Editorial Essay

Sound Therapy for Learning and Wellness

Dorinne Davis, MA, CCC-A, FAAA, RCTC, BARA

The Davis Center

Sound is all around us and affects our whole being, our emotions, and how we learn. In today's world, sounds are heard from the electronic equipment we use in our homes and offices, as well as from nature's water lapping on a shore or leaves rustling in the trees. We are constantly being affected by sound. Some sounds are pleasant to hear and others are not. Sound must be heard correctly and then perceived correctly in order to listen, comprehend, and follow through with what was learned or asked.

Not everyone has the same response to the sounds around them. Positive responses are noted as: feeling relaxed, being motivated, feeling energized, or being more focused. Negative responses can be demonstrated as: irritability, anxiety, avoidance of noisy situations, or difficulty listening in background noise. For the developing child, negative impacting sound can be demonstrated by: sensory overload, covering the ears, social withdrawal, temper tantrums, tuning out the world, or showing fear to sounds.

Most people know that we process sound through the cochlea of the ear. However, we also process sound through our bone structure, sense of touch and body's cell structure. Sound impacts the entire body. Our bodies first perceive sound stimulation and then respond to it. Some people respond more efficiently through the other modalities (bone, touch, or cell structure). This slower response creates poor listening, vestibular, and attention skills. People have to hear sounds correctly in order to process what is being received. This does not mean that the deaf do not perceive sound. They understand sound because of the different ways that our bodies receive and perceive sound stimulation. They often vibrationally respond to sound received through bone conduction.

The ear

The ear is our hearing mechanism. However, the ear appears to also be the major sensory stimulator for the body. It has many sensory connections that help send information to all parts of the body.

Sound travels down the ear canal and vibrates the eardrum, which in turn, vibrates the three smallest bones of the body, the malleus, incus, and stapes. They, in turn, send sound vibrations through the fluid in the inner ear. The cochlea responds to the frequencies and patterns of the sound as it relates to hearing, and the semi-circular canals and vestibule responds to movement and rhythms of the sound as it relates to the body. There is a protective muscle, the stapedius muscle, attached to the third bone of the middle ear. It is sometimes known as "the acoustic reflex muscle" and protects our bodies from excessively loud sound and creating damage to the cochlea. When this muscle is over-reactive, the sound vibrations received in the ear are over-stimulated. This over-stimulation affects the cochlea, the semi-circular canals and the vestibule. It is this phenomenon that

Correspondence regarding this editorial can be emailed to ddavis@thedaviscenter.com or sent to Dorinne Davis, MA, CCC-A, FAAA, RCTC, BARA, President/ Founder, The Davis Center, One Mannino Dr, Rockaway, NJ 07866. All statements are the author's personal opinion and may not reflect the opinions of the College of Optometrists in Vision Development, Optometry and Vision Development or any institution or organization to which she may be affiliated.

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appears to create one type of hearing hypersensitivity.

The perception of motion and turning is provided by the semicircular canals, because their positioning in the inner ear covers all the dimensions in space. They are responsible for our body's proprioception skills. Our balance center is housed in the vestibule. From these two areas, sound's stimulation responses for the 'body' are then sent to the brain.

From the cochlea, sound is sent to the brain for interpretation of 'hearing'. Sound's responses first travel through the Superior Olivary Complex, which is a relay center for auditory information helpful in the integration and interpretation of binaural listening, sound localization, and two ear integration. The Lateral Lemniscus is the primary auditory pathway within the brain stem and lies between the Superior Olivary Complex and the Inferior Colliculi. The Inferior Colliculus, the largest auditory structure in the brain stem, has auditory fibers and sensory receptors for body movement, skin, hearing and vision. It is the relay system to higher levels of the brain, and is important for frequency specific information, time and space information, eye, head, and body movement towards sound localization, and binaural hearing. In the thalamus, the Medial Geniculate Body acts as a relay station for auditory information, transmitting information to the auditory cortex via the internal capsule to Heschl's gyrus and via the external capsule to the Insula. It responds to acoustic stimuli, responds to sensory and acoustic stimuli, and transmits auditory discrimination information, auditory attention information, and multisensory arousal information. Neurons originating in the Medial Geniculate Body branch outward to the auditory areas of the cerebral cortex. Heschl's gyrus is the main auditory area of the cortex, and is the site of auditory sensation and perception. It can retain frequency specific or tonotopic information from the cochlea.

The thalamus also controls the rhythm of the brain waves. The thalamocortical neurons release the brain waves and allow them to spread throughout the brain, the nervous system, and to every part of the body. They regulate the sensitivity and activity of the nervous system. The entrainment (patterning in regular sets like boxcars on a train) of brain waves allows the nervous system to respond to stimulation. This patterning enhances the overall responsiveness of the stimulation.

The neurological system

The neuron is the functional unit of the brain. It receives information from the dendrites, processes the information within the cell body, and sends the information to the other neurons and cells along its axon. The axon's small fibers have terminals that form a connection, called a synapse, to another cell. Synaptic connections are the way neurons communicate. By processing information and conveying this information to other neurons, behavior and experiences are established. This system is always working. New synapses develop and it is the networking between the neurons that form the activity of the brain, allowing us to continually learn and grow.

The brain receives external stimuli through its sensory system: touch, smell, taste, vision, and hearing that enhance this development. However, without proper stimulation, the connections that allow the brain cells to process become distorted or confused.

Of the 12 cranial nerves, numbers 2-11 are directly or indirectly connected to the ear through the branching effects of the neurons.[1] Four of these nerves, the trigeminal, facial, glossopharyngeal, and vagus, seem to be impacted by sound stimulation more than the others.

The trigeminal, or fifth cranial nerve, has three branches: the ophthalmic, maxillary and mandibular, and stimulates many portions of the face: jaw, lips, nasal passages and palate. It supplies sensation to the motor nerves of the muscles of the head, and helps control pain, temperature, touch, and proprioception of the head. It also innervates the chewing muscle, and provides the tactile sensation from the nasal and oral cavities.

The seventh cranial nerve (facial) is a motor nerve that supplies the proprioceptive and motor fibers to four muscle areas: the stapedius muscle, the posterior digastric muscle (allows the opening of the mouth), the stylohyoid muscle, and the muscles of facial expression. It has nerve fibers that supply:

1. sensation of taste from the front two thirds of the tongue
2. sympathetic innervation to the lacrimal gland, nose and salivary glands
3. the sensation of pain, temperature and touch to portions of the ear canal
4. motor innervation to muscles of second branchiogenic origin.

The glossophyaryngeal, or ninth cranial nerve uses the eustachian tube as the connection with the ear. It supplies sensation to the tonsils, pharynx, soft palate, posterior third of the tongue, eustachian tube, and tympanic cavity, and has reflex control of respiration, blood pressure, and heart rate.

The vagus, or tenth cranial nerve, does not play a part with audition but is important for its

response to sound stimulation. It contains motor, sensory, and parasympathetic fibers and extends from the head to the gastrointestinal tract. It stimulates many muscles (in the pharynx, larynx, esophagus, lungs, and the intestine), glands, and glandular organs (most major organs including the spleen, pancreas, kidney, gallbladder, liver, small intestine), and regulates the function of the pharynx, larynx, thorax, and abdomen. It conveys information about local hormone secretions, gut distension, and immune and inflammatory signals, as well as the sensation of nausea and impulses regulating respiration and blood pressure. It has implications for understanding the physiology and pathophysiology of functions such as pain sensitivity, feeding behavior, mood disorders, and acute and chronic inflammatory diseases.[2] When overactive, this nerve can disrupt one's well-being with states of anxiety, angina, stomach distress, or lack of appetite.[3]

Cochlear emissions

David Kemp, in 1978, reported that a weak acoustic signal emanated from the cochlea about 6 ms after the presentation of a click was introduced to the ear. This was called an otoacoustic emission, and diagnostic testing developed around this phenomenon. From this finding, it was discovered that the ear actually generates a sound naturally, and this became known as a spontaneous otoacoustic emission. It is thought that the source of these otoacoustic emissions are within the cochlea. To date, researchers say that they may be present in one or both ears for some people and absent in others.[4] Researchers are unsure of why we have spontaneous otoacoustic emissions. The sound frequencies absorbed by a molecule are identical with the frequencies emitted by the molecule when excited. This is known as the Kirchhoff's Principle.[a.]

Hearing vs listening

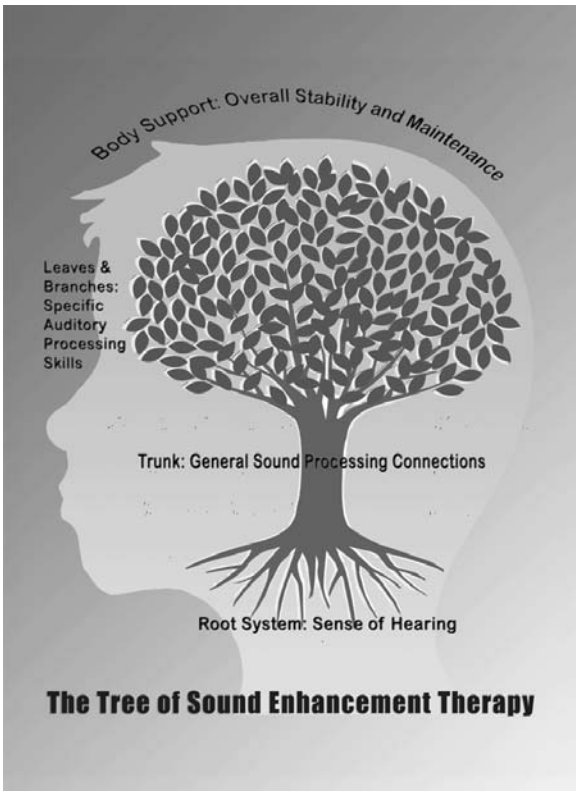
Hearing is the physical act of receiving sound in the cochlea. The ear is responsible for both hearing and listening. Listening is a motivated, active process of tuning into what one wants to hear and tuning out what they don't want to hear. It involves a mental process. The brain has to receive the sound and figure out how to use it. This is perception.

Auditory deprivation

Hearing, listening and perception do not always develop appropriately for some and therefore, affects their development. The connections between the voice, the ear, and the brain were never fully established, and the sensory stimulation necessary to establish these connections was also never fully stimulated. As a result, the connective networks were not enhanced. This is seen as auditory and/or sensory deprivation.

These misperceptions of sound result in poor skill development and overall body imbalances. The following are often demonstrated as a result of misperceptions of sound:

- **Stilted learning:** When the full sensory message is not received in the ear or the brain, only bits and pieces of the message can be processed. The person can only respond, interpret, and learn from those pieces of information. The resulting learning is accomplished in chunks which limits how much information can be processed and retained at one time.
- **Hypersensitivity to sound:** Three (3) different types of hearing hypersensitivities to sound have been identified.[6] Negative reactions to sudden loud sounds, certain pitches, babies crying, reverberant rooms, low frequency sounds, people talking, and more have been reported. The responses often interfere with the individual's ability to pay attention, tune in, and respond.
- **Difficulty listening in background noise:** When background noise is present, it masks the person speaking, and the listener has to work extra hard to listen to foreground speech. The listener must be able to discriminate sounds well, differentiate far and near sounds, and tolerate extraneous sound. People with sound processing issues find this difficult.
- **Disconnected speech:** The brain must receive good input from the rhythm, timing, inflection, prosody (stress and pitch), and tone of the speaker's voice, as well as the sequence of the phonemes within their words. Speech can become choppy or disconnected when not perceived properly.
- **Weak auditory discrimination skills:** The ability to discriminate between the speech sounds within words is important for understanding speech. The difference for example between a /t/ and a /d/ sound can be major for comprehension. If a child is told, "The bat is in the closet," and instead hears, "You're bad and go to the closet," the child will become very confused. He knows he heard the second sentence and is in disbelief when the speaker indicates he heard it incorrectly.
- **Localization of a sound:** Knowing where a sound comes from is important for communication. The listener must be able to locate the speaker's voice in order to tune into what they are saying.
- **Auditory processing timing lag:** Some listeners hear the entire word or message in one chunk, while others hear it in parts and must put the pieces together for comprehension. It takes longer to put together the pieces and this



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can be seen as a timing lag. This can be minimal or significant, yet impact the listener's response skills.

- **Emotional Instability:** While traveling from the cochlea to the brain, sound passes through the limbic system, a main emotional response center. People, who have misperceptions of sound, often demonstrate emotional instability.
- **Attention/focusing weaknesses:** To maintain attention and focus, the listener must be comfortable with the sound, understand it clearly, and not be distracted by extraneous sound. This is often not the case when the listener does not perceive sound well.
- **Vestibular/balance disorders:** Sound's vibrations stimulate the semi-circular canals and the vestibule as well as the cochlea. Because of these vibrations and the resulting neurological responses, all sensory integrations skills affect overall body responses. Vestibular issues are demonstrated in balance, coordination, oral motor skills, gross and fine motor skills, eye-hand coordination, handwriting, and the need for or the exclusion of sensory input: touch, taste, smell, sound, and vision.
- **Health and well-being issues:** When the body is constantly working with inefficient processes, it does not function maximally. This eventually is evidenced in a person's wellness.

The Tree of Sound Enhancement Therapy®

Sound-based therapies have become one solution for making positive change for people whose perceptions of sound are not fully functioning or established. The Tree of Sound Enhancement Therapy was created as a developmental flow chart for the correct administration of the various sound therapies that exist today.

The 'Tree' is divided into parts. The 'Root' system demonstrates one's sense of hearing, not so much hearing loss, as over-reactions to sound. The 'Trunk' represents general sound processing connections, incorporating all the anatomy and physiology of the ear and its related functions. It identifies the foundations of the voice-ear-brain connection established by Dr. Alfred Tomatis (explained in the section under Trunk) and works at establishing a better functioning and balanced system. The 'Leaves and Branches' addresses specific auditory processing skill weaknesses, such as auditory discrimination, sequencing, memory, and the more academic skills such as reading, spelling, and handwriting. The 'Maintenance' of the Tree is accomplished with the voice, either by knowing how to use one's own voice to support the body (voice-ear repatterning), or by using vocal analysis to determine how to support the body (explained in the section under 'Body Maintenance'). This entire Tree analogy uses the power of sound to enhance the Voice-Ear-Brain Connection to make positive change in auditory processing, learning, development, and wellness.

The term 'auditory' throughout the entire framework of what the Tree incorporates is more than just language and responsiveness to 'hearing' sound. The word 'auditory' for all levels of the Tree encompasses everything that the ear does, including vestibular function. The development of the vestibular function is a precursor to the development of language so when watching for developmental changes, all areas of skill development must be watched.

Diagnostic evaluation for therapy protocol (DETP®)

How does one know where to start on The Tree of Sound Enhancement Therapy? The Diagnostic Evaluation for Therapy Protocol (DETP) was developed to help determine the starting place. Tests from the initial assessments of the different sound-based therapies as well as standardized audiological tests are used to determine if a sound-based therapy can be supportive for an individual. If more than one therapy is needed, the correct order for the therapies to be administered can also be determined from the DETP. This test battery is currently being tested and standardized for future dissemination to audiologists.[a.]

Root system

The Root System encompasses one's sense of hearing. A person can have normal hearing thresholds (ranging from 0 to 20 dB) yet also demonstrate hypersensitivity to sound (thresholds of minus 5 or minus 10 dB). Dr. Berard's Auditory Integration Training (AIT) addresses this type of hypersensitivity to sound. Dr. Guy Berard, a French Ear, Nose, and Throat physician, while trying to help a personal hearing problem, studied under Dr. Alfred Tomatis, the founder of sound therapy, and went on to develop a different method. Research has demonstrated that AIT's main purpose is to retrain the acoustic reflex muscle in the middle ear. Davis reports that consistently 91% of individuals tested pre and post AIT demonstrated change in this muscle from very low levels to normal levels after 10 days of listening.[7] The program lasts 10 days. Specially chosen music is played through an approved device that through a system of high and low pass filtering, gating, loud sound and between ear sound changes, accomplishes a permanent change in how the muscle reflex works. A Hearing Sensitivity Audiogram is administered pre, mid, and post sessions to monitor changes and set programs appropriately. Results have demonstrated:

1. a decrease in hypersensitivity to sound (only one type of hearing hypersensitivity)
2. an interest in communication
3. an improvement in attention to auditory stimuli
4. an increase in eye contact, a decrease in restlessness, an improved 'sense of self', longer sentence length, better auditory comprehension, and fewer perseverative behaviors.[b.]

The trunk

The Trunk of the Tree includes all body processes associated with the anatomy and physiology of the ear including branchial stimulation of the cranial nerves. There is only one method that addresses all of these processes—the Tomatis Method®, a method of sound stimulation affecting the entire body.[8] Dr. Tomatis began researching sound's impact on the body in the late 1940's to early 1950's. In 1957, the French Academie of Science established three laws known as 'The Tomatis Effect.' Those laws state:

1. The voice only contains the harmonics that the ear can hear.
2. If you give the possibility to the ear to correctly hear the distorted frequencies of sound that are not well heard, these are immediately and unconsciously restored into the voice.
3. The imposed audition sufficiently maintained over time results in permanently modifying the auditory and phonation.

These laws helped to establish the Voice-Ear-Brain Connection, from which Dr. Alfred Tomatis developed the Tomatis Method. With his method, a special device plays appropriate musical selections during a specific program established after a careful evaluation that determines the individual's listening skills. The intensive sessions stimulate the voice-ear-brain over many days. The typical program is for 15 consecutive days, listening two hours per day, then waiting one month and returning for another 15 consecutive days, listening for two hours per day. The second session may be divided into eight and seven days with various spacing intervals between them. Some individuals need more than this basic program to get them to the stage where the voice will be able to support them. Dr. Tomatis in his second law emphasized that the voice is the vehicle by which a listener can support and maintain the learning changes over time. These additional sessions are only determined after continued testing and monitoring of progress. A few of the reported benefits are:

1. decreased hearing hypersensitivities
2. a sense of well-being
3. a sense of being more connected to the world
4. better eye contact
5. improved social skills
6. less aggressive behaviors
7. enhanced self image
8. improved language skills
9. improved academics such as reading, writing, and spelling
10. improved posture/balance/coordination
11. better organizational skills
12. improved attention.[9]

The leaves and branches

The 'Leaves and Branches' portion of the Tree addresses specific auditory processing skills important for learning and development. The Roots and Trunk

must demonstrate a sufficient foundation to support the changes that occur at this level.

The specific therapies incorporated at this level are working on separate skill sets. One therapy at this level is Fast ForWord®, a computer based program that enhances temporal sequencing of sounds. Temporal sequencing is important for language development, and subsequently with reading development. The program is typically six to eight weeks in length, lasting from 1½ to 1¾ hours per day, and incorporates various learning game activities intended to challenge and improve temporal sequencing. The reported benefits have been: improved temporal sequencing, faster response time to input, enhanced overall learning skills, improved reading skills and improved listening in background noise.[12]

Another therapy appropriately applied at this level is Interactive Metronome®, which uses a metronome beat and an interactive response to develop rhythm and timing. Rhythm and timing is important in understanding the subtleties of language, as well as being able to maintain focus and attention, or planning and sequencing an activity. The person makes a tapping response with their hands or feet and is monitored by a body sensor connected to the computer while responding to a steady metronome beat. The program typically lasts 15 days for one hour per day, after which individuals report:

1. increased attention without distraction
2. improved planning and sequencing skills
3. improved mental concentration
4. improved physical motion skills
5. improved cognition and academic performance
6. better control of aggression.[13]

Other therapies that can be included at this level of the Tree are: The Listening Program®, the Listening Fitness Training Program (LiFT®), and the Samonas Method. At the very top of the Tree is the program "Read-Spell-Comprehend®" which pulls together the foundational skills working toward completion for learning.

Body maintenance

In order for the Tree to thrive and maintain the learning changes accomplished through the development of the other Tree portions—Roots, Trunk, and Leaves and Branches, the entire tree needs to be nourished or at least maintained. The Voice-Ear-Brain Connection plays a pivotal role at this level because, as Dr. Tomatis described, the voice is key to the body's stability, and therefore the maintenance of the Tree.[7] It is the voice at the 'Body Maintenance' level that helps the body reach its maximum potential. The learning changes will only be maximally supported when this level is working appropriately. As the voice is the key ingredient at this level, the science of Human BioAcoustics® is used, because it explores the potential that the voice is a mathematical representation of the body and was developed with an understanding of the voice-ear-brain connection.

BioAcoustics, means 'life sounds,' and the science of Human BioAcoustics was established by Sharry Edwards. Through vocal analysis, Ms. Edwards has demonstrated that the body is a mathematical matrix of predictable frequency relationships.[12] Vocal analysis identifies those frequencies that are out of balanced. These frequencies are placed within the mathematical matrix and a frequency specific sound protocol is then created to support body change. This sound protocol helps maintain or enhance the learning and developmental changes obtained with the other sound-based therapies. The benefits are numerous and help people with learning, developmental, and wellness issues.[13]

Davis Addendum® to the Tomatis Effect

There is a continuous inter-connected web of cells called 'the living matrix'[14] that allows sound energy vibration to channel information to all parts of the body. Sound is not only heard through the ear but through every cell of the body because every cell is a sound resonator and responds to sounds from outside the body. All parts of the body respond to vibrations and affect physical, emotional, and mental states. A voiceprint displays when the body's vibrations or frequencies are distorted or not working well.[13]

The body has a distinct combination of frequencies for each structure and process which must be present and balanced to maintain integrity. The body can diagnose itself but is incapable of self-generating frequencies for corrective purposes. The voice is the most obvious and readily available frequency source for obtaining information about the body. The voice is the sound source and the ear is the receiver. Together they form a dynamic system. The ear establishes the foundation for energy patterns and the voice displays the patterns.[13]

The connections between the frequency output of Spontaneous Otoacoustic Emissions (SOAE) and the frequency output of the voice through vocal analysis have been studied. One hundred percent (100%) correlation between frequencies noted as 'stressed' (or out of the normal pattern) from both SOAE's and voiceprints was

reported,[15] and led to the creation of "The Davis Addendum® to the Tomatis Effect."[16] These two new laws are added to Dr. Tomatis' original three laws and state:

1. The ear emits the same stressed frequencies that are emitted by the voice.
2. When complementary frequencies of stressed frequencies are introduced, vocal patterns regain coherence.

Simply stated, the ear emits the same frequencies that are in "stress" (outside of the normal pattern) as the voice, and when a frequency known to balance the 'stressed' frequency (or complementary frequency) is listened to, the voice patterns demonstrate coherence or a continuity of the relationship between the phases of the wave patterns.

This effect occurs with brain waves, bio-electrical responses for sending vibration through the circulatory system, the peripheral nerves, and the perineural system.[8] These brain waves regulate the nervous system operation, and create the energy field around neurons to change, thereby determining sensitivity. They only respond when the energy field is sufficient to create a response. The science of Human BioAcoustics entrains brain waves to assist the body in supporting its own natural form and function through non-intrusive analog sound frequency presentation.[7]

Summary and conclusion

Our bodies search for ways to feel in balance or ways to feel good. Our bodies search for stability between external sound sources and internal body vibrations to create that balance and react physically and psychologically. When this balancing cannot be done by itself, sound-based therapies have been used to accomplish the change.

To best support the person, "The Tree of Sound Enhancement Therapy" becomes the developmental flow chart for the administration of sound therapies when the need is determined by the Diagnostic Evaluation for Therapy Protocol (DETP®). Any sound-based therapy can be supportive but maximum benefit can only be accomplished when the protocol established with the DETP is completed. Success is formulated on adherence to the entire protocol in order to maximize the development of an individual's overall sound processing skills. If the protocol is interrupted, maximum benefit is not achieved. If more than one therapy is suggested, and only one is completed, maximum benefit is not possible.

This protocol is founded on a 'total person approach' where maximum learning is supported by maximum wellness. This is accomplished by using the interventions described in The Tree of Sound Enhancement Therapy, allowing the person to maximize and maintain the body's changes.

Importance to optometrists

Vision therapy and sound-based therapy are complementary. Optometrists often see people with many of the same issues discussed in this article. Treatments involve retraining the sensory vibrational systems. Vision therapy is to seeing as sound-based therapy is to hearing. Vision therapy supports the changes made with sound-based therapy and vice versa.

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Footnotes

a. Davis DS. personal correspondence 2005.
b. Davis DS. unpublished research, 1992-2000.