in social situations, and in their lives, in general. This is what makes using treatments such as TLP worthwhile.

Regardless of all the positive improvements noted after TLP training in the present study, all research has its limitations. The greatest limitation in the present study is that there was no control group used. The comparison of improvement in auditory processing was totally based on changes between pre-therapy and post-therapy results on the SCAN test. Future research should look at changes in auditory processing, such as on the SCAN test, for matched groups, one that undergoes TLP training versus another that does not undergo any listening therapy. The expectation based on the results of the present study is that there would still be significant improvements in the group receiving training compared with the control group. This expectation is based on review of the standard norms provided with the SCAN test. Looking at age difference, especially for children, one sees that comparing norms for the same scores between ages that differ by 1 year typically shows only a difference of one or two scaled score points. That is, at one age level, a raw score of "X" might yield a scaled score of 10 (50th percentile) while the norm for children 1 year younger yielding the same raw score might yield a scaled score of 11 (63rd percentile) while a year older the same raw score might yield a scaled score of 9 (37th percentile). This one scaled score value difference is not even close to a one-standard deviation difference. One standard deviation in scaled scores is three points. Thus, a one standard deviation difference from a scaled score of 10 would be a lower score of 7 (16th percentile) or a higher score of 13 (84th) percentile. Looking at the effect size calculations for the four subtests of the SCAN used in the present study, the improvement was close to or above one standard deviation so that the difference between the initial and final tests was about 3 or more scaled score points. However, future research could use a control group that undergoes no listening therapy to compare the differences between those participants and the group that undergoes TLP training. Outcomes from such research could support the significant findings from the present study.

Furthermore, when considering age, the present study found some significant differences based on age. Future research could look specifically at age factors to see at what specific ages differences are and are not found pre- versus post-TLP treatment.

In addition to completing a controlled sample comparison and looking at changed specific to age, future research might look at changes in auditory processing using measures other than just the four subtests of the SCAN used in the present study. Additionally, research could look at other listening therapies not merely TLP to see what changes occur using these different therapies as well as compare therapies between groups of participants. For example, the introduction to this paper discussed research using the Tomatis Method, but the evaluations employed were not standardized measures of auditory processing abilities such as the SCAN test used in the present study. Additionally, research can be completed looking at iLS training when such training is used by itself. In the studies cited earlier looking at iLS, the researchers used a combination of therapies that included this listening program.

In the end, the present investigation supports a conclusion that one should expect to find improvements in auditory processing abilities in people who complete TLP training. Overall, comparisons based on age indicated that young children as well as elderly adults can complete such training and show improved auditory processing abilities. It is hoped that future research will be completed supporting the findings from the present investigation. Additionally, it is hoped that professionals will feel more comfortable recommending listening therapies such as TLP to improve auditory processing abilities in people.

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Disclosure Statement

Tracey Butler is an Authorized Representative of Advanced Brain Technologies (ABT) in both Australia and New Zealand and has been a member of their training faculty since 2004. Jane Schueler is an independent brain fitness and high-performance researcher, innovator and educator at TEAHQ. Jay R. Lucker is a member of the scientific advisory board of ABT. **There are no financial conflicts** as neither Ms. Butler, Ms. Schueler nor Dr. Lucker received financial benefit from ABT, and ABT did not support this study financially.

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