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Use of Acoustically Modified Music to Reduce Auditory Hypersensitivity in Children

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Abstract

Background: Some children cannot tolerate sounds so their systems "shut down" and stop taking in what they hear, or they fight not to listen or run away from listening situations. Research has demonstrated that the underlying problem is not with the children's auditory systems, but with the connections between the auditory system (listening) and the emotional system leading the children to have over sensitivities to sound and respond with negative emotional reactions when listening[1,2].

One treatment found effective in helping children with hypersensitive hearing is the use of specially recorded and acoustically modified music and sound, such as found in The Listening Program® (TLP)[3]. Following a regiment of daily listening to this music, research has demonstrated significant improvements in listening (called auditory processing) and educational performance as noted by greater focusing and listening in the classroom, improvements in educational performance on standardized measures, and greater participation in educational activities[4,5].

Objective: The purpose of this paper is to discuss TLP describing some of the acoustic methods used to enhance the sound to make it therapeutic for listening.

Methods: What specific music was chosen and why that music is used is discussed. An overview of the material and equipment used in TLP training is presented. To demonstrate the effectiveness of TLP training, research completed on children who went through such training is presented as well.

Results: Review of the research on the effectiveness of TLP demonstrates that through the use of the specially recorded music, significant improvements can be found in children's listening, auditory processing, and educational abilities.

Keywords*: acoustically modified music, listening therapies, the listening program, hypersensitive hearing*

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Use of Acoustically Modified Music to Reduce Auditory Hypersensitivity in Children

Health care professionals come across children having overly sensitive hearing. These children cannot tolerate sounds, often loud sounds. Research has demonstrated that the underlying problem for children with hypersensitive hearing is related to the connections between the auditory system and the emotional system so that the children have over sensitivities to sound and respond with negative emotional reactions when listening[1,2]. Often, one recommended treatment is through a listening therapy. One such program uses special, acoustically modified music and sounds to help improve listening skills; this is The Listening Program® (TLP) developed by Advanced Brain Technologies[3]. The recorded music and sounds are carefully chosen and systematically produced to enhance positive emotional and calming reactions during listening. The listening method uses specially recorded instrumental music. The music is acoustically modified to lead the child to react less negatively to sounds and, thus, reduces the child's hypersensitivity while opening the auditory system to listen more effectively.

In TLP, a trained provider oversees the program. The provider typically establishes the actual protocol based on the individual child's needs. The listening therapy may be carried out in the child's home, at the child's school, or in the professional's clinical practice. When using TLP, especially through specially designed air and bone conduction headphones, the sound signal is believed to travel along both the classical and non-classical auditory pathways[1,2]. One of the first outcomes often see in children undergoing TLP training is that they are calmer. This is a good indicator that the listening has tapped into the emotional areas of the limbic

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system via the non-classical auditory pathways. Over the course of training, children are often reported to be more attentive to sounds, better able to detect sounds they hear, and more verbally communicative, likely because they are more open to listening. As the training proceeds, the child continues to relax and becomes calmer when listening. It is hypothesized that this is because a reprogramming of emotional memory in the amygdala is occurring. The training reprograms listening and sounds as positive experiences and helps improve stress regulation so the child no longer has fight/flight responses to non-threatening sounds. When the child is in real-world situations and hears sounds that may have been frightening or annoying in the past, the training allows the child to process the sounds in a more neutral manner[1,2]. For many children, the use of a program such as TLP is sufficient to reprogram their systems so that sound is no longer frightening.

Research using TLP has largely been anecdotal, but the evidence base is growing as studies continue to be conducted. For example, Gee, Thompson, and St. John[6] present a case study of a child with ASD who was overly sensitive to sound and completed TLP training. They report that the child showed a decrease in negative behavioral reactions to previously "annoying" and feared sounds after completing this training.

In contrast to anecdotal studies, some investigations have used groups of subjects. Two such studies provide more quantitative analyses of the findings. They were conducted and published by Jeyes[7,8]. Both studies looked at changes after TLP training in the subjects used. In the study, Jeyes [8] reported improvements in auditory processing abilities in 12 children diagnosed with autism spectrum disorder (ASD). The children were evaluated using one of the standard measures of auditory processing called the SCAN-3:C[9]. Their auditory processing abilities were found to improve significantly when the effect size, or improvement after therapy, was statistically analyzed[4,5]. The effect size found was 1.67, meaning that an improvement of one-and-two-thirds standard deviations was seen after completing the listening therapy. Thus, TLP training demonstrated large improvements in auditory processing and listening skills for these children with ASD after they listened to the special acoustic recordings provided through TLP.

In the other study, Jeyes[7] looked at changes in educational performance for a group of 38 children identified as academic underachievers which, likely, meant that the children had learning disabilities which may have included auditory processing deficits. These children also completed TLP training and were found to show a large effect size on statistical analyses after such training when tested on educational tasks including measures of reading and writing abilities as well as some listening/auditory processing tasks involved with auditory discrimination and memory. The effect size found[4,5] was 1.19, over one standard deviation improvement. Thus, again, listening to this special, acoustically modified, and enhanced music improved listening and academic abilities in these children.

A review of other studies and descriptions of individual cases can be found at the Advanced Brain Technologies website (http://a.advancedbrain.com/scienc.jsp?scienceLink=research). The research has demonstrated that after going through this listening program, children, adolescents, and adults find their abilities to tolerate sounds improves for both loud sounds and other annoying sounds. Many find listening to be more pleasurable and positive so that negative emotional reactions rarely, if ever, occur. From the limited evidence available, there appears to be indications that TLP training provides a reduction in negative emotional reactions when listening. Additionally, quantitative research has demonstrated positive outcomes from TLP training improving auditory processing abilities and educational factors[4,5]. Thus, professionals working with and parents of children who have auditory hypersensitivities might wish to try TLP training focusing on seeing changes in the children's reactions to listening tasks and sounds in their environment. Since listening is an important part of learning, it is expected that the improvements in listening will improve learning for these children.

The Acoustics of The Listening Program

The classical music recorded for The Listening Program® includes original arrangements of works by Mozart, Haydn, Vivaldi and Danzi for strings and woodwinds, performed by the Arcangelos Chamber Ensemble. Production is focused on enhancing the natural attributes inherent to the music in such a way that the brain can better pick up on each acoustic element and learn to better discriminate and understand what is heard.

The acoustic features include frequency, amplitude, temporal and spatial elements, melodic structure, key, and more. Each recording is done with a 24-bit depth, and 192 kHz sampling rate to capture a High Definition image of each instrument across the entire range of human hearing. Recordings are done in commercial studios with rooms that are acoustically designed and treated, providing the best recording conditions. Each musician plays in an individual, live room to capture separate channel recordings of each instrument and for complete isolation of the microphones. This ensures no spill between instruments and microphones; thus, each instrument is recorded in complete isolation. During recording, the complete ensemble plays together wearing monitoring headphones with the ability to see and interact with one another while playing. When recording is complete the individual tracks are edited and mixed in post-production prior to digital signal processing (DSP). The primary DSP methods applied to the music include the following.

Audio filters are applied for frequency enhancement from 20 Hz - 20 kHz including carefully selected and applied low-pass, band-pass, and high-pass filters, which are set to enhance multiple bands of low, mid, and high frequencies which correlate to the tonotopic organization of the inner ear (cochlea) and auditory cortex like the keys of a piano are organized from high to low pitch. This method is intended to enhance frequency discrimination. The child moves through phases listening first to full spectrum sounds without filters, then low frequency bands, followed by mid to high frequency bands, progressing to high frequency bands, then in reverse sequence over the course of training.

Certain sounds, provided in the right context, can re-organize neural activity, support health, balance emotions, bring calm, and provide energy to carry one through the entire day. The Listening Program® trains the brain through listening to modules of music which is acoustically-modified and arranged into frequency zones. These zones are mapped to brain regions which respond to different properties of sound according to their vibratory frequencies, just as the keys on a piano are tuned to play different musical notes. This mapping is referred to as tonotopicity.

Four training zones (blue, red, orange, and green) provide music which progresses across the full range of human sound perception. Each zone focuses on a different band of frequencies which have qualities contribute to one's brain health and performance. Within each zone, the listener progresses through different types of training which are rated by level. Higher levels of training are presented as the listener gains listening experience.

Auditory tone bursts are applied during brief periods in the middle of each listening session. The bursts vary in duration and amplitude to help the individual attune to sounds in the environment, such as human speech, and to attenuate background noise and loud annoying sounds. These tone bursts are specific to instruments within the target frequency bands and are mixed with lower amplitude full spectrum music to provide a ground sound reference for the dynamic figure of the tone bursts.

Spatial Surround® is a music recording and production process developed for TLP in which multi-channel sound is presented to provide music in five individual channels or locations. Spatial Surround Dynamic is Spatial Surround® with movement of the individual instruments or nature sounds using dynamic panning. Spatial Surround® was developed to replicate the natural environment to provide more complete training to the auditory system. Rather than simply stimulating perception of sound from the right and left, which can be done in stereo, Spatial Surround® increases perception of all directions. Mixing is done so the listener is the center reference with a front left, front right, and center channel, as well as rear left and rear right channels. At certain points in TLP, instruments are dynamically panned between channels, left to right, right to left, front to back, back to front, clockwise and counterclockwise in various spatial patterns to stimulate sound localization, and other skills of auditory perception. The music is encoded using a specialized algorithm owned and licensed from Dolby Laboratories that provides playback of five channels through stereo headphones.

ABC Modular Design is critical to the success in producing the recordings for TLP. This sound design is important because effective stimulation depends on more than carefully selected classical music and neuroacoustic modifications. It also helps the listener's brain to be prepared to receive acoustic information.

When someone experiences stress or anxiety, the ear cannot easily discriminate higher frequency sounds. This leads to a decline in attention and auditory processing. Further, research asserts that a listener needs to be relaxed to receive appropriate neural feedback from the ear to the brain and back to control and to improve the function of the brain. The ABC Modular Design enhances the effect of TLP specially engineered music which prepares the person to listen as well as providing the right amount of stimulation to restore the listener to a state of focused relaxation.

Each module of TLP follows Advanced Brain Technologies' proprietary ABC modular progression which takes the listener through multiple levels of sound training in 15-minute segments. The modules include seamless tempo entrainment from moderate tempos of 50-60 beats per minute (bpm), increasing to 120-150 bpm, then back to 50-60 bpm. There are transitions of musical complexity, tone density, spatial training, frequency focus, and volume dynamics. These transitions move through a sequence of low-moderate-high-moderate-low intensity training over the course of the 15-minute segments, which provides a balance of stimulation and grounding to support self-regulation to provide the brain with the right training challenge without overloading the child.

Procedures for Completing TLP Training

The Listening Program® training is personalized to each child based on the individual's presenting functional needs and goals for the protocol which may go beyond reducing auditory hypersensitivity. The provider gathers information regarding the child, determines the best protocol for the child and sets the schedule. The child does not choose which music will be used, the choices are made by the provider. Each protocol has specific music recordings used for the listening therapy.

There are several protocol options and schedules available with TLP. Protocols include Spectrum (developed specifically for listeners with sensory sensitivities), Spectrum Plus, Achieve, Achieve Plus, Level One, and Level Two. Schedules include Extended which is once daily for 15 minutes; Base, twice daily for 15 minutes; and Condensed, once daily for 30 minutes. Schedules are selected based on age, attention, and behavioral characteristics of the child. The child engages in quiet play or art activities during listening sessions which are

done five days per week. The duration of TLP is a minimum of 50 hours training carried out over the course of 20-40 weeks. The training is typically continued for another 20-40 weeks to build on the improvements experienced during the initial cycles of training.

The provider conducts a training session with whomever will implement the program (known as the monitor). The professional checks-in weekly, bi-weekly or monthly through in-person appointments, video conferences, or phone calls with the monitor, as well as keeping in contact between these regular sessions to make sure any questions are answered. Listening is done through high-quality headphones tested and approved based on performance for use with TLP. Both open-air (preferred) and closed type circumaural headphones are used depending on the noise level in the listening environment.

Advanced Brain Technologies has developed a specialized semi-open circumaural headphone system optimized for TLP called Waves. Waves is a multisensory audio system delivering sound using the two natural modes of hearing: through the ears (air conduction) and through the bones of the head (bone conduction). This bimodal approach provids simultaneous air and bone conduction sound delivery which is a more immersive listening experience than conventional headphones provide.

Benefits of Bone Conduction

The choice for using bone conduction (along with air conduction) is that this bimodal method of delivering the auditory stimulation supports stress reduction and regulation of the "fight or flight" response to help achieve a state of calm and relaxed/alertness. Using TLP with combined bone and air conduction offers internal and external sound stimulation, which can increase vocal awareness and supports the development and refinement of language and communication skills.

The Waves headphones are driven by a dedicated headphone amplifier which allows for separate control of volume for air conduction and the vibrational output of the bone conduction transducer. The Waves amplifier has USB rechargeable batteries and connects to TLP audio source via a 3.5mm input cable provided with the program's equipment.

The audio sources used in TLP training are high-quality digital media players having the program's music files preloaded loaded using audio codec (Apple Lossless) available for the device. The programs are organized into specialized playlists which correspond to the protocol and schedule that has been determined for each child, so that the monitor knows exactly which files to play for the child each session.

Advanced Brain Technologies has developed a high-quality audio streaming platform called "TLP Online" in which the child can listen on virtually any web-connected device using the TLP Mobile Apps. The child obtains a membership to TLP Online and follows the same programs provided on digital media players. The child can access the personalized TLP protocol anywhere there is internet or data connection available by logging in with the child's username and password. TLP Online automatically tracks the child's progress with baseline and progress measures and instantaneously streams the correct module for listening for each session adjusting the program compliance. The provider can remotely monitor the child and make program and schedule changes as needed.

Research on The Listening Program®

Using this acoustically modified music and sound program may lead to significant changes in children's listening and auditory processing abilities. Research conducted on The Listening Program® has used small sample, case studies and small group studies. However, applying a meta-analytic approach, Vargas and Lucker[4,5] looked at changes in listening and auditory behaviors reported in nine studies. They used a quantitative, statistical analysis of the effect size changes in performance of children with a variety of disorders affecting listening, auditory processing, and learning. The effect size was based on comparing pre-training test results with post-training results using the same measures. The effect sizes demonstrated significant changes with the magnitude of the effect being highly significant. Some of the findings from their effect size research were discussed earlier in this paper. What was seen for studies using groups of subjects was that the effect sizes often revealed improvements of more than one standard deviation after completing TLP training. Thus, listening to this acoustically enhanced and modified music and sound can positively improve auditory skills in children.

Other research on The Listening Program® can be found at the Advanced Brain website (www.advancedbrain.com/research). Overwhelmingly, the research has found positive changes in listening, auditory processing, and learning for children who complete training. Thus, the specially modified and acoustically enhanced music used in TLP appears to improve listening. Other research[1,2] has identified that these changes appear to be related to improved emotional reactions.

How the Listening Program® Might Help Listening and Emotional Reactions

Earlier it was stated that this acoustically modified and enhanced music appears to calm the emotional system, reprogram emotional memory, and lead to changes by having neural reactions occur in the non-classical auditory pathways[1,2]. The following is a discussion of these non-classical auditory pathways and how they relate to the auditory system and the emotional system in the brain.

To begin, a brief review of the classical pathways is provided. Any standard textbook on auditory neuroanatomy shows the central auditory nervous system involving the following structures and pathways. From the inner ear, cochlea, the auditory signal is processed and converted to electrochemical neural impulses that travel from the cochlea to the low brainstem level via the auditory or eighth cranial nerve. The nerve transmits the initially processed signal to the cochlea nucleus with the signal from the cochlea nucleus traveling either to the same or opposite side superior olivary complex (SOC). From the SOC, the signal travels to higher brainstem levels including the lateral lemniscus, the inferior colliculus, and, then, the medial geniculate bodies of thalamus. At this upper brain stem level, the neural impulse travels to the auditory areas of cortex in the brain. The two cortices connect via the corpus callosum. Through this classical pathway, we process what we hear so that, eventually, we can make sense out of what we have heard.

In the early 2000, Moller and his associates[10,11] discussed another pathway involving the auditory system identified as the non-classical auditory pathway. Moller and his associates[10,11] discuss that research on this pathway began in the 1970s, but the best understanding of this pathway became apparent in studies from the early 2000s. In their research, Moller and his associate[10,11] identified that this non-classical auditory pathway was very active in young children, but by age eight years, the pathway was suppressed so that the classical pathway became the prominent one. However, under times of stress, the non-classical pathway may become reactivated.

According to Moller and his associates[10,11], the non-classical pathways begin from the classical auditory pathway at the level of the lateral lemniscus. The non-classical pathway branches off from the classical pathway with this non-classical pathway projecting and receiving neural input from the reticular system. The reticular system is involved in awareness activation. Under normal circumstances, when we hear loud or annoying sounds, we receive information from our reticular systems and determine whether that information is dangerous or scary. We then react. However, if the non-classical pathway receives the input that this is a danger situation. it sends information through this pathway to emotional neural systems in the limbic system of the brain deep in the temporal lobe. The limbic system then reacts to this "danger" by setting up a series of neural responses in the autonomic nervous system (ANS). These responses lead to negative emotional reactions often referred to as the "fight" or "flight" response. Thus, these non-classical pathways are protective mechanisms. In response to the "danger," we react and. Over time, learn to relate what sounds are "danger" and what are not. Eventually we learn to react to the sounds of danger and remain calm. This learning is remembered in the emotional memory center of the brain, the amygdala. But, what if the emotional system is not functioning properly or is not being regulated appropriately?

For some children older than eight years, Lucker[2] and Lucker and Doman[1] hypothesize that the non-classical auditory pathway remains active. Sounds initially frightening remain frightening, and when such sounds are heard, the still functioning non-classical auditory pathway reacts sending messages to the limbic system so that the emotional reaction is to continue to set up ANS responses, and the child continues to behave in a fight/flight mode. This reinforces the negative memories of these sounds which are stored in the amygdala. Thus, similar sounds even of less intensity pull from memory fear of the sound, and the reaction can lead to fight and flight responses which are seen in children with hypersensitive hearing.

For children who continue to have these negative emotional reactions to perceived loud and annoying sounds, the emotional memory continues to "label" these responses as fearful, extremely annoying, intolerable, and being out of control. However, listening to the specially modified and recorded acoustic characteristics of music in TLP seems to send messages through the non-classical pathways that sound and listening are not frightening or potentially harmful. The neural responses are that the music calms the system.

The importance of the non-classical auditory system was identified by other auditory researchers. Dr. Frank Musiek and his associates[12] write, "Some children with developmental disorders may have emotional learning problems caused by the brain's inability to reduce the involvement of the non-classical pathway and the amygdala" (p. 6). Thus, professionals involved in research regarding auditory hypersensitivity have identified the importance of this non-classical auditory pathway to hypersensitive hearing in children.

Autonomic Nervous System Responses

We have two nervous systems. The CNS responds to and processes incoming sensory stimuli to which we become aware and react. In contrast, the ANS reacts automatically to certain things such as getting us to respond appropriately when we are in a fearful situation. Typically, in a fearful situation, there is increase in heartbeat, faster breathing, loss of voice, upset feelings in the stomach, etc. These are due to ANS reactions.

ANS responses are often set forth by neural impulses from the emotional systems in the limbic system of the brain. One of these reactions is the secretion of neurochemicals such as GABA. This neurochemical helps to inhibit auditory sensory processing so that we do not over react to sounds we hear. One hypothesis is that abnormal production of GABA might occur in people with auditory hypersensitivities. Rubenstein and Merzenich[13] identified such abnormal production in children with auditory hypersensitivity,

especially children with autism spectrum disorder (ASD). Thus, when hearing sounds initially fearful, the child may have ANS responses, but the release of GABA inhibits such responses. For children with hypersensitivity hearing, the GABA release is abnormal and does not inhibit reacting to the sound. For these children, their reactions are of the fight/flight mode. However, after completing TLP training, the non-classical pathway re-program the negative emotional reactions so the children react more neutrally with less fear and fewer flight/flight responses. What may occur is that more appropriate GABA release occurs and more normal inhibitory reactions to sounds lead to the child being more open to listen and learn.

In addition to GABA, another neurochemical identified as being of abnormal functioning in children with hypersensitive hearing is 5-Hydroxytrypamine (5-HT) also known as Serotonin. Marriage and Barnes[14,15] identified that abnormal secretion of serotonin in animals led to a heighted behavioral response to sound compared with the reactions to such sound in similar animals with normal serotonin production and secretion who responded normally. The researchers hypothesized their animal research indicated that abnormal secretion of serotonin in reaction to sound could contribute to negative behavioral/emotional reactions in children with auditory hypersensitivities. Research by Baguley[16] identified how abnormal production of 5-HT can be associated with hypersensitive hearing in humans. Baguley investigated hypersensitive hearing in children with William's syndrome. Further research is needed to look at 5-HT/Serotonin functioning in children and relate this to listening and auditory hypersensitivities in these children.

When considering these neurochemical abnormalities which may come under better control after completing a listening therapy like TLP, one may wonder what specific neural mechanisms within the ANS might be responding. One theory related to such neural mechanisms is known as the "Polyvagal Theory". This theory, developed by Porges[17], hypothesizes that the vagus nerve provides the neural activity to change responses in different parts of the body when the nerve is innervated through ANS responses. One incoming response that can set the vagus nerve into action is sound. The initial reactions via the vagus nerve is through the ANS.

In 2010, Porges and Lewis[18] identified how the vagus nerve is innervated via limbic system connections, thus, through emotional system reactions. The nerve's response is in response to what is interpreted as the person being under emotional stress or involved in a fearful condition. The nerve innervates the heart, and under stress or negative emotional conditions, heart rate increases because of this innervation. The nerve also innervates the vocal folds which are involved in the production of voice. Under stress and fearful conditions, one can lose one's voice or the voice can crack or get out of control. These reactions may all be due to ANS reactions to the processed sound.

Another neural mechanism that may be innervated through the limbic system and react via ANS control is the hypothalamus. Mazurek et al.[19,20] looked at changes in behaviors of rats under different types of stressful conditions. What these researchers identified is that rats under stress were overly sensitive to sounds, and, thus, had auditory hypersensitivities. These rats were then investigated further and were found to have abnormalities in their hypothalamic functioning when under stress. The hypothalamus is one of the mechanisms within the limbic system, and the abnormal functioning of the hypothalamus led to abnormalities in the pituitary glands and adrenal glands of these rats. The stress that led to these abnormal functions was brought on by sound, thus, auditory hypersensitivity was present. Mazurek et al.'s research[19,20] suggests that children's hypersensitivity may also lead to abnormalities in their hypothalamus and contribute to abnormal functioning in ANS systems including the pituitary and adrenal glands.

Conclusion

Music and sound have been demonstrated to improve listening in people for many years. Using acoustically enhanced and modified music and sound recorded based on the descriptions provided in this paper has demonstrated significant improvements in listening skills, reductions in hypersensitive hearing, and significantly better auditory processing abilities and learning in children[4,5]. It is concluded that practitioners should consider recommending listening therapies such as TLP when they come across children with auditory problems not specifically involved with hearing loss.

When we consider the specific music used in TLP, one can see it is sound modified as described in this paper. Additionally, the music is modulated and varied between ears which is not the normal method for listening to music. The research supports that after completing TLP training, significant improvements of more than one standard deviation can be found for children's listening, auditory processing, learning, and tolerance of sounds.

The focus of this paper was to explain the value and importance in using acoustically modified music when the purpose of that music is to calm emotional reactions of people, i.e., reduce stress, relax people, improve overall listening. It is hoped that more research will be conducted revealing the benefits from listening to acoustically modified and enhanced music such as music developed for and used in The Listening Program®.

References

1. Lucker JR, Doman A. Auditory hypersensitivities and autism spectrum disorders: An emotional response. Autism Science Digest: 2012: 4, 103-108.
2. Lucker JR. Auditory hypersensitivity in children with autism spectrum disorder. Focus Autism Other Dev Disabil: 2013: 20(10): 1-8.
3. Advanced Brain Technologies. The Listening Program® (TLP) Available at: http://a.advancedbrain.com/tlp/the_listening_program.jsp. Accessed August 30, 2017.
4. Vargas S, Lucker JR. A Quantitative Summary of The Listening Program (TLP) Efficacy Studies: What Areas were found to improve by TLP intervention? Poster session presented at: The 2015 Annual Conference on The Listening Program, Ogden, UT, July 2015.
5. Vargas S, Lucker JR. A quantitative summary of The Listening Program (TLP) Efficacy Studies: What areas were found to improve by TLP intervention? Occup Ther Int: 2016: 23(2), 206-217.
6. Gee BM, Thompson K, St. John H. Music based intervention with a child with autism spectrum disorder and auditory sensory over-responsivity. Occup Ther Int: 2014: 21(1): 12-20.
7. Jeyes G. Evaluating the effectiveness of The Listening Program® intervention for children

1. who are underachieving in a state school. Paper presented at: The British Dyslexia Association International Conference, March 2004. Available at: http://www.advancedbrain.com/pdf/research/research_nottingham_tlp.pfd. Accessed August 30, 2017.

8. Jeyes G. A study to establish whether the use of The Listening Program® is effective in improving auditory skills for children with autism. Paper presented at: Children's Complementary Therapy Network Conference, Birmingham Children's Hospital, May18, 2013. Available at: http://www.advancedbrain.com/pdf/research/jeyes_study_autism.pdf. Accessed August 30, 2027.
9. Keith RW. SCAN-3:C Test of Auditory Processing Disorders in Children. New York: Pearson Education; 2009.
10. Moller AR, Rollins PR. The non-classical auditory pathways are involved in hearing in children but not adults. Neurosci Lett: 2002: 19(1), 41-44.
11. Moller A, Kern JK, Grannemann B. Are the non-classical auditory pathways involved in autism and PDD? Neurol Res: 2005: 27(6), 625-629.
12. Musiek F, Mohanani A, Wierzbinski E, Kilgore G, Hunter J, Marotto J. The non-classical pathway: Too great to be ignored. Hearing J: 2011: 64(10), 6–8.
13. Rubenstein JLR, Merzenich MM. Model of autism: Increased ratio of excitation/inhibition in key neural systems. Genes Brain Behav: 2003: 2(5), 255.
14. Marriage J, Barnes NM. Is central hyperacusis a symptom of 5-hydroxytryptamine (5-HT) dysfunction? J Laryngol Otol: 1995: 109(10), 915-921.
15. Marriage J, Barnes NM. Is central hyperacusis a symptom of 5-hydroxytryptamine (5-HT) dysfunction? Int J Audiol: 2003: 42(5), 279-288.
16. Baguley DM. Hyperacusis. J R Soc Med: 2003: 96(12): 582-585.
17. Porges SW. The polyvagal perspective. Biol Psych: 2007: 74(2), 116-143.
18. Porges SW, Lewis GF. The polyvagal hypothesis: Common mechanisms mediating autonomic regulation, vocalizations and listening. Handbook of Behavioral Neuroscience: 2010: 19, 255-264.
19. Mazurek B, Haupt H, Joachim R, Klapp BF, Stover T, Szczepek AJ. Stress induces transient auditory hypersensitivity in rats. Hear Res: 2010: 259 (1-2), 55-63.
20. Mazurek B, Haupt H, Klapp BF, Szczepk AJ, Olze H. Exposure of Wistar rate to 24-h psycho-social stress alters gene expression in inferior colliculus. Neuroscience Letters: 2012: 527(1), 40-45.

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