



2021

AUDACITY

AUDIOLOGY UNLEASHED

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Evidenced-Based Practice: Music Training for Better Hearing

Jill Davis, AuD



Agenda: Components of a Song

- Introduction
 - Music Training vs. Music Therapy
- Verse: Telling the Story of a Song
 - Music and Audiology
- The Pre-Chorus: Helps Heighten the Impact of the Chorus
 - Research Review
- The Chorus: The Culmination of All the Ideas in the Song
 - Protocol and Real-World Examples
- The Bridge: An Unexpected Change of Pace for the Listener
 - Clinic Protocol Roadmap and Common Myths
- The Outro: The end of the song

The Introduction

Music Training



Music Training vs. Music Therapy

- Music Training
 - Playing a musical instrument
- Music Therapy
 - The clinical use of music interventions to accomplish individualized goals within a therapeutic relationship by a credentialed professional who has completed an approved music therapy program. Music therapy interventions can address a variety of healthcare and educational goals:
 - Promote wellness
 - Manage stress
 - Alleviate pain
 - Express feelings
 - Improve communication
 - Promote physical rehabilitation

“We really do know that making music can change our brain for the better throughout our lives”

Nina Kraus

OPERA Hypothesis

- OPERA hypothesis
 - **Overlap:** there is anatomical overlap in the brain networks that process music and speech
 - **Precision:** music places higher demands on these shared networks than does speech
 - **Emotion:** the musical activities that engage this network elicit strong positive emotion- reward centers and feelings
 - **Repetition:** the musical activities that engage this network are frequently repeated
 - **Attention:** we learn best what we pay attention to the most

Patel AD. Why would Musical Training Benefit the Neural Encoding of Speech? The OPERA Hypothesis. *Front Psychol.* 2011;2:142

Verse: Telling the Story of a Song

Music and Audiology



Music and Audiology

Why music training may play an essential role in the future of hearing healthcare. *Hearing Review*. August 2014

by Nina Kraus, PhD and Samira Anderson, AuD, PhD.

“a music-based auditory training program may provide significant benefits for neural processing and speech perception in older adults. Because music can be intrinsically reinforcing, it may provide sufficient motivation for perseverance with training”

Music and Audiology

Research suggests new avenues for music training in aural rehabilitation.

A review of more recent music-related findings and their possible implications. *Hearing Review*. August 2018

by Himanshu Kumar Sanju and Prawin Kumar, PhD

“It would appear that some of the new findings may eventually be applied to rehabilitative concepts related to people with hearing loss and cochlear implants, children with developmental language disorders, central auditory processing disorders, learning disabilities, dementia and schizophrenia.”

Music and Audiology

Musical training improves the ability to understand speech-in-noise in older adults. *Neurobiology of Aging*. September 2019.

by Benjamin Rich Zendel, Greg L. West, Sylvie Belleville, and Isabelle Peretz

“These findings support the idea that musical training provides a causal benefit to hearing abilities. Importantly, these findings suggest that **musical training could be used as a foundation to develop auditory rehabilitation programs for older adults.**”

Music and Audiology

Musical training for auditory rehabilitation in hearing loss. *Journal of Clinical Medicine*. April 2020.

by Jacques Pesnot Lerousseau, Celine Hidalgo, and Daniele Schon.

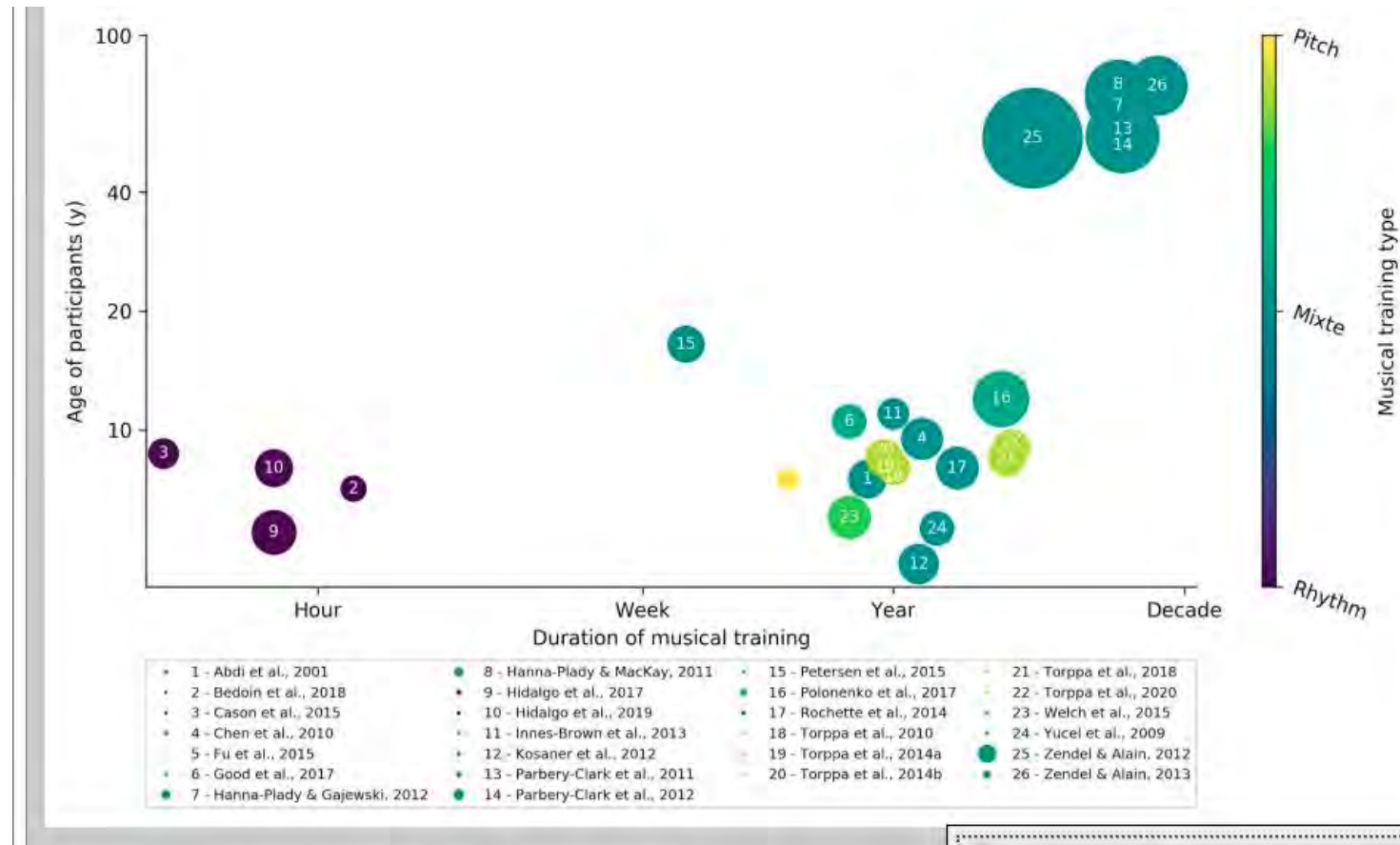
“Encouraging results are provided in the literature, and **musical training offers significant potential for auditory remediation therapies.**”

Pre-Chorus: Helps Heighten the Impact of the Chorus

Neuromusical Research
Aging, Hearing Loss, Cognitive Decline

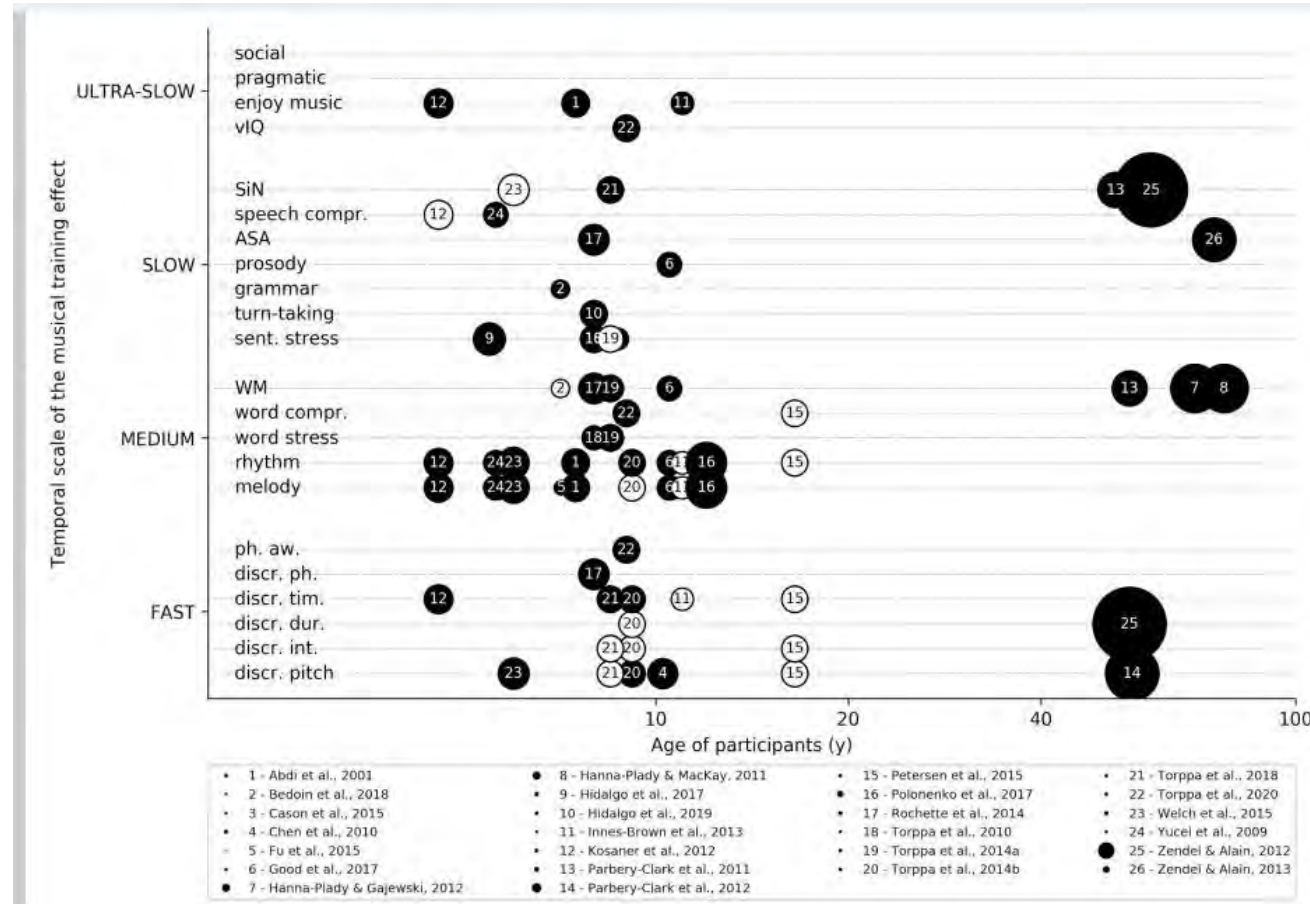


Review of Musical Training Protocols



Pesnot Lerousseau J, Hidalgo C, Schön D. Musical Training for Auditory Rehabilitation in Hearing Loss. *J Clin Med*. 2020;9(4):1058. Published 2020 Apr 8.

Review of Musical Training Effects for Hearing Impaired

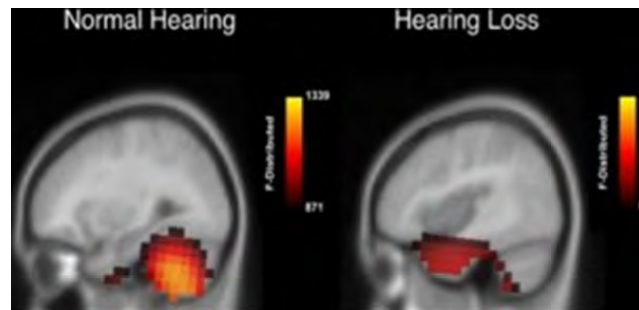
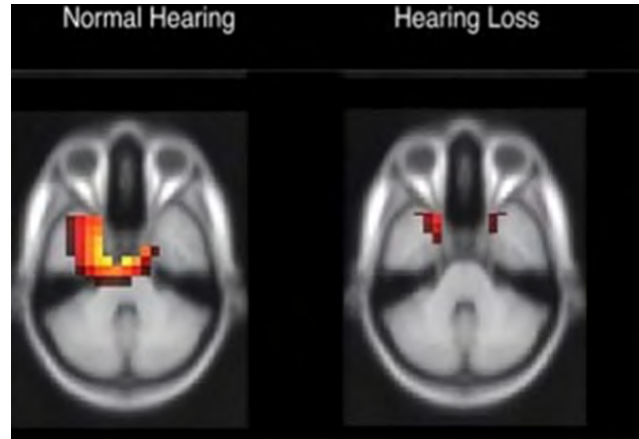


Pesnot Lerousseau J, Hidalgo C, Schön D. Musical Training for Auditory Rehabilitation in Hearing Loss. *J Clin Med*. 2020;9(4):1058. Published 2020 Apr 8.

Brain Changes with Aging

- Two Main Concerns:
 - Understanding speech in background noise
 - Cognitive decline
- Aging causes a reduction in speech processing, sensory, cognitive, and motor systems
 - “I can hear but I can’t understand”
 - “It is more difficult to hear when it is noisy”
- Aging causes delayed neural responses
 - But neuroplasticity shows age-related declines are reversed with training

Brain Changes with Hearing Loss



- Researchers exploring ways in which our brains respond to hearing loss found that the brain reorganizes, which may be the link between age-related hearing loss and dementia
 - As listening becomes more effortful, it leads to changes in the brain
 - As hearing loss increases, the brain has to work harder to listen
- “Cross-modal recruitment” of the hearing portion of the brain by the senses of vision and touch happens not only in deaf patients, but is also in adults with only a mild degree of hearing loss.
 - The hearing areas of the brain shrink in age-related hearing loss
 - Vision and touch take-over
 - Memory centers of the brain are compromised

Aging: From *Of Sound Mind*

- Even with normal hearing thresholds, some adults simply cannot understand the sounds they can hear
 - This failure usually takes the form of difficulty understanding speech in noisy places
- The brain needs sound to function optimally. Age-related cochlear deterioration can also deteriorate the hearing centers of the brain
- Wearing hearing aids can improve memory and listening in noise
- Brain changes are often unrelated to hearing loss
 - Slow neural timing, reduction in connectivity, increased neural noise, disorganized tonotopic map
- Blood flow is reduced and our brain shrink, about 5% per decade after the age of 40 (both gray and white matter are affected)
 - Mild cognitive decline involving processing speech and memory can occur

Aging: From *Of Sound Mind*

- Using FFR, there is a decline in brain's response to sound in older listeners
 - Smaller, delayed, less stable, less synchronized response to sound
- Using hearing aids for 6 months found listening and noise and cognition was better, even when not wearing their hearing aids, and brain reorganized.
- The decline cannot be blamed on hearing alone
 - Even with best hearing aid programmed to target, aging brain may still struggle to hear speech in background noise

Amplification and Speech in Noise

- Hearing aids/CIs can reverse negative changes (psychological and emotional) and may offset cognitive decline from untreated hearing loss
 - Wearing hearing aids show reversal in cross-modal recruitment
- Difficulty hearing in noise is the top complaint of older adults with or without hearing aids
- Hearing aids are increasingly remarkable in ability to suppress noise but is brain receiving proper stimulation to correct the aging auditory system?
 - Directional Microphones
 - Decrease gain in high frequencies
 - Increase noise reduction
 - Fast acting compression

Amplification and Auditory Training

- Amplification alone is not enough
 - Separating speech from noise is a brain task, not an ear task
 - Some patients need to train the brain on the sounds coming from the aids
- Auditory training provides improvements in speech processing and auditory working memory, which is crucial for hearing speech in noise
- Auditory training accelerates the brains rebuilding process
 - Its like physical therapy for the brain
- Training partially reverses the effects of aging on neural timing and improving central auditory processing
- Current Programs include:
 - Amptify (cLEAR)
 - LACE
 - Brain HQ
 - Angel Sound
 - CoPilot
 - HEAROes

Training: From *Of Sound Mind*

- 8-week brain exercise program (Brain HQ)
 - Improvements in memory, listening in noise, and processing speed
 - Directed auditory training over a short period of time can offer tuning of the brain to improve listening in noise.
 - Unfortunately, the gains do not persist beyond training

Why Music-Based Auditory Training?

There is emerging evidence to suggest that music may help to delay the onset of dementia and improve brain function and information recall.

[HTTPS://PRACTICALNEUROLOGY.COM/ARTICLES/2017-JUNE/MUSIC-AND-DEMENTIA-AN- OVERVIEW](https://practicalneurology.com/articles/2017-june/music-and-dementia-an-overview)

Music and the Brain

- Brain regions involved (from fMRI)
 - Movement
 - Attention
 - Planning
 - Memory
 - Language
 - Emotion
 - Vision
- Benefits of music
 - Reduce stress and anxiety
 - Increase mental alertness
 - Release endorphins that make us
 - Smarter
 - Healthier
 - Happier
 - More creative

Musicians vs. Non-Musicians

- Research shows that musicians automatically perform better than non-musicians on difficult speech in noise tests
- Music stimulates different parts of the brain and that stimulation can help reduce cognitive decline and improve speech understanding
- Musicians have superior auditory skills
 - Speech perception in noise and cognitive abilities
 - Working memory and attention
- Non-musicians rely on pitch of speech for understanding where musicians hear with melody and rhythm

Music Training: From *Of Sound Mind*

- “Music training can contribute to a healthy older life”
 - Listening to speech in noise is better in older musicians than non-musicians
 - Older musicians maintain better memory and cognitive skills
 - Older adult musicians’ brains resembled those of healthy adults
 - Older adults with hearing loss listening in noise matched or exceeded non-musician’s with normal hearing (even half their age)
 - With or without hearing loss, the musician brain keeps producing crips, young-adult-like neural activity into older age
 - Positive outcomes of playing music last even if you do not continue to play

Benefits last a lifetime

- Positive outcomes of making music last even if you do not continue to play music. Once the brain has learned to make strong connections between sound and meaning, the brain continues to reinforce the skill automatically

Why are musicians so good at hearing speech in noise?

- OPERA hypothesis gives clues but adding rhythm and working memory as 2 more key components. (“OPERRAW feels undercooked”)
- Rhythm of speech allows us to fill in the gaps in noise
 - When noise obscures speech, the underlying rhythm helps us predict the words we cannot make out, drummers are excellent examples
- Working memory is essential for following a conversation, musician or not

Music Training Research

- Johns Hopkins: Musicians display strengthened brain networks for selective auditory attention that non-musicians do not
- Baycrest Health Sciences Study: Playing piano improved the attention, memory and problem-solving abilities
 - Learning to play sound on a musical instrument alters the brain waves in a way that improves a person's listening and hearing skills over a short time frame
 - Learning the fine movement needed to reproduce a sound on an instrument changes the brain's perception of sound in a way that is not seen when listening to music
- Univ. of Toronto: Musicians showed less brain activity when completing difficult listening tasks
 - Require less effort to perform the same task, which protects them against cognitive decline and delay the onset of dementia
- Neuroimaging studies found significantly increased grey matter volume in musicians compared to non-musicians
 - Grey matter: associated with memory, emotions, muscle control, speech, and decision making

“Making music shapes brain networks to strengthen sound processing”

Nina Kraus

5 Benefits of Music Training on Cognition

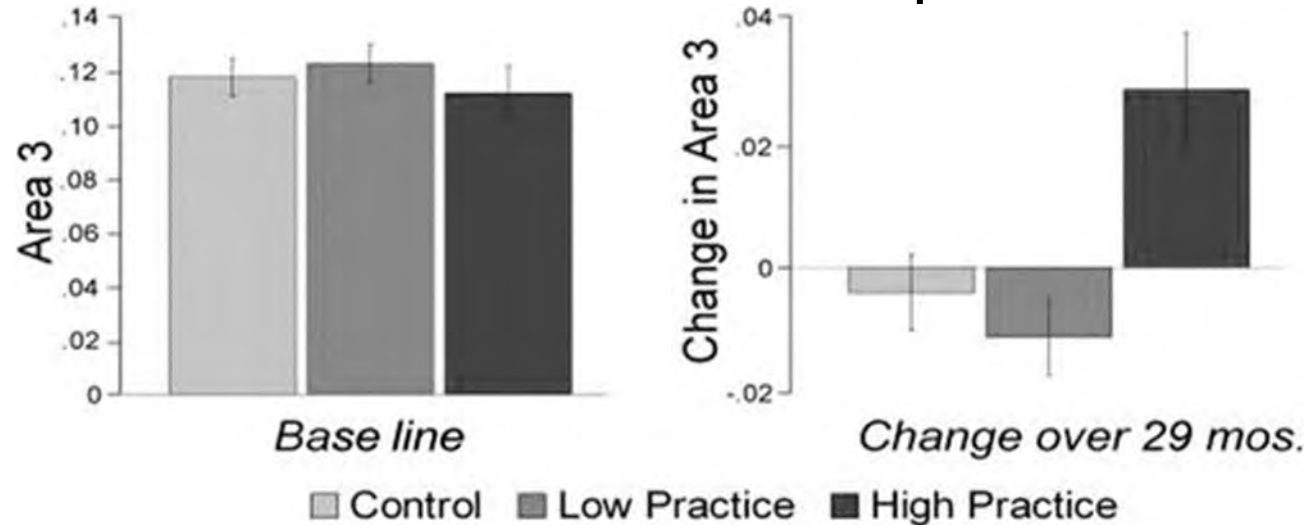
- Promotes Neuroplasticity
- Improves Cognitive Abilities
- Promotes Healthy Aging of the Brain
- Beneficial for Overall Health
- Is a Rewarding Activity

1. Music Training Promotes Neuroplasticity

- The more you engage in any activity, the more consistently neurons are firing together, which results in stronger connections. What is unique about music training is its capacity to induce neuroplastic changes in ***all*** areas of the brain
- Music training uses:
 - Occipital lobe to read and interpret pitches and rhythm
 - Temporal lobe to process sound
 - Frontal lobe to attend to the music, inhibit irrelevant distractions and remember what you just played
 - Parietal lobe to integrate all of the incoming sensory information

Training Induced Neuroplasticity in Young Children

- Significant increase in the size of the corpus collosum after music training



Schlaug, Forgeard, et al. "Training-induced Neuroplasticity in Young Children" Annals of the New York Academy of Sciences. 2009 July. 1169: 205-208.

2. Music Training Improves Cognitive Abilities

- Studies have shown that music training improves cognitive abilities (e.g., working memory, attention and inhibition) across our life span. This has been shown with both short-term and long-term music training.
- Moreno, et al found that after 20 days of music training, 90% of participants had improved executive function and verbal intelligence
- Moreno, Sylvain et al. "Short-term music training enhances verbal intelligence and executive function." Psychological science vol. 22,11 (2011): 1425-33.

3. Music Training Promotes Healthy Aging of the Brain

- Piano as a cognitive intervention to mitigate normal age-related cognitive decline in older adults (age 60-85)
- Musicians have an advantage in maintaining their cognitive abilities during the aging process
 - Executive function and short-term memory
 - Better ability to hear in background noise

Schneider, Hunter, Bardach. "Potential Cognitive Benefits From Playing Music Among Cognitively Intact Older Adults: A Scoping Review" Journal of Applied Gerontology. 2019 Dec. 38 (12) 1763-1783

Bugos, Perlstein, et al. "Individualized Piano Instruction enhances executive functioning and working memory in older adults" Aging Mental Health. 2007 Jul 11(4) 464-471

Parbery-Clark, Strait, Anderson, Hittner, Kraus. "Musical Experience and the Aging Auditory System: Implications for Cognitive Abilities and Hearing Speech in Noise" PLOS ONE 6(5).

4. Music Training Beneficial for Overall Health

- A recent study has shown that group musical activities are potential ways to maintain physical and psychological health. For example, a lowered risk of dementia has been associated with playing musical instruments

- Verghese, Lipton, et al. “Leisure Activities and the Risk of Dementia in the Elderly” The New England Journal of Medicine. 2003. June(348):2508-2516

5. Music Training is a Rewarding Activity

- Your brain is more apt to learn if an activity is inherently rewarding and motivating.
 - Studies have shown that listening to music is a rewarding experience in and of itself, activating brain structures involved in reward processing, including the nucleus accumbens, ventral tegmental area, hypothalamus and insula.
-
- Menon, Levitin. “The Rewards of Music Listening: Response and physiological connectivity of the mesolimbic system” *NeuroImage*. 2005. Oct (28) 175-184.

Factors Involved in Music Training

Listening vs. Playing an instrument

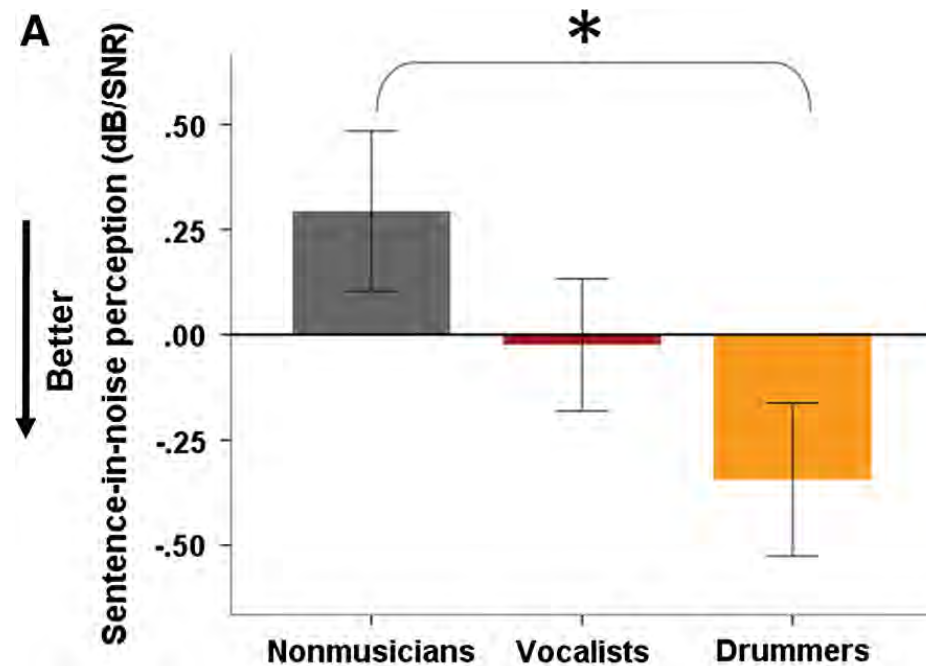
- Listening:
 - Relaxation, stress relief, mood regulation, temporary attention, memory, motor synchronization and reasoning skills: dopamine production
 - Lack of evidence that merely listening to music has much lasting impact on the sound mind
- Playing:
 - Brain changes are not evident until hands-on music-making stage
 - There must be training, repetition, and practice for long-lasting brain changes

What Kind of Music Training?

- Choir
 - Social and cognitive benefits
 - Can pick up relatively easy at any age
 - 2 hrs/week for 10 weeks
- Instrument playing
 - Piano or violin lessons
 - 30 minutes/day
 - 3 days a week
 - 12 weeks
 - Adults 65-80 without previous music training increased speech processing and memory

Instrument vs. Singing

- Our brains are wired for music learning through song far before we play an instrument. “If you can’t sing it, you can’t play it”
- Cognitive benefits of learning music come from a foundational level of singing which is enhanced by playing a musical instrument
- “the more extensive engagement of motor systems during instrumental practice may be an important factor for enhancements in inhibitory control, consistent with evidence for overlapping neural circuitry involved in both motor and cognitive control.”
- Participation in school music (instrument playing) was related to higher exam scores and were over 1 year ahead of non-musically trained peers in Math, Science, and English (112,000 participants)



- Guhn, M., Emerson, S.D., & Gouzouasis, P. (2019) A population-level analysis of associations between school music participation and academic achievement. *Journal of Educational Psychology*
- Slater J, Azem A, Nicol T, Swedenborg B, Kraus N Variations on the theme of musical expertise: cognitive and sensory processing in percussionists, vocalists and non-musicians. *European Journal of Neuroscience*. 45, 952-963.

Which Musical Instrument is Best?

- Harmony instruments scored higher on 5 of 8 cognitive tests

Table 2. Test battery.

Dependent Variable	Test	Test type
Cognitive flexibility	Wisconsin Card Sorting Test	Form
Verbal Working Memory	Digit Span (WAIS-IV)	Form
Cognitive Inhibition	Stroop Test	Form
Visual-Spatial W. Memory	Binding (YellowRed)	Tablet
Go/No-Go	Cats&Dogs (YellowRed)	Tablet
Divided Attention	Divided Attention (HAL2)	Tablet
Fluid Intelligence	FIX (HAL2)	Tablet

Table 1. Musical instrument classification examples by music element.

Rhythm	Melody	Harmony
Cymbal	Flute	Piano
Snare	Trumpet	Guitar
Timbale	Saxophone	Organ
Agogo	French Horn	Harpsichord
Jam Block	Ocarina	Harp



BBB Professional Reading - October 2020

The Chorus: The Culmination of All the Ideas in the Song

Protocol and Real-World Examples



The logo features a stylized human figure with arms raised, positioned between two sets of three curved lines that resemble sound waves or wings.

VICTORY

Brain Training Program

The logo consists of a central treble clef flanked by two sets of three curved lines, similar to the ones in the Victory logo.

Music to Your Ears

Music Training Candidates

- Candidates:
 - Patients struggling to hear in background noise
 - Patients who do not improve cognitive function after hearing aid or CI treatment
 - Patients with Auditory Processing Disorder (APD)
 - Anyone who would like to exercise their brain
- What is it:
 - 3-month piano playing auditory training course
 - Uses a smartphone or tablet in addition to a piano keyboard
- How:
 - Patient plays 3 days a week for 30 minutes a day

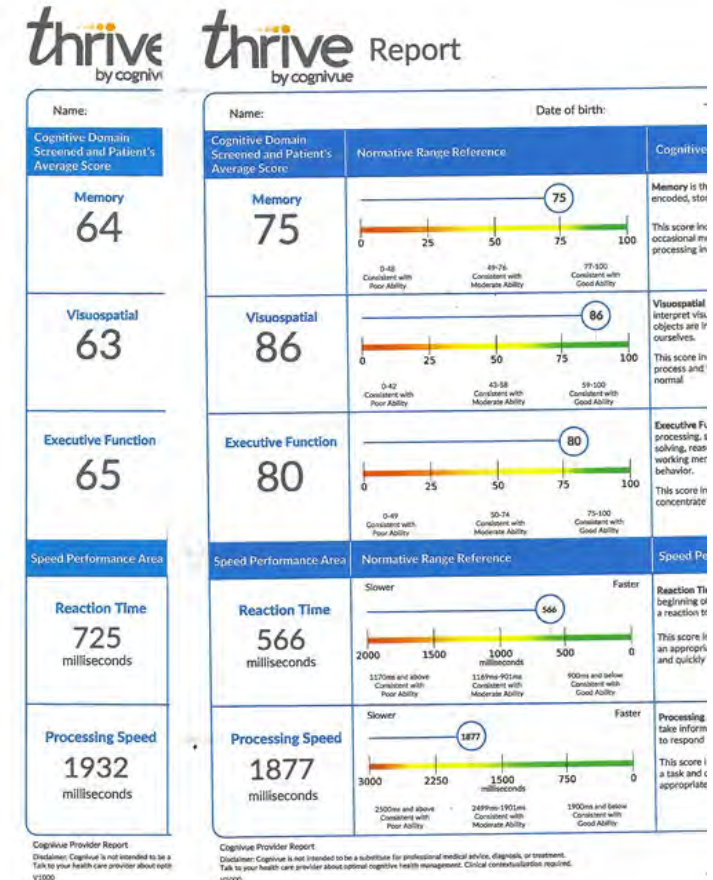
Music Training: 67-year-old Female

Pre-Training

- HHIE: 42
- QuickSIN: 2.2 dB
- Aided QuickSIN: 2.2dB
- Cognivue: mild

Post-Training

- HHIE: 26
- QuickSIN: 1.8 dB
- Aided QuickSIN: .5 dB
- Cognivue: improved



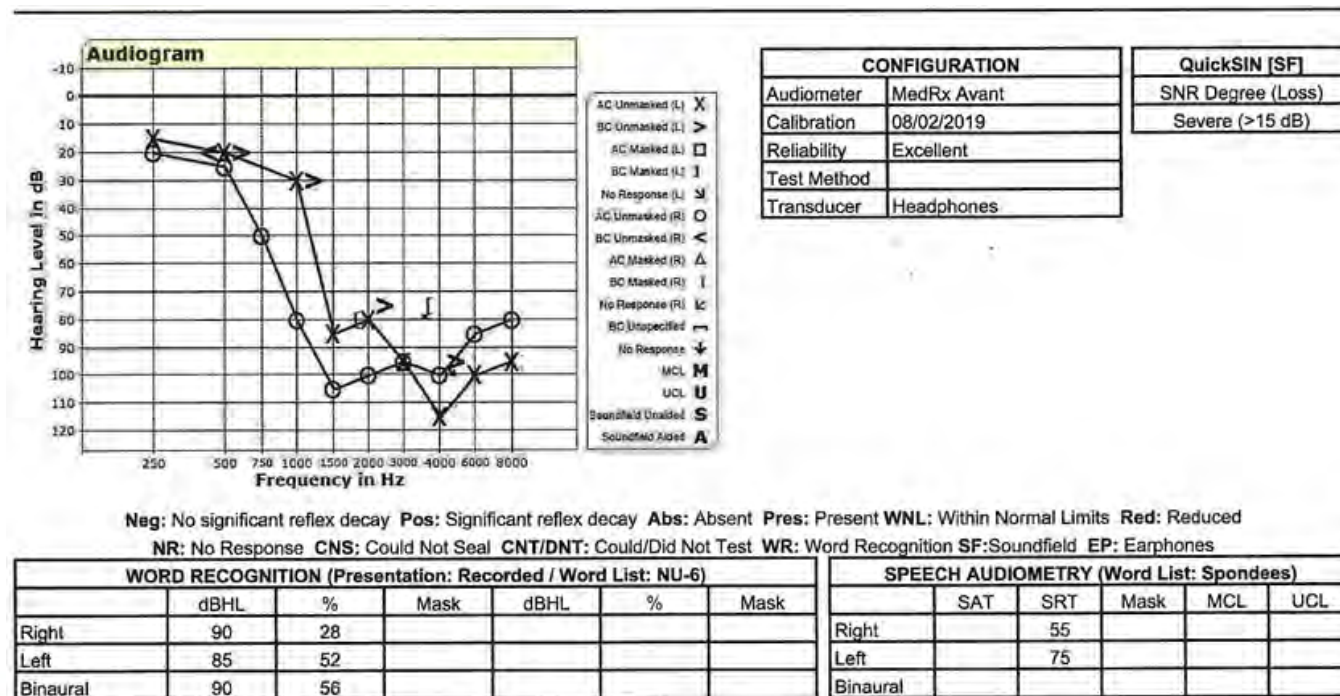
Music Training: 64-year-old Male

Pre-Training

- Az Bio +5 dB SNR: 56%

Post-Training

- Az Bio +5 dB SNR: 72%



Music Training: 74-year-old Female

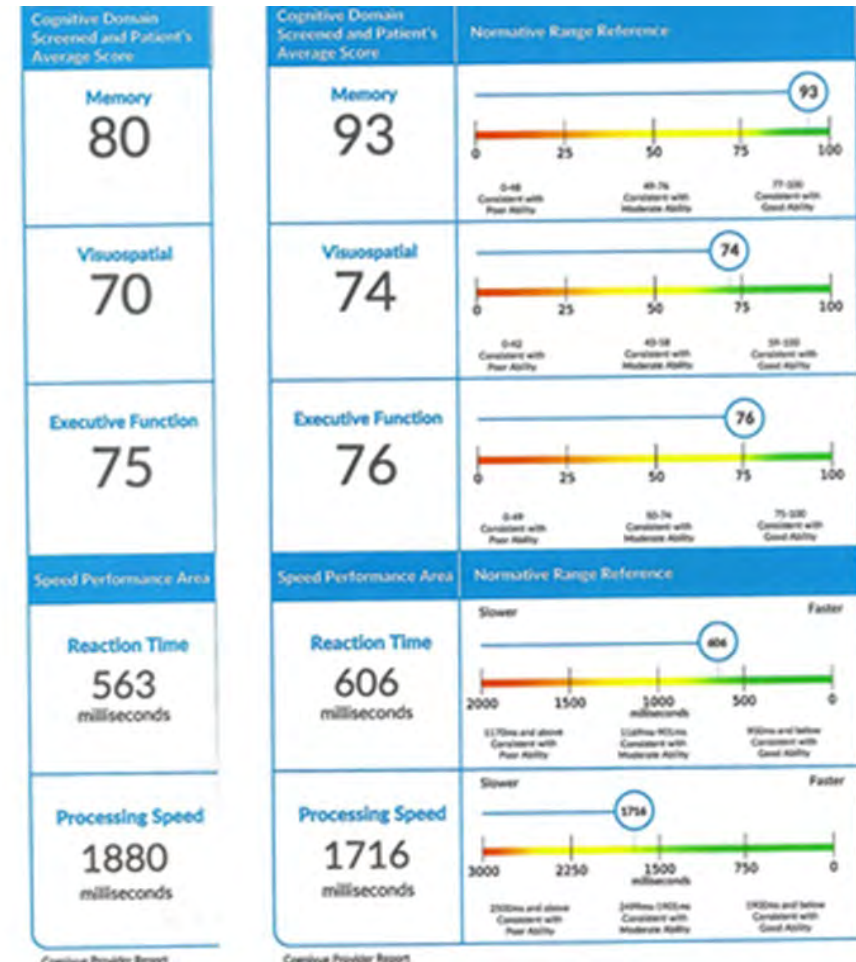
Pre-Training

- HHIE- 34
- Unaided QuickSIN- 1.2 dB
- Aided QuickSIN- .5 dB
- Cognitive Screening- WNL

Post-Training

- HHIE-20
- Unaided QuickSIN- .5 dB
- Aided QuickSIN- -.2 dB
- Cognitive Screening- improved

“I have more energy at the end of the day”



Music Training for APD

Central Test Battery	Task	Level of Skill	
		Initial Test Date: 7/9/2020	Retest Test Date: 6/10/2021
W-22 Words	Right Ear in Quiet	Mild weakness	Normal
	Right Ear in Noise	Severe weakness	Normal
	Left Ear in Quiet	Moderate weakness	Normal
	Left Ear in Noise	Severe weakness	Mild weakness
	Total NOE	Severe weakness	Moderate weakness
SSW Test	Right Non-Competing	Severe weakness	Normal
	Right Competing	Moderate weakness	Normal
	Left Competing	Severe weakness	Moderate weakness
	Left Non-Competing	Severe weakness	Normal



The Bridge: An Unexpected Change of Pace for the Listener

Clinical Protocol Roadmap

Myths



Clinical Protocol Roadmap

Three Types of Patients

- Perceives hearing loss (no measurable loss) and low cognitive screen (10%)
 - Differential Diagnosis: Brain issue
 - APD testing
 - Auditory training
- Hearing loss and normal cognitive screen (30%)
 - Differential diagnosis: Ear issue
 - Treat hearing loss
 - No auditory training
- Hearing loss, poor speech in noise, low cognitive screen (55%)
 - Differential diagnosis: ear and brain issue
 - Treat hearing loss
 - Re-test
 - if performance improves: ear issues
 - If performance remains low: auditory training

Music Training Protocol

- Initial Consultation:
 - Hearing Questionnaires (HHIA, COSI, etc)
 - Cognitive Screening (Cognivue, etc)
 - Comprehensive Audiometry
 - Speech in Noise (QuickSIN, AZBio, etc)
- Recommendations based on results
 - Hearing aids
 - Music training
 - Hearing aids and music training
 - Adjustments to current aids and music training

Treatment Plan:

- Initialize Brain training program
- Patient downloads the Flowkey app and enters free code
- Purchase or rent a keyboard
 - I keep keyboards in my office for patients to rent if they do not want to commit to purchasing
- Initial training appointment together if necessary

Follow Up:

- 4-week (coaching phone call to check in)
- 12-week post-training appointment
 - Re-administer questionnaire (HHIA, COSI, etc)
 - Re-administer cognitive screener
 - Re-test Speech in Noise

Myth 1: It's too late for me to learn the piano

It's never too late: From ***Of Sound Mind***

- Brain continues to be shaped into old age
- An older person who starts playing today will see benefits in neural processing and real-life listening abilities
- 10 weeks of 2-hour weekly choir sessions improved listening in noise and boosted neural responses in adults from mid-50s to late 70s
- 60 to 80-year-olds who made music vs. listened increased working memory and hand-eye coordination

Myth 2: I'm not musical enough

Music is in all of us! With interactive tools and online lessons, it's easier than ever before to express your inner voice on piano

Brain-Training Apps

- Lumosity, Elevate, Fit Brains Trainer, Cognito
- 75 million people playing and 50,000 downloads a day
 - Advertises its ability to “train memory and attention through a personalized training program”
 - Speed, memory, attention, flexibility, problem solving
- 23 studies (as of 2014) found that brain training programs improved performance on the tasks at hand, but it never actually translated to any increase in intelligence or cognition.
- Benefits were short-lived, where benefits of training with music lasts late into adulthood

Improving fluid intelligence with training on working memory. Susanne M. Jaeggi, Martin Buschkuhl, John Jonides, and Walter J. Perrig. PNAS April 25, 2008

Myth 3: I have to practice for hours

- Actually, practicing in short bursts is proven to be more effective. It's not about how long you practice, it's about consistent practice.
- Lappe et al. (2008) showed that even short-term musical training in adults can induce cortical plasticity. In their study, a group of adults learned to play a piano sequence, while the control group just listened to the music and judged it. Their results indicated that the group that actively played piano had an enlargement of Mismatch Negativity Potentials after training, while passive listeners did not show such a pattern.

Cortical Plasticity Induced by Short-Term Unimodal and Multimodal Musical Training. Claudia Lappe, Sibylle C. Herholz, Laurel J. Trainor and Christo Pantev. Journal of Neuroscience 24 September 2008, 28 (39) 9632-9639.

The Outro

Conclusion

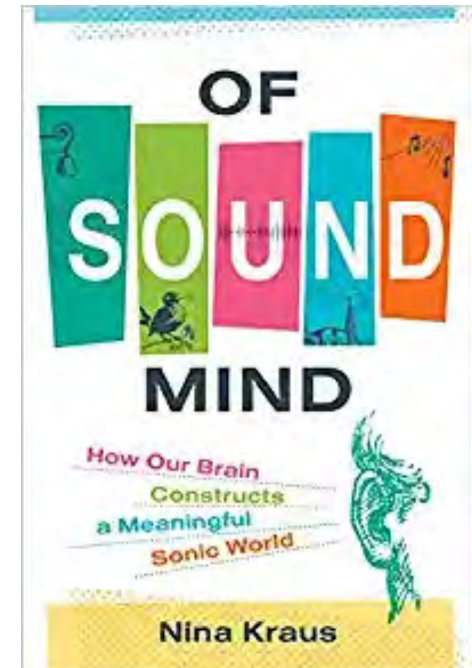
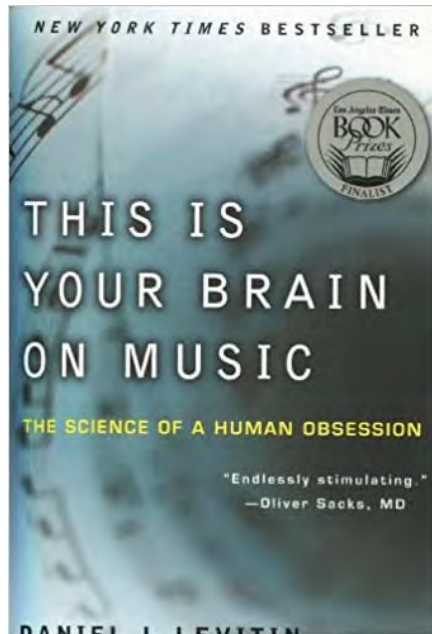


Conclusion

- Hearing loss and aging create changes in the brain that lead to cognitive decline, memory loss, and difficulty hearing speech in background noise
- Hearing aids and cochlear implants can amplify sound but cannot correct for the changes in brain due to aging
- Auditory Brain Training supplements hearing aids in order to improve hearing in background noise and working memory
- Musicians perform better in background noise and have better brain function on Brain Training exercises
- Music training results in better speech understanding in background noise and improved working memory
- Everyone can benefit from music training

Conclusion

- Music Therapy referrals: www.musictherapy.org



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