

OFFICIAL PUBLICATION OF THE CANADIAN ACADEMY OF AUDIOLOGY  
PUBLICATION OFFICIELLE DE L'ACADÉMIE CANADIENNE D'AUDIOLOGIE

# Canadian Hearing Report

Revue canadienne d'audition

CAA Canadian Academy of Audiology  
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ACA Académie canadienne d'audiologie  
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Vol. 8 No. 2  
2013



## Hearing Loss and Music: Special Issue

### A Musician's Hearing Loss Awareness Program in Turkey

### Beethoven and Me: The Effects of Hearing Loss on Music Composition

Publications Agreement Number 40025049 | ISSN 1718 1860

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# 3

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Not everyone is a musician but music is something that everyone needs. This is true whether its background “noise” as a distraction when doing aerobics or jogging, or whether one actually derives

pleasure from listening to, or playing music. The field of music and hearing is relatively new, and the branch of music and hearing aids is even newer. A misconception about the field is that it is about musicians. This is not the case. The field of music and hearing is relevant to everyone who, from time-to-time, just wants to listen to music. This is as true for my mother and father who occasionally attend a musical production at the local theatre, as it is for the hard of hearing 64-year-old jazz musician who need some amplification to hear the harmonics and other instruments also being played in the venue.

My son Shaun recently graduated from the Berklee College of Music in Boston and when home for summer breaks, I was always amazed at how much his computer screen for composition and song production looked like a typical hearing aid programming screen. He has control over all aspects of compression-attack, release time, and compression ratio. He has control over gain and output, and his equalization is similar (but more frequency specific) than those found in my hearing aid clinics. It can be said that an audiologist is simply a recording and production engineer for hard of hearing people. I suspect that we can learn a lot from the field of music and it is hoped that, in the not too distant future, our programming screens will allow as much “fine tuning” as the ones

used in the composition and recording fields.

As you have probably guessed, this issue of the *Canadian Hearing Report* is about music and music-related issues. We have articles from virtually every realm of music. This includes articles from hard of hearing musicians, hearing loss in classical orchestral musicians, the various effects of MP3 players, as well as articles on the benefits of music in our brains.

I haven't seen Beethoven clinically for many years now, but I know that the last time I did, he had a progressive hearing loss over his lifetime. Jay Alan Zimmerman writes a most delightful piece on how Beethoven's music changed over the course of his lifetime – gradually shifting the key and playing range towards the left hand side of the piano keyboard (possibly in response to a gradually high frequency hearing loss). Like Jay, Richard Einhorn is a well-known hard of hearing American composer and musician who writes about the limitation of many modern hearing aids to handle the more intense components characteristic of music, along with some strategies that have worked for him. And let's not forget our own Peter Stelmachovich who writes our regular column *The Deafened Audiologist* – top ways to enjoy music with a hearing loss. Gael Hannan, who like me can only play the radio, asks in her regular column “The Happy HOH”, could somebody turn my music back on?

New knowledge about music induced hearing loss is conveyed to us by Nina Kraus who is a guest columnist for this issue for *All Things Central*. Dr. Kraus writes about the musicianship's effect on the brain. Patty Johnston is also a guest columnist in this issue of the *Canadian*

*Hearing Report* for Spotlight on Science with her column about noise and music induced hearing loss. Patty's guest column is adapted from a guest blog that she had written for me at *Hearing-HealthMatters.org* – a weekly blog about all aspects of hearing loss. And of course, Calvin Staples does his usual great job of selecting some recent music-related blogs from *HearingHealthMatters.org*.

Ata Akdag writes all the way from Turkey and shares the efforts expended to develop of musicians' hearing loss awareness from in his country and reviews some of the work that has been done to “convince” musicians about hearing loss prevention strategies. Closer to home Alberto Behar and I examine hearing loss in classical musicians.

And finally, Julia Ruth Hopkins writes about her struggles – personal and administrative – to become the first music teacher in Ontario to receive coverage for her hearing loss through the provincial Worker's Safety and Insurance Board (WSIB). To date, only British Columbia and Ontario provides coverage to music teachers.

2013 is a special year for hearing loss prevention for musicians – it is the 25th anniversary of the first flat attenuation musicians' earplug. I hope you all take a bit longer than usual to read through this issue. We can all learn something from music and our hard of hearing musician clients that we can bring to our own clinical environments.

Marshall Chasin, AuD, M.Sc., Aud(C),  
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*Canadian Hearing Report* 2013;8(2):3.

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Revue canadienne d'audition

Vol. 8 No 2 • 2013

Official publication of the  
Canadian Academy of AudiologyPublication officielle de l'académie  
canadienne d'audiologie  
www.canadianaudiology.ca

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Canadian Hearing Report is published six times annually by Andrew John Publishing Inc. with offices at 115 King Street West, Dundas, On, Canada L9H 1V1.

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Individual copies may be purchased for a price of \$19.95 Canadian. Bulk orders may be purchased at a discounted price with a minimum order of 25 copies. Please contact Ms. Brenda Robinson at (905) 628-4309 or brobinson@andrewjohnpublishing.com for more information and specific pricing.

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About the Cover:

Courtesy of Etymotic Research  
(www.etymotic.com) the front cover shows a  
pair of musicians' earplugs that are now  
celebrating their 25 years of age. These have  
uniform attenuation that allows the musicians  
to play and to listen to their music at a safe  
level while maintaining the original balance of  
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Loin de nous l'idée qu'on est tous musiciens mais tout le monde a besoin de musique. C'est vrai, quand c'est une musique de distraction en arrière-plan quand on fait sa danse aérobique ou son jogging, ou si on prend plaisir à écouter ou à jouer de la musique. Le domaine de la musique et de l'ouïe est relativement nouveau, et la filière de la musique et des appareils auditifs est encore plus récente. Une méprise sur le domaine est la croyance que c'est au sujet des musiciens. Ce n'est pas le cas. Le domaine de la musique et de l'ouïe est pertinent à toute personne qui, de temps à autre, veut juste écouter de la musique. Ceci est vrai pour ma mère et mon père, qui à l'occasion vont voir une production musicale au théâtre local, et aussi vrai pour le musicien de Jazz malentendant de 64 ans qui a besoin de certaine amplification pour entendre les harmoniques et les autres instruments aussi joués à l'endroit.

Mon fils Shaun a récemment obtenu son diplôme de the Berklee College of Music de Boston et quand il rentrait pour les temps des vacances d'été, j'étais toujours étonné de constater que son écran d'ordinateur pour la composition et la production de chanson était semblable à l'écran typique des programmes pour les appareils auditifs. Il a le contrôle sur tous les aspects de compression – attaque, temps de libération, et taux de compression. Il contrôle les gains et sorties, et son égalisation est similaire (mais plus spécifique à la fréquence) que ce que j'ai dans mes cliniques d'appareils auditifs. On pourrait dire simplement qu'un audiologiste est un ingénieur d'enregistrement et de production pour les personnes malentendantes. Je me doute bien que nous pouvons apprendre énormément du domaine de la musique et il y a lieu de croire que, dans un futur pas très lointain, nos écrans de programmation vont nous permettre autant de "réglage fin" que ceux utilisés

dans le domaine de la composition et de l'enregistrement.

Comme vous l'aurez probablement deviné, ce numéro de *La revue canadienne d'audition* est sur la musique et les enjeux qui s'y rapportent. Nous avons des articles virtuellement au sujet de chaque domaine de la musique. Parmi ces articles écrits par des musiciens malentendants, le sujet de la perte auditive chez les musiciens d'orchestre classique, les effets variés des baladeurs numériques MP3, et des articles sur les bienfaits de la musique sur nos cerveaux.

Ca fait des années maintenant que je n'ai pas vu Beethoven cliniquement, mais je sais que la dernière fois que je l'ai vu, il avait une perte auditive progressive tout au long de sa vie. Jay Zimmerman rédige une pièce exquise sur la musique de Beethoven qui a changé durant sa vie – Graduellement déplaçant la touche et la portée du jeu vers le côté gauche du clavier du piano (possiblement en réponse à une graduelle perte auditive de haute fréquence). A l'instar de Jay, Richard Einhorn est un musicien et compositeur malentendant américain bien connu qui se penche sur les limitations de plusieurs appareils auditifs modernes à traiter les composantes plus intenses des caractéristiques de la musique, et aussi sur certaines stratégies qui ont marché pour lui. Et n'oublions pas notre Peter Stelmachovich qui rédige notre chronique régulière "Laudiologiste devenu sourd" – étalage de la tête de liste des moyens utiles pour prendre plaisir à écouter la musique même avec une perte auditive. Gael Hannan, qui comme moi peut seulement jouer de la radio, se pose la question dans sa chronique régulière "The Happy HOH", Ya-t-il quelqu'un pour brancher ma musique?

Une nouvelle connaissance de la perte auditive induite par la musique nous est acheminée par Nina Kraus qui est la chroniqueuse invitée de ce numéro pour la chronique All Things Central. Dr. Kraus traite les effets de la musique sur le cerveau. Patty Johnson est aussi une

chroniqueuse invitée pour la chronique Spotlight on Science de ce numéro de La Revue canadienne d'audition avec sa chronique sur la perte auditive induite par le bruit et la musique. La chronique de Patty est adaptée de son blog qu'elle a écrit pour moi au [HearingHealthMatters.org](http://HearingHealthMatters.org) – Un blog hebdomadaire au sujet de tous les aspects de la perte auditive. Et bien sûr, Calvin Staples, comme à son habitude, excelle dans sa sélection de blogs qui ont trait à la musique dans le [HearingHealthMatters.org](http://HearingHealthMatters.org).

Ata Akdag nous écrit de sa Turquie lointaine et partage avec nous les efforts consacrés à développer la sensibilisation à la perte auditive chez les musiciens de son pays et revisite certains travaux qui ont été entrepris pour "convaincre" les musiciens qui souffrent de la perte auditive. Plus près de chez nous, Alberto Behar et moi-même examinons la perte auditive chez les musiciens de formation classique.

Et finalement, Julia Ruth Hopkins se penche sur ses difficultés – personnelles et administratives – pour devenir la première enseignante de musique à recevoir la couverture pour sa perte auditive à travers la commission de la sécurité professionnelle et de l'assurance contre les accidents du travail (CSPAAT). A jour, seule la Colombie britannique et l'Ontario fournissent une couverture pour les enseignants de musique.

2013 est une année spéciale pour la prévention de la perte auditive chez les musiciens – c'est le 25<sup>ème</sup> anniversaire du premier bouchon d'oreille à atténuation plate. J'espère que vous prendrez tous plus de temps que d'habitude à feuilleter ce numéro. Nous pouvons tous apprendre de la musique et de nos clients musiciens malentendants, un apprentissage que nous pouvons amener dans nos environnements cliniques.

Marshall Chasin, AuD, M.Sc., Aud(C), Reg. CASLPO

Éditeur en chef

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Canadian Hearing Report 2013;8(2):7.

Dear CAA members,

The recent *CBC Marketplace* report on the high cost of hearing aids was terrible journalism and a disservice to our members and to Canadians with hearing loss. It misrepresented the true cost of hearing aids and suggested that audiologists are grossly overcharging for hearing aids and services.

The *Marketplace* episode claimed that they contacted a “national audiology association” that was not helpful, and did not wish to appear on camera. **Unfortunately the national organization that Marketplace contacted was not the CAA.** When I learned about the upcoming *Marketplace* story I contacted the CBC on behalf of the CAA, but this was not included in the episode. I have every confidence that CASLPA and the other organizations responded to the CBC in good faith, but I am saddened that the CAA was not given the opportunity to respond to this very important matter.

This reaffirms my conviction that we need to increase our national profile and our advocacy to the public. As you know, the CAA is a volunteer-based organization. Please consider how you can get involved and support your profession. Together we can improve public awareness about audiologists, audiology services and the importance of hearing, and we can help prevent the type of disinformation that resulted from this poorly handled story. Together we can make a real difference in our profession and in the lives of the people that we serve.

Sincerely,  
Steve Aiken, President,  
Canadian Academy of Audiology

**THE FOLLOWING LETTER WAS  
SENT TO THE PRODUCERS OF  
MARKETPLACE**

*CBC News  
Marketplace, P.O. Box 500  
Toronto, ON M5W 1E6  
Fax: 416-205-2246*

To the CBC Marketplace producers:

I am writing in response to your segment on the cost of hearing aids that aired February 5 on *CBC Marketplace*.

As a practicing audiologist, I am concerned about your portrayal of audiologists as hearing aid hawkers who aim to rob the public of their hard-earned dollars.

My experience is that audiologists are drawn to the profession because they are passionate about hearing and hearing health care. And they do a lot besides dispense hearing aids.

Audiologists perform diagnostic tests for hearing and balance disorders. They alert physicians to possible medical problems picked up during testing. They run hearing screening programs to identify hearing loss in infants and children. They run cochlear implant programs for people too deaf to benefit from hearing aids. They teach speech-reading courses for those struggling with the invisible disability of hearing loss. They run hearing conservation programs to educate the public and workers on the hazards of noise and the use of hearing protection. They work with seniors to minimize the isolating effects of hearing loss. They teach educators, health care professionals and the public on hearing and balance disorders and their

management. They work to address classroom noise and poor acoustics that hinder children's ability to hear their teachers. They write letters supporting patients who need equipment or accommodation for hearing loss. They educate families on how to communicate with their hard-of-hearing loved ones. They reassure clients who fall apart when they learn that they are losing their hearing. They provide services for people struggling with tinnitus. They do research, often “off the side of their desk” and on their own time. They prescribe hearing aids. And yes, many audiologists are also licensed to dispense hearing aids, a complex process that requires commitment from both the dispenser and the consumer to be successful.

Your segment also portrayed our professional associations as organizations intent on hiding the cost of hearing aids from consumers. The two national professional organizations representing audiology – the Canadian Academy of Audiology and the Canadian Association of Speech-Language Pathologists and Audiologists - aim to promote the profession and encourage a high level of professional and ethical practice. They are not regulatory bodies and play no role in the business of selling hearing aids.

It is a shame that CBC Marketplace would misrepresent the profession of Audiology and its professional organizations. It certainly does a great discredit to your program.

Sincerely,  
Glynnis Tidball, M.Sc. (Aud, SLP) RAUD  
Registered Audiologist  

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Canadian Hearing Report 2013;8(2):8.

## SIEMENS

### MINITEK REMOTE APP

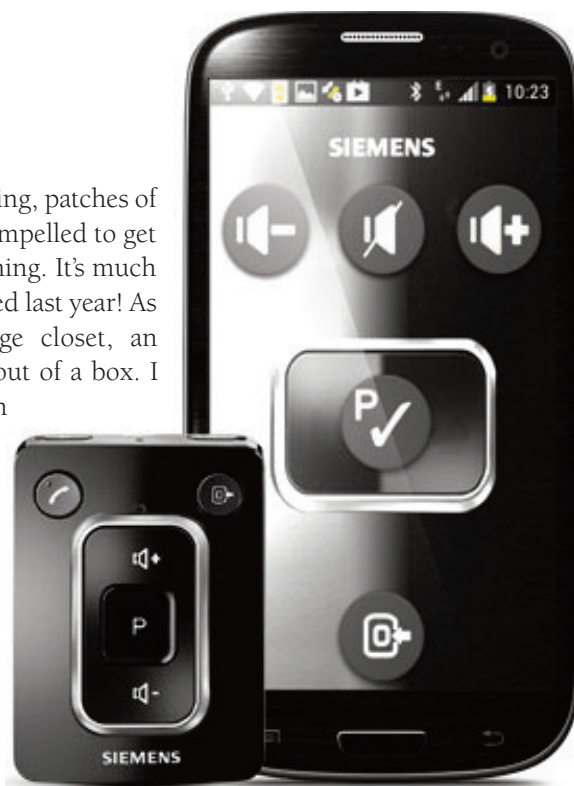
Manon Larivière

Spring is in the air! Snow is melting, patches of grass are appearing, and I am compelled to get an early start on my spring cleaning. It's much overdue, since I may have skipped last year! As I was cleaning out my storage closet, an impressive pile of old CDs fell out of a box. I haven't seen those since high school! And, so started, after a short musical walk down memory lane, the lovely task of sorting through the mess and transferring my favourite albums to my new Google Play library. Bon Jovi is in, Ace of Base is out. Just saying.

When I bragged about my accomplishment to my friends, they happily welcomed me to the age of mp3s! So now that I have all my old faves (including some new ones, I swear!) on my smartphone and at my fingertips, I can bop to them anytime, anywhere, and also use the Bluetooth remote+streamer to stream directly to hearing aids! But here is what's REALLY new:

Beginning in May 2013, the miniTek Remote App will be available for download free of charge via the Google Play Store. That means users can use their Android phone as a remote control to command and conquer every conceivable audio source for their hearing instruments, right on their smartphone! The download is free and simple to do, and the screen of the phone becomes a visual display for the remote+streamer. Whether they are watching TV, talking on the phone, or enjoying a conversation with a friend, users are freed from the hassle of juggling multiple devices. Everything is managed from their smartphone.

Techie types will love this because of the advanced functionality. The smartphone's screen becomes the display for the remote+streamer, so the user knows what is going on with their hearing instruments and the listening situation. Users don't have to guess the status, they can easily see it.



And there are two new cool features; users have the ability to directly select the hearing program they desire, and the phone's screen serves as a read out display informing the user of which program has been selected.

Non-techies will love the seamless integration of all electronic gadgets into one central piece, so no more juggling devices. Phone calls, watching TV, and listening to music are all possible with one device. The "buttons" are nice and large, making controlling friendlier, especially for those with dexterity or vision problems.

Users can configure their smartphone's Widgets. This is an Android feature that allows you to create a "favourite" command on your homescreen. The user could have access to their hearing instruments' volume and programs right on their homescreen without having to launch the App. For users who may not be familiar with the operation of the remote+streamer, a built-in interactive user guide is supplied with the Remote App.

Using your Remote App makes it look like you are simply texting, or checking your e-mail. No one has to know! Control of the remote+streamer and the instruments via the smartphone App provides the ultimate in discretion.

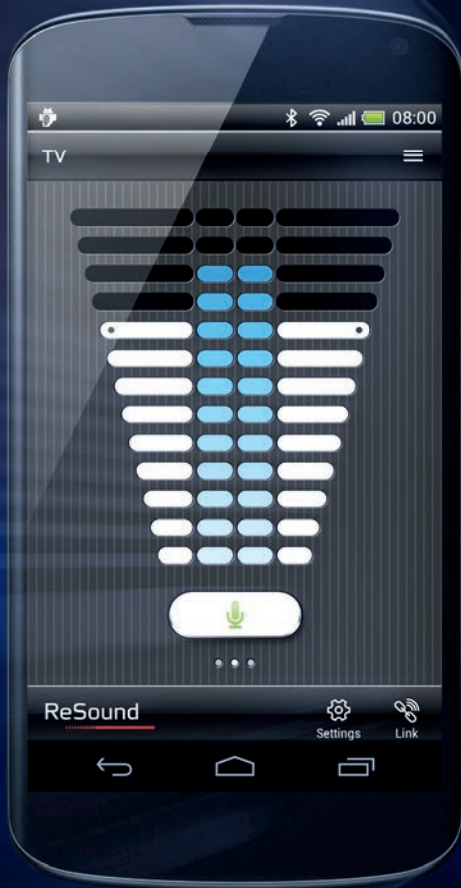
Offered in two languages, the Remote App has been available for download from the Google Play Store since in May 2013, free of charge; languages offered in Canada include English and French.

In my opinion, this smartphone application gets full marks on all fronts, including usability, simplicity, and overall coolness. My thirteen-year-old nephew would love this App. Wow, even my dad could easily use it. As for me, I'd love to discover a spring cleaning app that would finish the job for me! Since I can't find one, I'll just have to tackle the rest of the storage closet myself. Maybe with some good tunes in the background...

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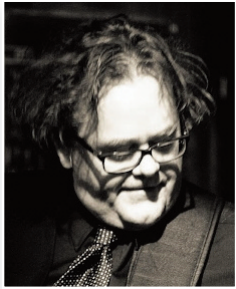
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# Top Ways to Enjoy Music with a Hearing Loss

By Peter Stelmacovich  
*Peter.Stelmacovich@phonak.com*



**I** really enjoy music. It might be due to my upbringing as both my parents sang in the Toronto Mendelssohn Choir as well as some smaller opera companies. My sister is an excellent

piano and clarinet player and is a professional mezzo-soprano. My brother plays piano quite well and pretty much knows most Elton John songs by heart.

I wonder if it could be genetic as well. My son Alexander has this innate ability to play guitar and write songs. If he was born 30 years ago, he would be teaching Jimmy Hendrix and Jimmy Page a thing or two.

And then there is me. The guy with the sensorineural hearing loss who became an audiologist, and then kept losing his hearing over time and needed to get a cochlear implant. I never had the same degree of success with music that my siblings enjoyed, which I am sure was related to my disability. But, nevertheless, I did get to grade 3 Royal Conservatory piano, learned to play guitar a bit, and played trumpet in high school.

As my hearing loss became progressively worse, it became more difficult to hear all the notes I needed to play. So I switched to playing bass guitar since I could hear low frequencies better than high frequencies. Then things reversed

when I got the cochlear implant in that now can hear the high frequencies really well, but not the lows.

In my quest to better understand my hearing capabilities, I decided to review the literature and see what the research tells us about music perception in cochlear implants (CIs).

If you look at some of the earlier research prior to 2000, you barely see much reference to music perception in CIs. I think the researchers, and engineers were busy working on getting good speech perception. This does make sense. And as the speech perception abilities of CI users began to improve, interest began to shift to other important listening abilities such as musical perception.

One researcher who has done a lot of work in this area is Dr. Kate Gfeller. In a 2000 article, Gfeller et al. found that 83% of adult CI users reported diminished music enjoyment post-implantation. In fact one third of the CI users even avoided music altogether as they found it to be an aversive sound.<sup>1</sup> These are not encouraging results. But do remember that these folks received their implants in the 1990s. This technology is now 20 years old. In 2007, Looi et al. did a study comparing the music perception of CI users compared to hearing aid (HA) users.<sup>2</sup> Note that the HA users were all potential CI candidates, so they all had significant hearing loss.

This study showed that while neither device (HA or CI) provided satisfactory music perception results, the CI users gave slightly better ratings than the HA users. So now we are actually seeing some data showing music perception getting better with a CI, but still not great.

Another study by Looi et al. looked again at CI users and HA users who were potential CI candidates.<sup>3</sup> So again these HA users also had significant hearing loss. On a rhythm recognition task, both groups did about the same. On the pitch perception task, the HA users outperformed the CI users. In fact many of the CI users needed two pitches to be at more than a quarter of an octave apart before the notes sounded any different. In western music you need to be able to hear a one semitone difference.

After reading this article, I checked what my skills were like using a CI only. I had my brother play a bunch of two note pairs on a piano keyboard. My task was to say if the two notes were the same or different and then secondly which note was higher in pitch. For the notes above middle C, I was able to reliably report if the two notes were same or different even if they were only one semi-tone apart. I was about 80–90% accurate at identifying which note was higher or lower. For notes below middle C, I needed notes to be at least one full tone apart to get the same level of accuracy, but performance deteriorated as the pitches got lower. Therefore, It appears

that I am not getting good low frequency pitch perception with the CI which is so critical for music. Low pitches may not be that important for speech as the consonants are mainly high pitched and consonants give you speech intelligibility. I therefore personally decided to use a hearing aid in my non-implanted ear. I hear music much better whilst using a combination of a HA and a CI.

Is this phenomenon idiosyncratic to just me, or do other patients experience the same thing? A study by El Fata et al. looked at 14 adults who continued to use a hearing aid in their non-implanted ear after getting a CI. Subjects were asked to identify excerpts from 15 popular songs which were familiar to them.<sup>4</sup> The presentations were done bimodally, with the CI alone and then HA alone. Musical excerpts were presented in each condition with and then without lyrics. Those subjects who had more low frequency residual hearing (> 85 dB HL in the lows) did much better on all the tasks with both a CI and an HA than either the CI only condition or HA alone.

Another study by Gfeller et al. in 2007 also confirms the need for better low frequency hearing for music perception. In this study, CI users which electrical only stimulation (the regular type of CI) were compared to subjects with a hybrid implant.<sup>5</sup> The hybrid implant uses a shorter electrode array for giving you the high pitches whilst still using a hearing aid type of air conduction for the low pitches. Using low frequency acoustic hearing significantly improved pitch perception compared with electric only CIs. But before you go rushing off asking for a hybrid implant, you need to know that not everyone can get one of those. You need to still have sufficient low frequency hearing.

So here's what I can conclude from these articles:

1. The newer studies seem to show better music perception in CI users than older studies. This is most likely due to improvements in technology in which the newer implants give a richer sound than the older devices.
2. Music perception with a CI via electrical stimulation could still be improved. It seems to be related to the poor perception of the low frequencies.
3. If you still have some usable residual hearing in your non-implanted ear, the use a hearing aid in that ear could assist you in your music perception.

I still play the bass in a band and enjoy music by incorporating various strategies. The strategies listed below reflect both personal experiential learning and learning gained during my formal audiological training. They can be incorporated by most patients with hearing loss.

### 1. USE A MUSIC PROGRAM ON HEARING AIDS

Most hearing aid companies provide a music program in their hearing aids. Some even automatically switch the user to the music program if that is what is in the environment. I encourage you to activate a music program for your client. These programs automatically make a number of important changes that will ensure music sounds better, because what is good for speech perception is not necessarily good for music perception. Generally speaking, less is more when it comes to a music program. This means turning off noise reduction features, frequency compression, and things of that nature. I tend to use the default settings of the music programs as a

starting point and fine tune from there. If there is hearing impairment at all frequencies, I tend to add more low frequency gain. In addition I try to avoid high compression ratios. Therefore I may add more gain for loud sounds and/or lower the gain for softer sounds to keep the compression ratios to 2:1 or less.

### 2. LISTEN TO MUSIC OR TALK, BUT NOT BOTH

People with normal hearing can enjoy music while talking to someone else or while driving. As a person with hearing loss, I find this does not work for me. The impaired auditory system cannot do both tasks simultaneously because one of them ends up being a competing noise for the other. I get much more enjoyment from listening to music in a quiet room with no one else talking at the same time.

### 3. TURN IT DOWN

Most hearing aids or cochlear implants cannot handle inputs that are too loud (over 90 dB). Keeping the music at a comfortable level ensures that the music sounds clean and undistorted.

### 4. USE A DIGITAL WIRELESS ACCESSORY OR AN FM SYSTEM

Since I use two different types of technologies (hearing aid and cochlear implant) I cannot use a ComPilot wireless streamer. Instead I use my SmartLink+ FM system to accomplish the same goal. Both strategies involve plugging the FM or DWA into the headphone jack of an iPod or home sound system. The advantage of this approach is that it bypasses the microphones of the hearing devices, keeping the music clear and undistorted.

### 5. USE AN FM FOR LIVE MUSIC

I play bass in a band and I also like to listen to live music. When I play in my own band, it gets too loud for my

hearing devices to handle. So, I plug an FM system into the headphone jack of the sound board and turn up the volume to a comfortable level. Listening to other bands can be tricky. But if I am feeling brave, I have asked the sound technician at shows to allow me to plug my FM into other bands' boards, the same way I do for my own performances. It sounds so much better that way.

## 6. WATCH MUSIC DVDS OR BLUE RAYS

I have a collection of about 50 live concerts on DVD or Blue Ray. Listening to music while watching it being played is a far more enriching experience for all of us, but this is especially true for people with hearing loss. Sometimes a person with hearing loss cannot identify the type of instrument being played; however, if you can see the instrument, it helps your brain make better sense of it all.

## 7. TAKE MUSIC LESSONS/PLAY AN INSTRUMENT

I had the pleasure of participating in a study on music perception in cochlear implant users at the University of Toronto Mississauga. We had to do various tasks such as pitch perception, pattern perception, song identification and instrument identification. The results have not been published yet, but I got a chance to see some of the preliminary data. It was quite striking in that those of us in the study who have had musical training performed much better at these music appreciation tasks. Note that there were no tasks in the study that required musical training per se such as asking someone to play a G major scale for instance. Instead, it appeared that the musical training enabled us to better "hear" the music.

## 8. LEARN SOME BASIC MUSIC THEORY.

To take this further, I highly recommend

learning a bit of musical theory. I found that after I did this, it seemed to further activate my top-down processing capabilities. For example, I now know that many popular music songs often use the first, fourth and fifth chord of a scale. Therefore, I now know that I need to use the Ionian (I), Lydian (IV), and Mixolydian (V) modes when playing my bass. I can therefore use brain power to compensate for what I lack in hearing capabilities.

## 9. PICK LESS COMPLEX MUSICAL GENRES

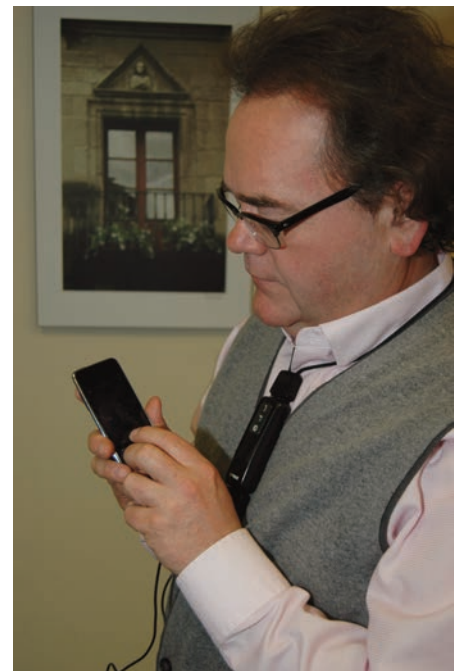
Easier music is just plain easier to listen to. So classical music is going to be harder to enjoy compared with popular music. Bach's Toccata and Fugue in D Minor requires more listening skill than John Lennon's Imagine. Yet both are still beautiful. Complexity can also refer to the number of instruments used. I find it easier to listen to a quartet of musicians compared a full-blown symphony.

## 10. FOLLOW ALONG WITH THE LYRICS

Back in the days of my youth, we did not walk around with iPods stuffed in our ears. Instead we had vinyl records, with gorgeous album art work on the cover and lyrics printed inside the album cover. We sat down and listened to the music with our full attention and followed along with the lyrics. This made it easier to figure out the song. You can still do that today with a wonderful invention called the Internet. People with hearing loss should download and print the lyrics to the songs and listen carefully. It will make the songs much more enjoyable.

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By Calvin Staples, MSc  
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Music is a vital part of everyday life for many Canadians. I know at our house we enjoy music in many forms, but also use music as a tool with our children. Music is often used in various forms of therapy and within the field of audiology we regularly use music to facilitate tinnitus treatment. The treatment of hearing loss however, is regularly and potentially rightfully focused on enhancing communication and not focused on music or other less common patient concerns. Our patients tend to focus or clinicians tend to focus on the amplification of speech and the difficulties we encounter in addressing background noise. Often the peripheral goals such as the appreciation of music for the hearing impaired is left without much consideration. Over the years, audiology has been blessed with a few wonderful researchers working tirelessly trying to improve the music listening experience for the hard of hearing. This volume of the *Canadian Hearing Report* focuses on music so please enjoy the following blogs from [Hearinghealthmatters.org](http://Hearinghealthmatters.org)

## FOUR STRATEGIES TO IMPROVE MUSIC LISTENING THROUGH HEARING AIDS

By Marshall Chasin

Because of the inherent problems with 16 bit hearing aid architecture, the “front end” of the hearing aid is frequently overdriven by intense inputs – specifically it is the analog to digital (A/D) converter and associated pre-amplifiers that is the culprit. Intense inputs frequently come from music, but a hearing aid wearer’s own voice can also overdrive the input. Normal conversational speech is not typically a problem.

The question that arises is “given a hearing aid that seems to be great for speech, what can be done to also make it great for music?” This has been covered in previous blogs so I will not retrace my steps, but following are four easy-to-implement strategies that improve the fidelity of music over what a hearing aid may currently provide.

### STRATEGY #1: TURN DOWN THE INPUT (STEREO) AND TURN UP THE HEARING AID VOLUME (IF NECESSARY)

If the excessive level of the input to the hearing aid does cause distortion of the A/D converter, then turn down the input if at all possible. If traveling in a car, turn down the level of the radio and (if necessary) turn up the level of the hearing aid to compensate. The output will be the same, but the input would have been reduced to a level that is well within the operating range of the front end of the hearing aids.

### STRATEGY #2: REMOVAL OF HEARING AID FOR MUSIC

Given the higher level inputs of music, the required gain may be close to 0 dB

for a desired output. Even for an 85 dB sensori-neural hearing loss at 1000 Hz, while a person may require 45 dB gain for certain speech sounds, they may only require several decibels of amplification for many types of music. The best strategy for many hard of hearing consumers may be to simply remove their hearing aids when listening or playing music.

### STRATEGY #3. USE SCOTCH TAPE

This is the lowest technology level and is perhaps the easiest to implement clinically. Like the use of a less sensitive microphone (e.g., one that has reduced sensitivity to the lower frequency region), using a temporary microphone covering such as Scotch tape shifts its ability to transduce sound downwards by about 10 dB for three or four layers of the tape. The A/D converter is therefore presented with a signal that is 10 dB less intense and can often be within its optimal operating range. There needs to be some trial-and-error and the hard of hearing consumer can be instructed to play with one, two, or three pieces of tape over both hearing aid microphones. The exact number does depend on the gauge and the brand of the tape. Attenuations of 10 dB which are relatively flat across the frequency range have been measured using this clinical “low tech” approach.

### STRATEGY #4. CHANGE THE MUSICAL INSTRUMENT

This is a common strategy used by many musicians. Change to an instrument that has more of its energy in an audiometric region of better hearing. Many violin players have switched to the viola which is a fifth lower in frequency. For many this is a simple approach that has extended a musicians’ enjoyment of their music for many years.

The above strategies are just a few of the many that have been found to be useful over the years. The Association of Adult Musicians with Hearing Loss is an organization of hard of hearing and deafened musicians as well as interested hearing health care professionals who work with those in the performing arts. In addition to their very active listserv blog, they have recently come out with a book entitled, *Making Music with a Hearing Loss* edited by Cherisse W. Miller (2011). Chapter 4 of that book is aptly entitled “Personal Stories and Strategies” where many musicians talk about what works best for them. Copies of this excellent book can be obtained through the AAMHL.org site.

<http://hearinghealthmatters.org/hearthemusic/2012/four-strategies-to-improve-music-listening-through-hearing-aids/>

## MUSIC LESSONS FOR KIDS WITH HEARING LOSS

By Jane Madell

Thanks to the advanced technology available today, many kids with hearing loss are playing musical instruments. Some will be good and others not – just like kids with typical hearing. I have two kids with typical hearing, both of whom took music lessons as kids. One was really good, and the other wasn't. It had nothing to do with hearing.

### MAKE KIDS WITH HEARING LOSS FEEL WELCOME IN MUSIC CLASS

Music teachers need to be told that kids with hearing loss can take music lessons and will be able to learn. They need to be reminded that some kids are good at music and others are not, but that every kid deserves a chance. Teachers need to

be reminded that they need to face a child to be sure they understand directions and try to have the child seated in a place where he or she can easily see and understand. Teachers need to understand the limits of technology – they need to know what the child will and will not hear and at what distance. And they need to know how to adapt.

### PICK AN INSTRUMENT THE CHILD LIKES

Kids need to like the instrument if they are going to make it work. They need to want to play it. There are easier instruments (ones like piano where if you hit a key it always makes the same sound) and more difficult ones (like violin where a slight move of the finger can really alter the sound.) Kids with hearing loss can and do play the violin so if that is what the kid wants to do, give it a try.

### DO HEARING AID SETTINGS NEED TO BE ADJUSTED FOR MUSIC?

Sometimes some pitches will sound tinny through the hearing aids. The audiologist may be able to adjust the hearing aid so the high frequencies are less tinny and have more timbre.

### WHAT PARENTS CAN DO TO HELP GET KIDS READY TO STUDY MUSIC

There are some basic things that parents can do at home to help prepare all kids for music lessons. Kids need to learn rhythm. Sing songs, clap in time to music, play clapping games where you clap a pattern and the child has to repeat it. As they get more complex, kids develop more skills. Start with rhythm instruments – bells, chimes, tambourines, drums. Let kids develop some musical sense from those.

### DON'T LET HEARING LOSS LIMIT A CHILD

Music is just one part of a kid's life, but it is important for everyone to always give a child the chance to do whatever he wants to try and do. With today's technology, the sky is the limit (but talent plays a role too). Oh, well.

<http://hearinghealthmatters.org/hearingandkids/2012/music-lessons-for-kids-with-hearing-loss/>

## THREE MYTHS ABOUT MUSIC AND HEARING AIDS

By Marshall Chasin

There are many myths about music and how hearing aids should be fit. This is about three of those myths.

1. As technology gets better so will music fidelity
2. Wider is better
3. More advanced features are better

Every single hearing aid design engineer has to come to grips with the similarities and differences between speech and music. Although this has always been the case, even more importantly with the advent of portable (and more accessible) music, both speech and music are desired stimuli for hard of hearing consumers. Both speech and music are necessary for most people to get the most out of life.

The design engineer's boss, however, would rather that they spend their time and energy dealing with speech. Speech quality is what sells hearing aids- music fidelity just goes along for the ride. Speech quality is number one, and music quality is its poor cousin and

really only addressed once the “number one” issue is taken care of.

Here are three myths about music and hearing aids:

## 1. AS TECHNOLOGY GETS BETTER SO WILL MUSIC FIDELITY

This sounds like a mother and apple pie statement. After all, hearing aids of the 1930s are not as good as those today. However since the late 1980s, hearing aid microphones could transduce 115 dB SPL with virtually no distortion. Since the 1990s, hearing aid receivers could be made broadband enough to provide significant output in the rarefied regions above the piano keyboard (>4000 Hz). And wide dynamic range compression (WDRC) hasn’t really changed in over 20 years (and I am going to get some “comments” about this statement- but I am really only referring to the level dependent characteristic of all modern non-linear hearing aids). So what needs to “get better”?

Well, not much but this is not an “evolutionary” change that gradually “hearing aids will simply get better.” Something specific needs to be done and this relates to the “front end” of the hearing aid. Specifically the analog-to-digital converter needs to improve so that it can handle the more intense components with minimal distortion. Several manufacturers have successfully addressed this problem but most have not. Unless this problem is resolved, aided music fidelity will not improve.

## 2. WIDER IS BETTER

The broader the bandwidth for music, the better it will be. The chart above shows a sampling of some manufacturer’s suggested bandwidths for music (as well as some other suggestions for the music program). These are not based on comprehensive science and

<b><i>Hearing Aid Manufacturer</i></b>	<b><i>Some Suggestions for Music</i></b>	<b><i>Frequency Response</i></b>
Oticon	Omni-directional microphone Deactivate noise management	100 Hz - 10,000 Hz
Unitron	Higher MPO Deactivate Anti-Shock™ -6 dB/oct microphone	Up to 8,000 Hz
Siemens	Adaptive sound classifier Sound Brilliance™	Up to 12,000 Hz
Phonak	Higher MPO Omni-directional microphone Soundflow program™	<100 Hz - 10,000 Hz
Bernafon	Lower MPO Omni-directional microphone Live Music Plus™	Up to 10,000 Hz
Starkey	Less noise management Flatter frequency response Static feedback canceller	Up to at least 7,000 Hz
Widex	Increased bass response Slower feedback cancellation	70 Hz - 10,000 Hz

Table 1. A survey of some hearing aid manufacturers with some suggested changes. Most state that there should be less compression and less noise management than for a speech program. As discussed in the text, these suggestions are probably quite valid but only for mild hearing losses, with a gently sloping audiometric configuration. Some manufacturer’s use a proprietary circuit and these are marked with a ™ symbol where appropriate. Note- this is not a complete listing of the manufacturers nor is this a full listing of all of the parameters suggested by the manufacturers for music.

many represent mere “opinions” of the respective marketing departments.

If the hearing loss is mild AND if the configuration of the hearing loss relatively flat, then a broad bandwidth does make sense and this is indeed supported by the literature. If, however, the loss is greater than about a 60 dB HL sensori-neural one, then because of the possibility of dead regions in the cochlea, a narrower bandwidth may be better. The same can be said of steeply sloping sensorineural hearing losses – a narrower bandwidth may be better than a wider one.

Table 1 does make sense, but only for mild hearing losses with a relatively flat audiometric configuration.

## 3. MORE ADVANCED FEATURES ARE BETTER

Noise reduction, feedback management, and impulse control to limit overly intense environmental signals may be useful for speech, but with the lower gains required with music (in order to obtain a desired output) these features may degrade music. Feedback management systems may blur the music (adaptive notch filters), cause rogue “chirps” in music (phase cancellation systems), and may even turn off the musical instrument (e.g., the harmonics of the flute may erroneously be viewed as feedback signals). Many manufactures (e.g., Siemens and Oticon) have restricted the function of their feedback management systems to 1500 Hz and above to minimize the above

problems, but this is a case where “less is more.” With the lower gains required of music (about 6 dB lower than the respective speech-in-quiet program), feedback management systems may not even be required.

The same can be said about noise reduction but again, if fewer advanced

features are implemented, the internal noise floor will be lower. And let's turn off the impulse control systems (as correctly pointed out by Unitron with a disabling of their Anti-Shock function). Impulse sounds occur frequently in music but rarely in speech – if they do occur in speech, they are of a low level such as for the affricates ('ch' and 'j').

More can be better, but when it comes to music, less is usually more.

<http://hearinghealthmatters.org/heart-hemusic/2012/three-myths-about-music-and-hearing-aids/>

Canadian Hearing Report 2012;8(2):14-17.

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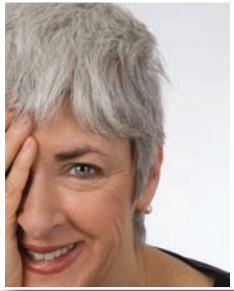
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# Could Somebody Turn My Music Back On?

By Gael Hannan  
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**H**ow and when can I get my music back?

I'm not exactly sure who I should direct this question to – would it be my audiologist, my hearing aid manu-

facturer, or the government who helps me pay for hearing aids? Or all three?

As my hearing loss progressed through the years, so did my music loss and I would like to have it back, please. I know that out there, somewhere, there are hearing aids, assistive technology, and listening courses that would help me appreciate music better. I'm always reading tantalizing news bits about breakthroughs in this area. But how do I, the consumer at the end of the supply chain, access all these new advancements? The research and new technology I read about is at a high level, using words that are outside my comprehension. I have yet to read anything that says: "Want to hear the music again? To get YOUR magic-music-making hearing aids, call this number today...or visit your local hearing care professional and ask for it by name!"

Like most people, I love music. Plato said, "Music gives a soul to the universe, wings to the mind, flight to the imagination and life to everything." And once you have

flown on the music, dreamed with it and lived it, losing the ability to *enjoy* it is a deep source of grief. When I could really hear it, music sent shivers down my spine. And now, when I have difficulty getting a tune, or when the violins or flutes go so high as to disappear off my audiogram, I feel deprived, cheated.

My family was very musical – I am the descendant of song-and-dance men on one side and church-singing preachers and teachers on the other. There was always music in our house. My father bought the best stereo "hi-fi" he could afford because he wanted me to enjoy music, in spite of my hearing difficulties. I would spend hours lying on the floor with my ear pressed to the cloth-fronted stereo, listening to records. On family road trips, in the time before everybody was glued to their own smartphone, we sang and harmonized to our favourite songs. Our collective taste in music wasn't terribly cerebral, but we loved a good tune.

As I grew up, I began to suspect I wasn't getting the full-on music experience that "hearing"

people enjoy. This first struck home when I was around 20; at a performance of Handel's *Messiah* my friend said something to the effect of, "Wow, that harpsichord is amazing!" I looked at the stage where I saw the beautiful harpsichord and then back at her, "I can see it, but I can't pick out its sound." And, I have never actually heard the sound made by the person hitting that triangle thing – so it just looks stupid to me (with all due respect to professional triangle players).

And the day I knew I was really in trouble was at age 41, when I went from a single BTE to bilateral CICs. Going to a dance, the sound of the band almost flattened me – it was a non-stop cacophony. I thought that perhaps I was still in an extended brain adjustment period, but since that time loud music made with more than one instrument has never been enjoyable because I can't pick out the different *bits* – like the harpsichord, or the



bass guitar, or the anything. The instruments tend to drown out the singer's voice, taking the lyrics completely out of my reach.

I now have two digital ITEs, with T-switches that I had to ask for, and things are a bit better. I think. But to appreciate music the most, I have to bring it right into my ears. I have good Bose over-the-ear-headphones which, if I position them just-so, won't cause any feedback. And I also have a neckloop to use with my iPod, but I have to walk where there are no telephone wires or I become alive with static.

Listening to music in a room is a

challenge, even non-existent. At a party, someone might ask if the music is too loud, and I would answer, "oh, is it on?" If music were played at the level I need – somewhere well above ambiance-level but below blowing out the windows – we would end up with a very different party – and I still wouldn't get the words.

I know we've come a long way. I sat next to a dear friend, a recent CI recipient, at a conference concert and watched her face as she realized she was hearing music for the first time in years. Another friend didn't know she could connect her CI to her iPod; it was Christmas time and her face, as she listened to *Silent Night* come into her ears, was enough to revive

your belief in Santa Claus.

So my question is this, how can I get my music back? If there *are* really good music programs available for hearing aids, do I have to wait until I buy my next set? Alternatively (and preferably), could we do something about the price of hearing technology to make them more widely available to those who need them and want them? Because, if I didn't have to wait another two years to get the government subsidy, I would buy another pair faster than you can say *name that tune!*

Canadian Hearing Report 2013;8(2):19-20.

## Professional Liability Insurance – Are You Covered?

Audiology malpractice errors don't often make headlines; but even the most competent among us can make mistakes. The issue was first brought to my attention by a university instructor who told our class the story of an audiologist who had made a clinical error with serious consequences for both the patient's family and, it turned out, herself: she had failed to counsel parents of a child with a congenital loss to have their other children's hearing tested. It was an unfortunate and cautionary tale.

An article by Younker and Beyers <http://www.audiologyonline.com/articles/preventing-medical-errors-for-audiologists-8060>) highlights common errors in audiology practice. These include inadequate documentation, errors in test interpretation, inadequate supervision of students, failure to make appropriate referrals and inappropriate masking. These are errors that could be made in any public or private audiology clinic.

Having worked for years in a public healthcare facility, I've always assumed that in the (hopefully unlikely) event that I found myself liable for a

clinical error – perceived or actual – I would be covered by my employer's liability plan. A discussion with colleagues led me to look into what professional liability coverage from an employer includes, and what it doesn't. Here's what I discovered:

- Regulatory bodies require audiologists to have a minimum amount of professional liability coverage per claim for liability arising from an error, omission or negligent act. The amount varies by province (e.g. \$1 million in Alberta, \$2 million in BC and ON). The insurance must be provided by an audiologist who is self-employed and working independently or by the employer of an audiologist.
- In provinces where Audiology does not have a regulatory body (which is distinct from a professional organization such as CAA or CASLPA), there may be no requirement for professional liability coverage although employers may provide coverage.
- Liability coverage from an employer will not

cover the following:

- Work done outside of your regular employment, including volunteer work or even advice given to someone outside of work
- Legal defense costs for complaints or disciplinary matters brought by or to professional regulatory bodies, such as a provincial college.
- Legal cost for defense of work-related criminal charges
- Sexual abuse therapy counseling fund for the injured patient.

While most of us likely have some liability coverage in place, it is worth considering the benefits of taking out an additional plan independently. Do you need additional professional liability insurance? This will depend on your current coverage, regulatory requirements, and professional activities, both paid and unpaid. Do you want additional liability insurance? I know I do. For the relatively small amount I pay each year, it's absolutely worth the peace of mind.



**CAA members are eligible for professional liability insurance through LMS Prolink. For more information, e-mail [CAA@LMS.ca](mailto:CAA@LMS.ca) or call 1-800-663-6826 or visit [www.LMS.ca/CAA](http://www.LMS.ca/CAA)**



# Facing the Music: Musicianship's Effect on the Brain

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## About the Author

Nina Kraus, PhD, Hugh Knowles professor, (communication sciences; neurobiology and physiology; otolaryngology) at Northwestern University, directs the Auditory Neuroscience Laboratory. Dr. Kraus investigates biological bases of speech and music. She investigates learning-associated brain plasticity throughout the lifetime in normal, expert (musicians), clinical populations (dyslexia; autism; hearing loss) and animal models. In addition to being a pioneering thinker who bridges multiple disciplines (aging, development, literacy, music, and learning), Dr. Kraus is a technological innovator who roots her research in translational science. <http://www.brainvolts.northwestern.edu>.

Musical training has a pervasive positive effect. This is manifested in number of interesting ways. First, unsurprisingly perhaps, musicians excel at pitch and rhythm perception and discrimination. Likewise, instrumental musicians tend to have superior fine-motor skills. More intriguingly, musicians outperform nonmusicians in ways that are farther removed from those that might be expected from exposure to the acoustics and mechanics of playing an instrument. For example various studies have found that musicians excel in vocabulary, reading, non-verbal reasoning, perception of speech in background noise, auditory memory, and attention. For a review, see Kraus & Chandrasekaran, 2010.<sup>1</sup>

With all of these perceptual and cognitive advantages, there must be underlying neurological changes that the brain undergoes with music training. There is evidence of this from a number of sources. A classic example is the reorganization of motor cortex that takes place in string-instrument players. The representation in the somatosensory

cortex of the fingers of the left hand, the hand in extensive intricate use in string playing, is larger in string instrument players than in non-musicians. This difference is not present in right-hand representation, consistent with the smaller motor demand arising from bowing.<sup>2</sup> In keyboard players, grey matter is larger in visiospatial, motor and auditory brain centers, consistent with the demands of the task.<sup>3</sup> Greater white matter volume, representing increased connectivity between and within cortical areas, is found in musicians, as well. This has been seen in the corpus callosum and other structures.<sup>4,5</sup>

There are other examples of brain changes in musicians explicitly involving auditory centers. In both adult and child musicians, there is evidence of structural and functional reorganization of cortex.<sup>6</sup> For example, in a magnetoencephalography (MEG) study, adult musicians have an increase in auditory cortical activation to piano tones relative to pure tones that is not seen in non-musicians.<sup>7</sup> Evoked electrical responses provide neuro-

physiological corroboration to these findings.<sup>8</sup>

Arguably more interesting, because they involve less obvious cause and effect outcomes than the somatosensory, motor and auditory examples that might be predicted from the inherent demands of mastering an instrument, are behaviour and brain changes in farther afield areas. For example, music training is associated with increased vocabulary, reading, phonological processing, attention, and reasoning skills in children.<sup>9-11</sup> Of particular interest to me is the tie-in between musicianship and literacy. Learning to read is very closely tied to the sounds of language and making the sound-to-meaning connections in speech. Therefore, an activity like music practice, which hones the auditory system as well as a host of other processes, provides a channel toward gaining literacy proficiency. Further, there are many overlapping attributes between music and reading, such as anatomical overlap in the brain systems that process music and speech, and the attentional and emotional

centres that are activated by music.<sup>12</sup>

In my lab, I have been building upon the body of research briefly reviewed above by examining the biological changes that accompany music training in a variety of populations, using both cross-sectional and longitudinal designs. The particular physiological metric I employ is the auditory brainstem response to complex sounds (cABR). The auditory brainstem is a central hub of sound processing. It is at the crossroads of the ear and the cortex and the response that is recorded from it is deeply tied to the rich acoustics of the evoking sound. At the same time, it is influenced by factors of experience and training. These attributes, as well as its ability to be reliably recorded in individuals, make cABR a valuable addition to the arsenal of the auditory neuroscientist studying experience-dependent brain effects of music training.

The cABR to speech sounds offers a rich approach to studying the neural changes experienced by musicians, first because of the tie-ins between music and literacy, and second because not all speech is created equal. Within the spectrum of spoken speech, certain consonants prove to be especially vulnerable to noise-masking, or otherwise “mishearing” because of their low-amplitude, fast-moving, and complex acoustic composition. So consonants, or in particular consonant-vowel syllables, form the bulk of the speech cABR research that I have investigated in musicians. These spectrotemporally complex acoustic sounds evoke a correspondingly spectrotemporally complex cABR that reveals musician advantages, particularly in the timing associated with the information-bearing consonant (but not the vowel) and the spectral encoding of the speech acoustics. Additionally, acoustic

distinctions in consonants, such as those brought about by changes in place of articulation, are detectible in the response, and these distinctions are more salient in musicians. Finally, the consistency with which the auditory system responds to the crucial consonant-vowel component of speech – measured by inter-trial correlations – is enhanced in musicians and relates to literacy. These findings have been replicated in a number of age groups, from very young children to older adults. Additional studies are underway to help address the question of whether musical experience brought about the changes or whether pre-existing physiological and literacy-based differences are inherent in those who are prone to pursue music education.

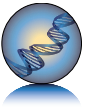
The implications of these findings are of a deep interconnection between music and language abilities including reading and hearing speech in noise. A purported commonality between brain regions and mechanisms between music and language is confirmed by findings from my lab and others using cABR and other methods. Taken together, evidence strongly supports the promotion of music practice in concert with the development of crucial literacy skills in children.

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Canadian Hearing Report 2012;8(2):21–22.



# New Knowledge on NIHL

By Patty Johnson

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## About the Author

*Dr. Johnson received her master's degree in audiology from the University of Iowa and her AuD from Salus University. Her professional experience spans pediatric and educational audiology, industrial hearing conservation, university teaching and private practice. For the past 17 years she has been a research audiologist at Etymotic Research, Inc., where she is involved in research, education, technical writing and new product development.*

**Science (noun):** *systematic knowledge of the physical or material world gained through observation and experimentation.*

It's a noisy world, and hearing damage from loud sound (hearing loss, tinnitus and/or hyperacusis) affects all of us in one way or another. Noise-induced hearing loss (NIHL) is caused by exposure to sound that's too loud for too long. It can occur from a single activity such as an explosion or a loud concert, but it usually occurs gradually, imperceptibly, over many years. Those affected are typically unaware of the damage until it's significant, and by then it's too late: NIHL is permanent. We all know we should protect our hearing from loud sound, but new information suggests that the consequences of not doing so may be worse than we thought.

In this month's Spotlight on Science, I'd like to share what I think is one of the most (if not *the* most) important scientific observation of our time. This new information on noise-induced hearing damage will (I hope) influence you to completely rethink NIHL and lead you to adopt and recommend new

practices based on this knowledge. It's a pretty strong claim, supported by solid scientific evidence.

You're probably familiar with TTS (temporary threshold shift), which is a change (worsening) of pure tone hearing thresholds after a noise overdose. Temporary threshold shift is just what the name implies – temporary. The outer hair cells (OHCs) in the cochlea were overexposed, suffered metabolic exhaustion, lay down and took a nap. Because OHCs are amplifiers for quiet sounds, when they stop working our hearing for quiet sounds gets worse. After a period of auditory rest (quiet) the OHCs perk up, start working again, and our pure tone hearing thresholds recover. Because of this recovery, most of us assumed that the primary damage from noise occurred at the level of the OHC only, and that the structure and function of the auditory system was only temporarily affected by the noise overdose. We consoled ourselves that the damage wasn't permanent and vowed to do better to protect our hearing next time, believing that permanent changes in auditory anatomy happened only after

repeated auditory insults over many years.

Yes, OHCs are affected by noise exposure, but they're not the only structure in our auditory system that's damaged by a noise overdose. Kujawa and Liberman<sup>1,2</sup> studied the effects of noise exposure in mice and found that while outer hair cells are affected and do recover post-exposure (with a corresponding recovery of hearing thresholds and otoacoustic emissions [OAEs]) there are other changes in the basal region of the cochlea that don't recover. Sound exposures that produced moderate TTS in mice (100 dB SPL for two hours, equivalent to an 800% noise dose using a criterion level of 85 dB and an exchange rate of 3 dB) resulted in dramatic degeneration of both pre- and post-synaptic elements of the inner hair cells and spiral ganglion cells. There was acute loss of afferent nerve terminals and delayed degeneration of the cochlear nerve.

What does this mean? All signals going to the brain from the auditory system come from the inner hair cells (IHCs).

When the connections (synapses) to the IHCs are damaged, the nerve fibres connecting to them eventually die. Degeneration of synaptic elements of the IHCs and spiral ganglion cells means a loss of signal transmission to the brain, and the damage may be expressed as tinnitus, hyperacusis, or difficulty hearing in noise. This concept is so important I'm going to repeat it: a noise overdose in animal models causes dramatic, irreversible degeneration of pre- and post-synaptic elements of the inner hair cells and spiral ganglion cells. These changes aren't seen until weeks or months after the noise exposure, and they can't be measured using standard audiometric tests (pure tones thresholds, OAEs, ABRs). This damage eventually is expressed as tinnitus, hyperacusis, or problems hearing in noise. You're probably wondering if animal models apply to humans. This can't be answered definitively yet, but sub-clinical damage has also been found in other mammals after noise exposure<sup>3,4</sup> so the evidence suggests that we may be at risk.

So, how's your hearing? Have you had a noise overdose lately? Don't think you've ever been exposed to an 800% noise dose like the mice in these studies? Think again. How about the loud music at the last professional convention you attended? Your kids' school dances and sporting events? How about concerts or live music in a bar? Ever use power tools, a lawn mower, snow blower, or vacuum cleaner? All of these have the potential to give you a noise overdose. But how do you know if your ears are receiving an overdose? Thanks to science, we have devices – and apps – for that.

A sound level meter (SLM) measures sound level at a single point in time, which is useful when noise is steady-state (power tools, lawn mower, vacuum cleaner, etc.). To measure these I use a

**TABLE 1. REAL-LIFE DOSE LIMIT EXAMPLES**

Event	Time	Final Dose
Middle School Basketball Game	1 hour	91%
Consumer Electronic Show	9 hours	190%
Shop Vac	1 hour	200%
Half Drumline (measured at 3 m)	45 min	300%
Summerfest (Milwaukee, WI) (outdoor music festival)	6 hours	690%
Half Drumline (measured on snare)	45 min	1,400%
Live Music Green Mountain Tavern, Vermont	1 hour	1,600%
Poi Dog Pondering concert	4 hours	17,000%

Radio Shack analog sound level meter, which has A or C weighting, fast or slow response, and a scale of 60–120 dB. The analog model was discontinued several years ago but similar digital models are available at Long and McQuade and other music stores. You can also download SLM apps; I like “SPL Meter” by Studio Six Digital, which looks and behaves just like my analog Radio Shack SLM. While I haven't done extensive testing, when I've checked the two side by side results were remarkably close. When noise levels vary (concerts, sporting events, live music) you'll need a noise dosimeter to get an accurate estimate of your risk. A noise dosimeter measures sound levels continuously over time and integrates them into a single value, the noise dose. As far as noise dosimeters, I'm admittedly biased: I like the Etymotic ER-200DW7 Personal Noise Dosimeter. It's small, lightweight, inexpensive, and can be programmed to measure noise dose using just about any criteria you'd want.

An explanation of damage-risk criteria, noise exposure limits and noise dose is beyond the scope of this paper; for more information see “Noise Exposure: Explanation of OSHA and NIOSH Safe-Exposure Limits and the Importance of Noise Dosimetry,” available at [http://www.etymotic.com/pdf/er\\_noise\\_exposure\\_whitepaper.pdf](http://www.etymotic.com/pdf/er_noise_exposure_whitepaper.pdf).

For our purposes we'll use an 85 dB criterion and 3 dB exchange rate, with an 8-hour 85 dB Leq constituting a 100% noise dose. Exposure limits originated in the occupational realm, so we're allowed 8 hours per day, but only 5 days per week (40 hours total; the standards assume non-occupational quiet). This produces a weekly dose limit of 500%. Based on these numbers, let's look at some real-life examples (see Table 1).

The first thing to note is that every one of these exposures, with the exception of the Poi Dog Pondering concert, would not produce a noise overdose if the listener were wearing earplugs with a reasonable amount of attenuation. The Poi concert, measured in the front row, resulted in a noise dose of 17,000%, equivalent to three weeks plus two days' worth of exposure, and more than double the dose used in the Kujawa & Liberman experiments. It's absolutely essential that concert-goers protect their hearing, but informal observation suggests that few of them do. A reduction of 20 dB produces a 100-fold decrease in exposure, so with 20 dB earplugs the 17,000% dose is reduced to a 170% dose. While this is still over a single-day's limit, it's a far cry from the unexposed level. Other exposures are much less; for example, the middle

school basketball game (crowd noise, referee whistle, and buzzer) resulted in a 91% dose. Not terrible, but other factors need to be considered: this was a tournament day and parents, players and referees attended up to five games per day over a two-day period.

The bottom line: the damage produced by a noise overdose appears to be worse than we thought and noise overdose is not uncommon. The good news is that there are tools to measure our exposures and there are many great options for

protecting our hearing. All we have to do is use them.

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Canadian Hearing Report 2013;8(2):23-25.

# Save the date!



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# An Audiologist is a Recording Engineer for Speech

By Marshall Chasin  
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It is always tempting to look at the field of recording engineering for music to see what can be gleaned for hearing aid fittings. Sound engineers (incidentally called “tone meisters” in German) are concerned with the ideal

mix for the various elements of music and their goal is optimization for the normal hearing person. Audiologists are concerned with the ideal mix of the various elements in speech (and music) but for the hard of hearing person. In this sense, an audiologist can be thought of as a recording engineer for speech.

It is frequently surprising how similar the two fields of recording engineering and audiology are. Both are concerned with gain and output; both are concerned with non-linear level dependent compressors and expanders; both are concerned with appropriate attack and release times; and both are concerned with appropriate equalization. In short, the factors that concern a sound engineer and similar to those factors that concern an audiologist.

When we turn on the equipment in our offices, we boot up the computer and the familiar NOAH screen pops up (at least we hope it does) and depending on the parameters of the fitting software, we can have control over everything that is required. In fact, we have control over

much more than we typically require, but like a few things in life, more is better.

Figure 1 shows the computer screen of a recording engineer. Other than some customization for ease of use, it is really identical to the screen we see in a typical audiology office.

I have always viewed the realm of hearing aid amplification as being a recording engineer for speech. An audiologist has well defined attributes that need to be accomplished. Overly compressed signals tend to be less intelligible than ones that are more linear. The correct balance or equalization between the lower and higher frequency ranges is crucial for optimal speech clarity and naturalness. The same is true for recording engineers – an overly compressed jazz performance sounds dull and unexciting, and a wideband balanced response tends to be the best equalization for most forms of music.

One difference between our two fields is the limitation that hearing aids need to be stable down to about 1 volt (and a couple of hundred milli-amps). No such limitation exists for a recording engineer. While this may not make a major difference it does point out that not everything that is available in the recording industry can be transferred to the hearing aid industry. There are some wonderful (and new) anti-reverberation software fixes in the recording industry

and perhaps it is just wishful thinking that this, one day, may be available to the hard of hearing.

I suspect that are two fields can learn quite a bit from each other.

## ACKNOWLEDGEMENT

I would like to acknowledge the assistance of my son, Shaun Chasin, B Mus, who just graduated from the Berklee College of Music in Boston, MA. Canadian Hearing Report 2013;8(2):26.



Figure 1. This is a screen shot from Protools – a popular music recording and processing program – showing the “compressor” section. This is essentially the same screen that one would see when programming a hearing aid through NOAH, replete with adjustments for compression ratios, as well as attack and release times. Equalization is also possible.

# Work Related Hearing Loss – A Difficult Journey

By Julia Ruth Hopkins, ARCT, Mus.Bac, BEd.

Former Music Specialist for the Toronto and Peel School Boards



My life has always been full of music, studying classical piano, competing in festivals, singing and travelling with an award-winning Toronto choir, playing in the high school band and orchestra, and listening to wonderful recordings. Even though becoming a professional musician was a viable option, I had always felt a calling to be a teacher.

And, so, having obtained my ARCT in piano performance in high school, I entered the Bachelor of Music in Education Program, Faculty of Music, University of Toronto, continuing advanced piano study, private singing lessons, playing in the faculty concert band, in a brass ensemble, and singing in the concert choir.

My career began at Bloor Collegiate teaching band classes and vocal music. After we moved to Mississauga, where at the time no high school jobs were available, I accepted a position teaching middle school music for the Peel School Board.

Later on, I stayed home to raise my two children but soon again returned to middle school music classes and running extra-curricular groups such as percussion ensembles, jazz and concert

bands, jazz and concert choirs, and Orff keyboard ensembles. I worked in junior schools too and later accepted a plum job at a middle school in Brampton where our administrator encouraged the development of a flourishing arts program that included instrumental music, vocal classes, and a fully equipped keyboard lab.

In this supportive atmosphere, I loved my job and so welcomed as many students in my classes and extra-curricular groups as was allowed. My band classes were larger than normal and my vocal program included Orff keyboards and percussion. I remember thinking how terribly loud my classes were; yet, I continued teaching for another seven years in this wonderful school. In my ignorance, I didn't realize that by enduring loud music year after year, I would permanently and seriously damage my hearing!

On one momentous morning in January, as usual I entered a grade 8 band class. As soon as my percussionists began warming up, I suddenly became dizzy and my ears hurt unbearably. Quickly I summoned another teacher to supervise the class while I ran down to the principal to tell her I could no longer tolerate the noise! Since this was not the case before Christmas, she accepted my explanation with doubt and confusion in her eyes.

In hindsight, I realize that I had already showed signs of hearing loss. For example, my own children at home would complain that the TV was too loud. But now, on that memorable day in January, I knew the damage was done! From that point on my professional and private life changed forever. How could I continue in my present assignment? I was devastated. What could I do now?

Now my battle with the Peel Board began. Not only did I have to prove to them that my hearing loss was caused by my work environment, but I also had to apply for and be interviewed for a type of job for which I had had no previous experience; a daunting task indeed!

The first of many steps in this process was to see a local audiologist in Mississauga who recommended Marshall Chasin at the Musicians' Clinics of Canada. Once I saw Marshall, he diagnosed the severity of my hearing loss, concluding that my work environment was indeed the cause. He guided me on the path to PROVE that my hearing damage was the result of my work as a music teacher, not caused by genetics or advancing age!

Marshall began by giving me a hearing test and then took a mold of my ears. This mold was used to make my new hearing aids, and also to make ear protection filters. These filters would

moderate the decibel levels in the classroom so I could continue my present job until the end of June.

Since I had always taught music and was also only qualified to teach history and English in high school, I needed to retrain for a different teaching job! In Peel, elementary and high school teachers are on different panels. If I were to move back to high school, I would lose all my seniority, certainly not a risk I was prepared to take! Would the board rehire me in an entirely new elementary capacity? Frankly, I was terrified!

After speaking with my administrators, I made a decision to retrain for a junior school position teaching a core curriculum that included English, math, and science in grade 4 or 5 along the quieter planning-time vocal music.

In the meantime, I would have to wear hearing protection in my classes. When I put in a health claim for the cost of the \$79 ear filter protection, the health and safety officer was convinced that my hearing loss was the result of my age and/or family genetics. As I expected, he did not approve my claim! Furious at his reaction, I immediately called Marshall for help.

At this point, Marshall sent a detailed letter and my hearing chart to the Peel Board. However, Marshall's expert opinion was not enough for the Peel Board! Over the course of the next few months, they compelled me to see a myriad of doctors and audiologists in order to collect more evidence to prove my point. The "sick" days I used to see

the required experts I could not recoup either! Once these appointments were completed and the results sent to the board, the WSIB approved my claim. I was the first music teacher in Ontario to have done so.

In the aftermath of my ordeal, the Peel Board adjusted their health and safety rules for music teachers, suggesting that teachers wear hearing protection in their music classes. Once in my new position in the junior school, I also felt a responsibility to share my experience with my students and also warned all the music teachers I knew about the possible danger of their work environment.

In this article, I wish to point out to you that elementary music rooms characteristically have low ceilings and reverberating noise from black boards. No acoustic ceiling tiles are present either. Most new schools built only contain an "all purpose" room designed like any other classroom. And many junior schools have NO music room whatsoever! Planning-time music teachers have to "cart" their program down the halls to the core classrooms. To make matters worse, performances often take place in echo-ridden gyms with high ceilings!

Perhaps you are not aware that in the elementary system, the delivery of arts programs varies widely according to individual administrator preference! And as always, music programs often disappear in response to austerity measures when lack of funds for the school system becomes an issue.

When I moved schools, which I did twice after I changed my job description, my colleagues were empathetic to my plight. However, people do not understand that hearing damage is not like natural hearing loss. In my case, certain decibel levels are relatively normal but listening to speech is difficult without hearing aids. The worst symptom for me is that I am very sensitive to loud decibel levels.

Over the years, I successfully adapted to my new jobs in the junior school setting, but now my life contains permanent tinnitus and acute pain in loud environments. I can no longer sing in the large Mendelssohn Choir which I loved. Not surprisingly, I have severe difficulty in loud movie theatres even with my hearing aids turned down or on mute! Very loud performances are painful and sometimes impossible for me to attend. When singing in the Oakville Masterworks Choir that uses professional orchestral or band accompaniments, I must secure strategic seating further away from the instruments. Even then, my tinnitus becomes much worse for many days or weeks following the performance. Also, I no longer attend concert venues that use high decibel electrical amplification.

I want to leave you with this important message: hearing damage is permanent! Music damages your hearing just as effectively as exposure to factory noise. Please take care!

*Canadian Hearing Report 2013;8(2):27-28.*

# Do It With a Song

By Rachel Arntson, MS, CCC-SLP  
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## About the Author

*Rachel Arntson has been a practicing speech-language pathologist in the greater Minneapolis, Minnesota area since 1980 with a specific interest in using music to enhance the speech and language skills of children. Rachel has recorded 9 critically acclaimed CDs (2 in Spanish) and written a parent training book entitled, WE CAN TALK as well as other related products that serve as simple, engaging speech and language practice for young children. In addition, Rachel presents nationally and internationally, sharing her passion for music through creative and interactive workshops.*

*Check out her website at [www.TalkItRockIt.com](http://www.TalkItRockIt.com).*

Practice! That's what children often need to improve their speech and language skills. But where do we find practice tools that are so enjoyable and so motivating that a child would independently choose to practice each day? What kind of tools can provide the necessary practice for our children while allowing and encouraging participation by their parents and siblings?

Is there a tool out there that can help children with oral motor planning needs, articulation problems, receptive and expressive language delay, interaction and engagement issues, and poor turn-taking and imitation skills? I have one great answer to that HUGE question:

## DO IT WITH A SONG!

With almost every child and with every speech and language challenge I have faced, there has been a song that could have been used to help.

This journey of finding the power of music to help children with speech and

language began many years ago with a little boy named John. John was diagnosed with ASD (autism spectrum disorder) and was fixated on certain objects – especially fish and ducks. John also loved music, and I did my best to engage him in songs. He was interested and attentive to music but was never able to sing the songs I sang to him. Honestly, it was a one-sided conversation. His lack of verbal participation initiated my journey of finding music, and subsequently writing songs based on children's interests. My goal and dream was to entice and empower my students to practice speech on days when I did not see them for therapy.

My search for songs which would improve verbal skills was frustrating at first. There were many songs on the market, but there were very few that would meet the verbal needs of my students – the sentences were too long, the vocabulary was too complex, and the rate was too fast. There was no room in them for children to imitate, to respond,

and to take turns. They listened, but no verbal practice was achieved. Consequently, my song-search for John came to a screeching halt. I never found a song that could reach him, but I always kept John in mind...

There was no choice but to write my own songs, and years later, I am still writing songs – a new song whenever I see a child with a different need or different motivation. Let me give you some examples.

One of my students, James, omitted final consonant sounds and needed more opportunities to practice. Because of him, I wrote “**Put the Sound on the End**” – a song which has been helpful not only to him but to many other children.

Then there was Sam who didn't understand or use action words. Inspired by his love for puppies, I wrote the “**Puppy Song**.” This song, better than any other tool I could have used, taught him the actions of run, jump, sit, eat, and

talk. His mom and dad would sing the song with him and use a stuffed animal to demonstrate the actions. Such activities were motivating to him and became a part of his daily practice.

There was also Ben who needed simple verbal practice of vowel sounds and simple words. The result was the song “**Drive a Car.**”

From Kelsey’s need to imitate practice at a more reflexive level came yet another song, “**Noisy, Noisy, Noisy**” where she was encouraged to imitate sounds such as a kiss, a sneeze, or a cough.

The benefits of these songs became far-reaching as they created an opportunity for interaction, turn-taking, and FUN with parents and siblings. They gave the children something to listen to and to practice during daily activities, like riding in the car. They gave children new vocabulary to use in certain situations. For example, my little friend David was able to say “Owie all gone” to his mom for the first time after listening repeatedly to our “**Owie Song.**”

You may be thinking, “I can’t write music, so this is not for me!” Quite to the contrary, studies show that children do not mind how you sing. They only care

that you attempt to sing, and that you do it with them. They just want to be engaged with you. They simply want a simple song that they can ... putting it simply: sing! The key word here is SIMPLE. In my musical journey, I have explored what makes a truly enticing song for a child. What do I look for in a song that I know will create verbal practice in children? Well, that depends on the needs of each child, and that has been my journey with my first company, Kids’ Express Train and my company now, Talk It Rock It.

My job as a speech-language pathologist does not always include music, but to avoid the obvious gift of music is to avoid a power that can do so much for us in our work. Remember that every moment is a note, every situation a song, and every person is a player. If you hold on to that thought, your mind will be open to the endless possibilities that every day of your life brings, and you will reap the benefits.

### WHAT ABOUT FISH AND DUCKS AND JOHN?

Whatever happened to the little boy with ASD who was overly hooked on fish and ducks? I am happy to say that he is a young adult now and going to college. I wrote a song called “**Fish, Sharks, and Shells**” in his honor, and have been teaching it to children ever since. Was I a good speech-language pathologist for John? Yes, I think I was. Would I be better now? No doubt, because I have many more tools now than I had back then and the biggest one of all is the power of music and knowing how to use it.

Canadian Hearing Report 2013;8(2):29-30.

A blue rectangular graphic with white text. At the top, it says "FEATURE CAA MEMBER BENEFIT" in large, bold, sans-serif font. Below that, in a smaller, italicized serif font, it says "Professional Liability Insurance". Underneath, there is a list of four bullet points, each preceded by a tilde (~): "Exclusive reduced rates", "No administration fee", "Competitive limits of liability", and "Enhanced product offering". At the bottom of the graphic is the CAA/ACA logo, which includes a red maple leaf and the text "Canadian Academy of Audiology" and "Académie canadienne d'audiologie". Below the logo, the website address "www.canadianaudiology.ca/benefits" is written in a white sans-serif font.

**FEATURE CAA  
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*Professional Liability Insurance*

- ~ Exclusive reduced rates
- ~ No administration fee
- ~ Competitive limits of liability
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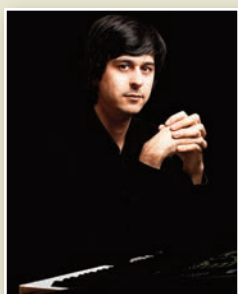
  
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# The Journey from a War to Loudness Wars: A Musician's Hearing Loss Awareness Program in Turkey

By Ata Akdag  
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## About the Author

*Ata Akdag is a student at Yildiz Technical University working towards a master's degree in art and design. He is also the singer/songwriter/keyboardist for Turkish progressive band Yaya He has been working to raise awareness about musicians' hearing loss in Turkey since 2009.*

## A DAY IN THE LIFE

14 P 844. I'm not sure if this counts as betraying military secrets, but that was the serial number of the rifle I used during my service in the Turkish army. A rifle is of great importance to a private. As Gunnery Sergeant Hartman says in *Full Metal Jacket*, "This is my rifle, this is my gun. This is for fighting, this is for fun!" To be honest, a G3 rifle was not much fun compared to the band G3, formed by guitar heroes John Petrucci, Joe Satriani, and Steve Vai. Back in those days I had never heard of noise-induced hearing loss (NIHL), head-shadow effect, or acoustic trauma. Nor did I know that this fun toy could produce a sound that could reach 161 dB SPL and that this could permanently damage my hearing. I was a young man playing keyboards in rock bands and studying sound engineering. But now I couldn't hear the frequencies above 4 kHz with my left ear and there was an audiometric notch in my right ear's hearing (which is how I

was introduced to the head-shadow effect). My rifle had caused me to age 40 years in a few minutes. I still saw the same person when I looked in the mirror, but my audiogram told me something else entirely: "You can't perform music without ear protection any more. You can't listen to the albums you love at loud volumes with earphones on. And, I leave you this ringing in your ear, so that you will never forget this trauma for the rest of your life." The army doctor who saw my audiogram was more optimistic: "Wouldn't you give an ear for your country?" Apparently the Hippocratic Oath had changed a bit in the army. I went back home. As someone with NIHL, it was quite difficult for me to become a sound engineer. In one day the course of my life had changed. That was my rifle and this really wasn't fun at all.

## O CANADA

I kept asking myself, if a rifle could do

this, could loud music do the same as well? I decided to base my bachelor degree's thesis around this question. Thankfully my faculty was open to interdisciplinary studies: "Right, focus your studies on that area, but we can't really help you. This is the Department of Music and Performing Arts and there are no doctors here!" I understood my situation; I was by myself. When I started my research I realized that there wasn't a single program or an article in my country about hearing protection for musicians. I felt I was under a heavy responsibility. Just when I was about to give up, I came across Musicians' Clinics of Canada on the Internet. When Dr. Marshall Chasin sent me his book *Hear the Music*, I knew where to start. The auditory system, classical orchestras and rock bands, hearing protectors... If it wasn't for this help from across the ocean, perhaps the studies about musicians' hearing health would never start in Turkey.

## WITH A LITTLE HELP FROM MY FRIENDS

I looked to the Istanbul State Symphony Orchestra to start my research. First of all, I had to meet with the ISSO members and join their rehearsals. Music history classes at my faculty were taught by ISSO flute artist Aydin Buke. How lucky! Thankfully I had survived the first part without getting bogged

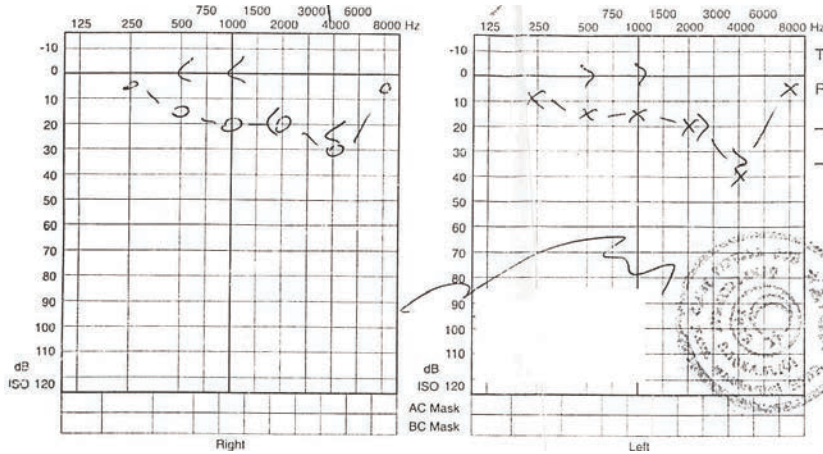


Figure 1. Author's audiogram before using a gun (hearing loss related to 15 years of music experience).

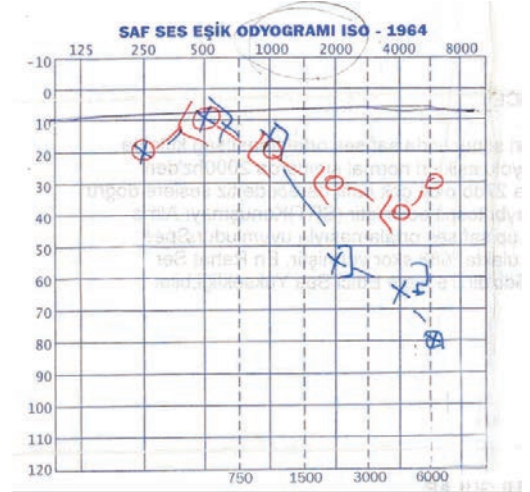


Figure 2. Author's audiogram after shooting a G3 rifle.

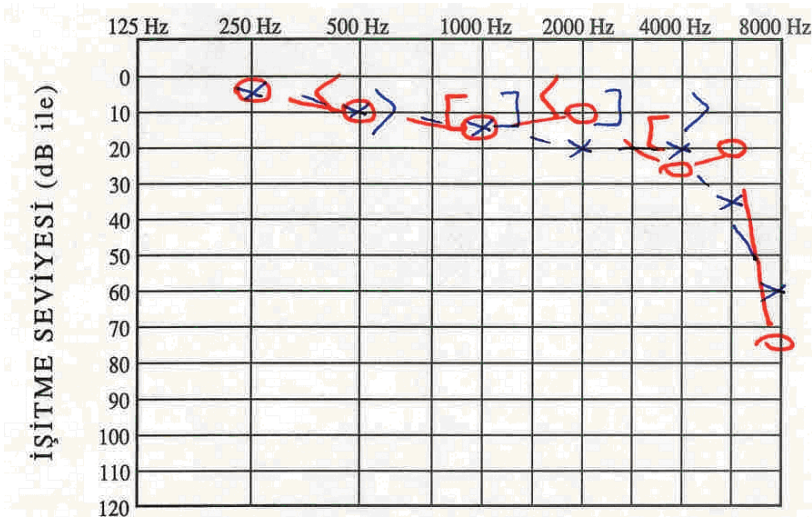


Figure 3. A french horn player's audiogram (27 years' experience in orchestra).

down by the state orchestra bureaucracy. The difficult part was “convincing” the musicians to participate in the hearing tests and the survey. I use the word “convince” purposefully, because Turkish people are quite reluctant to go through with routine medical examinations. And, filling surveys is a complete waste of time. I could read their first reactions in their faces: “I can hear just fine, where did this hearing test

come from?” Japanese movie character Kambei Shimada could find seven samurais to fight against the bandits; I was luckier. In the end I convinced eight orchestra members to participate in this “unnecessary” activity. The number of those who filled the survey was greater than I expected: 41 members. So, where would the hearing tests be held? I had to find a comfortable, private clinic in the city and there was no financial support

for the project. ME-DI ENT Center's founder Dr. Mehmet Omur, whom I had met during my studies, provided with all his resources – ear examinations and hearing tests. Completely free! Indeed, at first it had seemed like there wasn't anyone who cared about the subject enough to help. But after pressing the right buttons, all the doors were opening. I was also quite lucky to have Ali Barutcuoglu as my thesis advisor, who believed in the importance of my work and was helping me every step of the way. By then, the orchestra musicians seemed to be more interested as well. I think they had finally believed that I wasn't some sort of agent sent to inspect their performance and health adequacies!

The results of the exams were quite interesting. 60% of the orchestra members had never had hearing tests. None of them used hearing protectors. Most of those who thought there could be a connection between music and NIHL were those who had hearing tests done before. So, contacting a hearing centre even once was enough to see the

What type of ear protection (or pro equipment) do you use on stage?

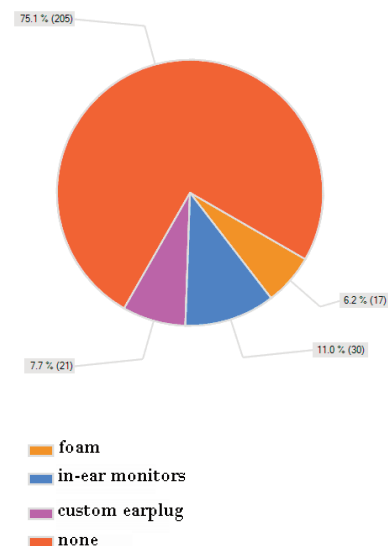


Figure 4. Percentage of musicians using various types of hearing protection.

link between noise and hearing loss. The musicians who had ringing in their ears after concerts or rehearsals also thought NIHL could be linked to music. And those with no tinnitus problems? Not one of them thought music could lead to hearing loss – psychological factors were significant as well. If there was no pain, there was no fear either. The woodwind players, who sat in front of the brass players, were the group with the highest risk factors due to the loudness level of the brass instruments. The audiogram results seemed to prove this. The horn players' hearing at the high frequencies was considerably damaged. The oboe players had sensorineural hearing loss. Even in the symphony orchestra, which rehearsed in an acoustically satisfactory environment, one could observe the traces of NIHL. So I moved on to a “noisier” domain: pop/rock musicians.

## MY GENERATION

Kathy Peck, executive director and co-founder of H.E.A.R (Hearing, Education,

and Awareness for Rockers) had suffered hearing loss and dedicated herself to raising awareness about musicians' hearing. The Who's guitarist Pete Townshend had experienced similar problems as well because of listening to loud music with headphones in the studio and had become an important supporter of H.E.A.R. I had also gravitated towards the same area since I had NIHL and tinnitus as well. We had all become figures in the same cause after our bitter experiences. I had acquired ear plugs which attenuated all sounds by 15 dB and I still continued to perform, but I could not reverse my hearing loss. I was wondering if there were others like me and I wanted to raise awareness among musicians who did not know about musicians' hearing problems. With this in mind, I prepared an online survey and reached 275 pop/rock/jazz musicians in Turkey who regularly performed on stage.

Inadequate venues, raised volumes, irregular working hours... Despite all these negative conditions, 75% of performing musicians in Turkey did not use any kind of hearing protection (Figure 4). Furthermore, 76% of those who filled the survey thought there was a connection between music and NIHL. They knew about the risk, but they took no precautions. 17% of those who took the survey had permanent tinnitus, especially the drummers. And, the instruments that the musicians with no hearing problems were most uncomfortable with? The answer was, none of them. Just as it was with the symphony orchestra, there were no problems for pop-rock musicians as long as there wasn't any pain.

I moved out of the “noisy” domain and turned to the group with the supposedly lowest NIHL risk factors: Sound engineers.

## WELCOME TO THE MACHINE

It's hard to point to a definite link between music and NIHL, since not only the loudness of music, but all sound levels are elevated in the industrial age and there are countless factors that threaten to damage our hearing. If we are living in a noisy world, the sound engineers working in studios are as at risk as any of us. So I simply ask: “Could a mixing engineer with NIHL continue to do his job with the help of visual references?” EQ's, frequency analyzers, spectrograms, and other visual tools. How much more can computers help us? I have designed an experiment in collaboration with Kadikoy Hearing Center for mixing engineers, which is still ongoing. Professional sound engineers in Turkey are also currently answering an online survey. I am impatiently waiting to share the results once they are done. SAE Istanbul, one of the organizations in Turkey with sound engineer certification programs, is raising awareness with audiology products company Hearsafe's seminars given by Eckhard Beste. Also, Westone's distributor in Turkey is endorsing well known performing musicians and moving forward in the in-ear-monitor and musicians' earplugs markets. The same company is marketing products for military use as well. God! Isn't it a bit late?

## STILL HAVEN'T FOUND WHAT I'M LOOKING FOR

There is still no cure for NIHL. Stanford University Otolaryngology Department is conducting promising experimenting on mice, but the answer Dr. Stefan Heller gave me today is still negative: “We are unfortunately still several years away from human trials.”

The current picture in Turkey is like this: There is a lack of a common terminology and communication between musicians

and audiologists. None of the organizations I spoke to keep a database of professional musicians' hearing tests. When you need to examine musicians about occupational hearing loss, there is only one way to do it: You have to do it yourself. So I gave the first seminar at Art Medicine Work Group's educational module. I advised the doctors of tomorrow to work on the subject of musicians' hearing loss. A common musician, telling doctors something they need to do and sharing the results of his research!

What will I do next? I'll be wherever there's a musician complaining about ringing in their ears. Wherever there's a soldier suffering from NIHL because of guns, I'll be there. And whenever musicians enjoy performing without fearing it, whenever mastering engineers stop the loudness wars, I'll be there, too.

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# Beethoven and Me: The Effects of Hearing-Loss on Music Composition

By Jay Alan Zimmerman  
musicbyJAZ@gmail.com



## About the Author

Jay Alan Zimmerman is a composer, author, and multimedia installation artist with a BFA from NYU/Tisch.

Theatrical works include his award-winning *INCREDIBLY DEAF MUSICAL* (seen at The Duke on 42nd Street), *A ROYAL SOAP OPERA* (with Prospect Theatre at The Clurman), and the multimedia song cycle *PUNCTUATED THOUGHTS* – originally directed by Broadway legend Tom O'Horgan. Visual music installations include *WINDOW MUSIC* (New York Academy of Medicine), *ART/SONG* (chashama Times Square), and *ROBOTICUS* – a video/robotic symphony created during residency with the LEMUR musical robots. He scored the dancefilms *THE LAST*

*LEAF* (Best Score – First Run Festival) and *DO NOT CALL IT FIXITY* (Pompidou Centre, Paris), and the London-produced plays *BOOTH* and *OUR BRUTUS*.

The son of a Midwestern music theory professor, Jay had normal hearing while studying piano, saxophone, oboe, and frequently performed as a boy soprano. Last month, despite becoming deaf to all sound above middle C, he was selected for the New Dramatists Composer-Librettist workshop where he created new works daily and collaborated with Tony nominated playwrights via transcribers and frequency-analysis software. He lives in New York City with his wife, the painter Lisa Ingram, and son.

Most scholars insist hearing loss didn't affect Beethoven's music. I say that's crazy... and he hid clues in his piano sonatas that prove it.

When people find out I'm a composer, the first thing they say is "You're like Beethoven!" And though our music is not remotely the same, it's actually true in many ways: We both grew up playing piano and other instruments as children; earned income performing, composing, and arranging music while still teenagers; and then moved to the major artistic city of our time and became self-employed composers who wrote many types of music.

Oh, and yeah, we both slowly became deaf.

It's jarring to see the phrase "deaf composer," because it's not a job anyone willingly pursues and few people understand what it really means. Yes, it's more challenging to compose music without normal hearing. But "deaf" rarely means "no sound." What it means for a composer that lives through all the stages of hearing-loss – normal, mild, moderate, severe, and ultimately profound deafness – is a life of disappearing notes, altered harmonics, and a never-ending quest to capture snippets of musical tones like a dying man seeking drops of water in the desert.

Sure, you can compose with just theory, memory, and virtual music in your head. But if you're like Beethoven (and me), you'll do whatever it takes – including chopping the legs off your piano — in order to hear a bit of what you've written... *for yourself*.

Understanding this reveals how hearing-loss can affect music composition. The changes aren't glaring wrong notes or bizarre music—mistakes are easily caught by reading the scores. No, the changes are small and subtle, probably unconscious most of the time. Because hearing-loss sneaks up on people, and you don't notice you're adjusting to it until it smacks you in the face.

This is the story of how Beethoven and I got smacked and how our music changed. In the great master's case, these changes might even have influenced what became known as the Romantic Era of music. At least it would be nice to say hearing loss was responsible for something positive!

## NORMAL HEARING

One of the first things I did after discovering my hearing loss was to make a new hearing chart. Because audiologists kept telling me I don't hear much, and I kept telling them I heard most of the piano, so what the heck is going on here? So I made a chart that covers the entire human hearing spectrum and includes musical terms I understand. A musician doesn't think of "frequencies." We think of pitch. We don't think in decibels for volume, we think in dynamics. And since music is louder and lower in pitch than speech, on an audiology chart I don't hear much – but on MY chart, I hear a lot. Guess which one I prefer to look at?

Since Beethoven (and me) grew up with normal hearing, this first chart shows what he hears from birth to about age 25: He hears all the frequencies in speech and music, from 20 to 20,000 Hz. He hears all the volumes, which were probably quieter than today's noisy world. He hears every note on his piano, the top one, which is smaller, brighter, and more quiet than the modern piano below (which was developed during his lifetime). Figure 1 shows the ranges of Beethoven's original piano and the modern piano keyboard.

In this normal-hearing phase of life, Beethoven is most focused on works for piano – his first and most intimate means of expression – and it's likely he developed them through sketches and

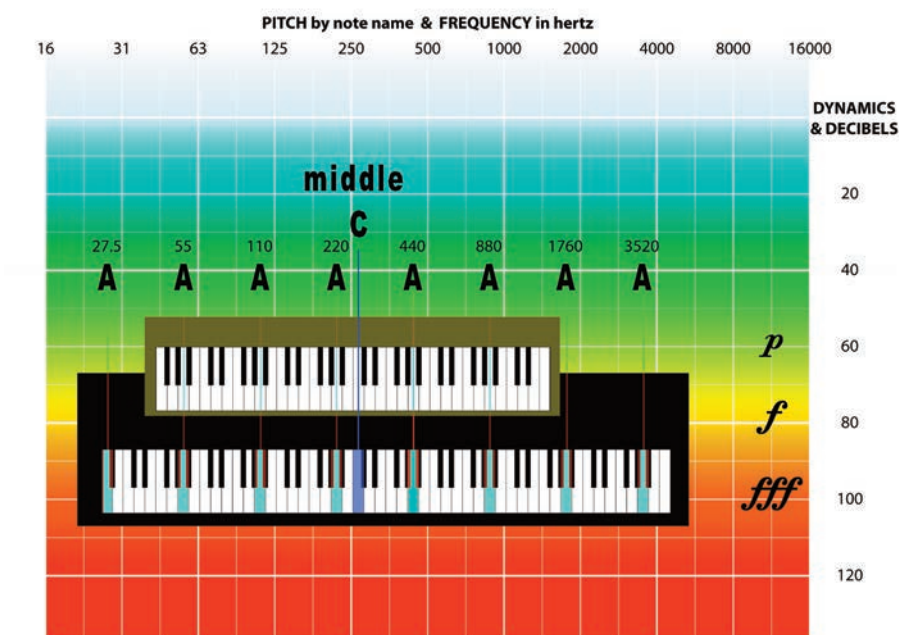


Figure 1. Beethoven's original piano (top) with the highest fundamental being about 1500 Hz and the lowest being roughly 40 Hz. The modern piano keyboard ranges from 27 Hz to just over 4000 Hz (4196 Hz for the purists among us). Audiologists rarely test below middle C (roughly 250 Hz).

improvisation. He's known as a brilliant improviser and performs often. So I focused on these early piano sonatas (Opus 2 Nos. 1, 2, and 3) to get a general sense of his composing style before hearing loss.

The main melodies of each movement of these works are in the soprano range and the left hand parts are very light. By light, I mean that there are no low, thick chords or "rumblings" (low tremolos) so characteristic in his later pieces. The only low triads appear briefly at end of movements (as in the F minor chord at the end of first movement of No. 1) and in a passage of No. 3 where the left hand sustains low triads under a right hand broken arpeggio (measures 108 – 119). The same is true of Opus 7, with the exception of the largo movement, which begins with an alto theme, centering around middle C. However, the left hand accompaniment is still written with open voicings, like the natural overtone structure.

The overall effect of these works fit perfectly with the Classical Era and reflect the influences of Mozart, who Beethoven wanted to study with but met only once prior to his death, and Haydn, who Beethoven studied with and to whom he dedicated his first sonatas. This is the result of a young man composing with normal hearing: You end up composing works similar in style and construction to your influences and what you hear others writing.

Similarly, my early works were piano-based and developed through improvisation. There's something thrilling about sitting at a piano and creating at the same time you hear the results. Every "accident" can lead to a new development. Every emotional outburst can flow from your fingers and be instantly translated into music. It's addictive, and hard to give up when faced with withdrawal...

*My hearing has become weaker*

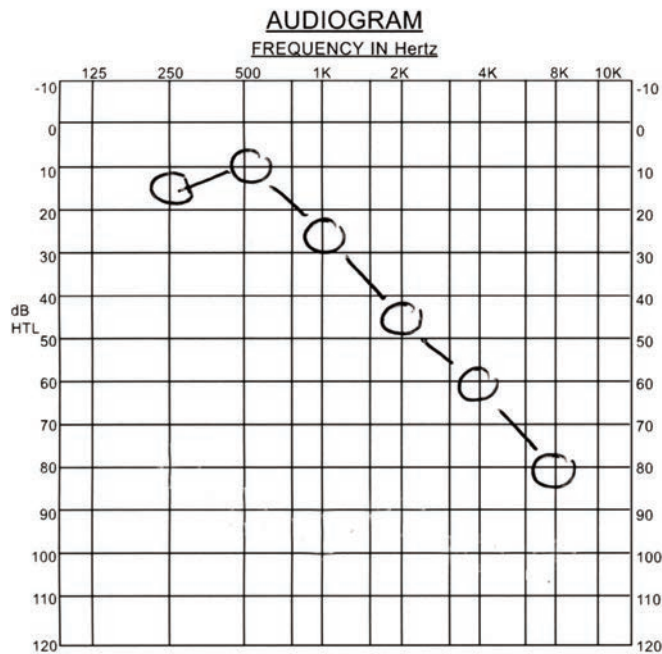


Figure 2. Audiogram with a high frequency roll-off above 750 Hz.

*during the last three years...  
When somewhat at a distance I  
cannot hear the high tones of  
instruments, voices... – Beethoven*

*How humiliating it was when  
someone standing close to me  
heard a distant flute, and I heard  
nothing, or a shepherd singing, and  
again I heard nothing. – Beethoven*

## HIGH FREQUENCY HEARING-LOSS

The best information we have on Beethoven's hearing-loss comes from his own letters. While it's possible he had a slight hearing loss in childhood, he (like me) didn't notice any loss until his mid-twenties (around 1796). There is no evidence that it appeared suddenly, and he is inconsistent as to when it began. His hearing also continues to get worse throughout his life. This means he had a progressive hearing loss. And, he has trouble hearing the high notes of voices

and instruments, which suggests he has a high-frequency hearing loss.

He writes that he cannot hear "soft speech." So if we assume that includes the volume of a whisper, sounds would have to be at least 20 decibels loud for him to hear anything. He also writes that he cannot hear the high notes of instruments, so if we use a modern piano as his limit, that would mean nothing above 4000 Hz. But, Beethoven's piano was only five octaves, and he says he has trouble hearing the high notes of singers – which means at a maximum, a soprano's high C – which is approximately 1046 Hz, though he may have still heard those notes at very loud volumes. Using these clues, the first stage of his hearing-loss (age 29) in audiometric terms, may have looked something like this (Figure 2):

As the high notes disappeared, Beethoven was still performing and

composing, but keeping his hearing loss a dark secret. And, when I looked closely at his piano sonatas of this time, there are some interesting changes:

Opus 10, No. 2 (1797) is the first time he begins a movement (the Presto) with a bass clef theme. But it is just a fugue, so not that unusual. Opus 10, No. 3 actually begins with the right hand in the bass clef, but it is short lived – a little more than one measure. The trio of this sonata also begins with a bass clef theme, but it has sparse voicings and is a very short movement. However, this sonata contains the most emphasis on the low register in Beethoven's work thus far.

With the Pathétique (Opus 13), low register emphasis begins to take over. The sonata begins a strong C minor chord stacked from middle C down to two octaves below. The left hand tremolos in the first movement go all the way down to the G two octaves below middle C – twice as low as the only other tremolos in Beethoven's previous work (Opus 2, No.1). The second movement begins with both hands in the bass clef and is that way for about half of the movement. Its melody is in the tenor range.

Opus 14, No. 1 & 2, composed in 1798, both seem to be a diversion from this trend. However, in No. 1 almost every melody note above a high D (octave above middle C) are doubled with the octave below. So, if Beethoven performed this work himself, he would hear the lower version of the melody while playing the higher one. He still gets to enjoy it.

With Opus 22 (1800), the opening melody is in the second voice in the right hand. The low tremolos are back, this time even lower than the Pathétique (F two octaves below middle C). One the

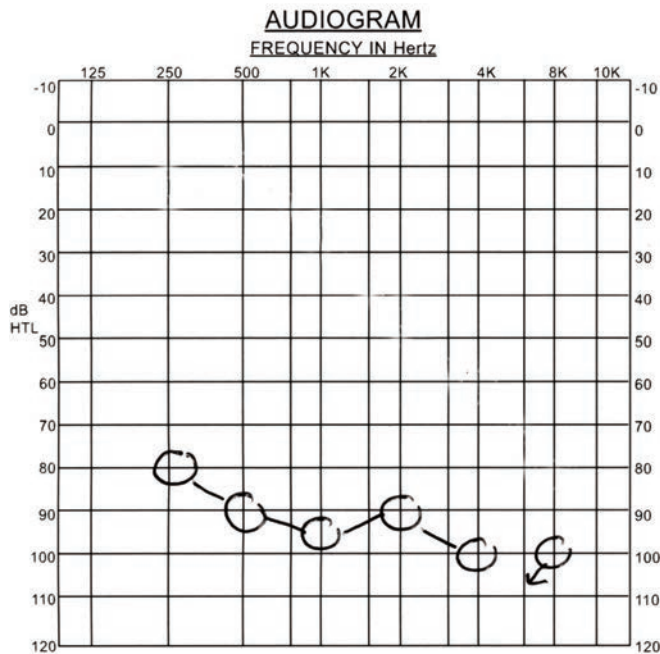


Figure 3. Author's audiogram with a moderate to severe high-frequency hearing loss.

themes of the first movement is written two octaves below middle C and constantly comes back to this same F. I'm going to skip the theme and variation sonata, Opus 26, except to say that four of its sections begin with both hands in the bass clef.

Around 1800–1801, Beethoven began to admit his hearing loss to his friends. His compositions have already stretched melodies to their lowest extremes, and this is now a permanent part of his writing. His use of thick, low chords has grown and will reoccur most prominently in Opus 31, No. 2 and Opus 53 (1803), as well as in many of his other sonatas. An interesting change, however, is that he now begins to reduce his usage of the extreme high register – no longer a major melodic element, but more for runs, repetition of lower melodies, and effects.

The melodies of Opus 27 Nos. 1 and 2

are quite low when compared to with three piano sonatas of Opus 2. If you compare the highest to the highest (Opus 2, No. 3 last movement vs. Opus 27, No. 2 last movement) and the lowest to the lowest (Opus 2, No. 2 second movement vs. Opus 27, No. 1 last movement) there is a difference of a sixth or seventh. This is also generally true for Opus 28 and the three sonatas Opus 31.

So the overwhelming trend in Beethoven's music of this period is a slow stretch of melody to its lowest possible extremes, followed by a reduction in its highest. He moves from open chords in the low register to thick triads. And, though the new, modern piano has extra high notes, he focuses instead on its ability to express a darker, louder, dynamic range.

Did this lowered "pitch shift" occur: Accidentally – as a part of his desire to create a darker, more emotional style of

music than the Classical Era? Subconsciously – as a result of his losing the ability to hear the high notes? Or, consciously – so that he could perform these pieces with more confidence?

As a composer who's gone through this same stage while writing and performing my own works, my guess is: a combination of all three. Sometimes I "hide" low note cues in my work so that I can perform it. Sometimes I just want to enjoy the hearing the music, so I write it in my hearing range. And, sometimes, frankly, I have no clue what I'm doing. It happens instinctively.

*It was owing to virtue, and to my art, that I did not end my life by suicide. – Beethoven*

## MODERATE-SEVERE

As Beethoven's hearing keeps changing, so does his music. Having considered suicide, he instead accepts his increasing hearing loss and the label "hard of hearing." He writes to himself at age 35: "Let your deafness no longer be a secret – even in art."

He can still compose but is soon forced to give up his first love – performing piano publicly. His last piano concerto was written at age 38. He only writes one opera, as he would have been unable to hear the sopranos nor most of the consonants required to understand what words they are singing. And, in his symphonies, which he began to write at age 30, he breaks the rules and introduces themes with lower pitched instruments than the standard violin. Even the tympani plays melodic motifs. In my opinion, these are not only creative choices but "musical treats" for his severely impaired hearing and cues to help him conduct. Unfortunately, he even has to give up conducting, having been humiliated by conducting a

performance long after the piece had ended.

Instead of loose sheets of staff paper he begins to use “sketchbooks” – bound books of staff paper and notebooks to carry with him on long walks. It is as if he is training himself to rely more on imagination and theoretical skill and less on improvisation. But at the same time he increases his output – as if hoping to compose everything he can before his hearing is completely gone.

To get an idea of his hearing-loss at this point, I include this chart of my own loss in the moderate-severe stage (Figure 3).

*Precisely because of that [your deafness] you are famous. Everyone is astonished, not just that you can compose so well, but particularly that you can do it in spite of this affliction. If you ask me, I believe that it even contributes to the originality of your compositions.— Beethoven's nephew Karl*

## PROFOUNDLY DEAF

By age 42, Beethoven could still hear some low frequencies but for the most part he was profoundly deaf. This is best illustrated by his friend Louis Spohr, a respected composer and violinist of the time, who met Beethoven in 1812 (age 41). Spohr wrote:

*At the time I made Beethoven's acquaintance, he had already discontinued playing both in public and at private parties; I had therefore but one opportunity to hear him, when I casually came to the rehearsal of a new Trio at Beethoven's house. It was by no means an enjoyment; the pianoforte was woefully out of tune which, however, troubled Beethoven little, since he could hear nothing of it. In the forte,*

*the poor deaf man hammered in such a way upon the keys that entire groups of notes were inaudible ...*

*I felt moved with the deepest sorrow at so hard a destiny. It is a sad misfortune for any one to be deaf; how then should a musician endure it without despair? Beethoven's almost continual melancholy was no longer a riddle to me now.*

There is a line you cross with hearing loss where you give up trying to hear even though some sounds still make it to your brain. I am loath to call this “acceptance,” because you can't move on from something that follows you. But, acknowledging your limits can be somewhat freeing.

In this phase, Beethoven's musical output slows down (he has finished all of his symphonies except for the ninth) but he doesn't quit. At age 44, he makes another shift in his compositional system and begins to use pocket notation sketchbooks. With these little sketchbooks he can wander in nature and write musical ideas completely free of the keyboard. And between ages 45 and 47 he tries to communicate with “ear trumpets” – specially designed for him. But they do not help, and he soon resorts to conversation books.

And yet, even though he has trained himself to compose mostly on notation paper, he is still desperate to hear his music. Special pianos are constructed for him that have extra strings for every note, making the piano twice as loud. Some sources claim he attached an ear trumpet to a specially designed “resonance plate” which, when placed on the piano, amplified the sound directly into his ear. And, famously, he cut off the piano legs so he can feel his music when it made the floor vibrate.

When working at the keyboard he also tried to overcome his tinnitus:

*Cotton in my ears at the pianoforte frees my hearing from the unpleasant buzzing.*

These struggles show up musically in his extreme changes in tempo, register, and dynamics, but the way is clear: when Beethoven is most emotional, passionate, depressed, confused, he writes in the bass clef – not only for its dark sound, but also where he can possibly hear it; thereby releasing these feelings through writing the music, performing the music, and hearing the music. This combined sensory experience is the only source of pleasure Beethoven can count on.

Beethoven – who had no wife, no children, no other source of income – was unable to participate in society and endured constant physical suffering, there was no choice. He continued to push himself, finally creating his greatest work: the ninth symphony.

Beethoven proves one can compose by using a combination of imagination, memory of sound, music theory, and maximizing whatever hearing remains. But the larger question for him (and me) has been “why bother?” If you can't ever enjoy the result, why go through all that struggle and pain?

The answer for me is that when I'm in the zone of creating, using vibration, tactile, technology, and yes, some hearing – sometimes I *think* I heard my music. And that's almost as satisfying as the real thing. As Beethoven said:

*I live only in my music.*

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Canadian Hearing Report 2013;8(2):35-39.



# Hearing Loss in Classical Orchestra Musicians

By Alberto Behar, PEng, CIH and Marshall Chasin, AuD

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## About the Author

Alberto Behar (far left) is a research fellow with the SMART Lab at Ryerson University.

Marshall Chasin is director of auditory research with the Musicians' Clinics of Canada

Quian et al. performed a noise exposure survey on members of the National Ballet Orchestra, using noise dosimeters.<sup>1</sup> They concluded that the noise exposure due to the musicians' activities with the orchestra was below the hazard level of 85 dBA. As a follow-up to the survey it was decided to perform hearing tests to the members of the orchestra. A questionnaire was also used to gather information on particulars of the surveyed members.

## QUESTIONNAIRE

Musicians had to be assured that the questionnaire will be anonymous with no names included, something essential to the participants because of the nature of their occupation. In addition to basic questions concerning demographics, questions were asked about the musician's principal instrument (some participants play more than one), the duration of exposure through practice and performance and exposure to other sources of noise.

Because of the small number of participants involved, musicians were

divided in five groups according to their respective locations on the orchestra floor (See Figure 1) and similarity of the spectral profile of the sound they generate. Groups were as follows: Group 1 (Violins); Group 2 (Violas/Cellos); Group 3 (Woodwinds); Group 4 (Brasses); Group 5 (Percussion / Double Bases).

## AUDIOMETRIC ASSESSMENT

After completing an audiological history and otoscopic examination a full audiometric battery including middle ear assessment was performed on all participants. Air conducted and bone conducted audiograms were obtained using a clinical audiometer with 5 dB steps. All measurements were conducted in a sound treated audiometric booth. Speech testing (word recognition scores and speech reception thresholds), and admittance measures (tympanometry and acoustic reflexes) were also part of the evaluation.

The results of the test were explained to each musician and a range of hearing loss prevention strategies, including the

use of uniform attenuation earplugs was discussed.

## RESULTS

### Noise Exposure

Normalized  $L_{ex,8}$  hs noise exposures levels were calculated and shown in Table 1.

### Questionnaire

Forty-four of the 52 musicians completed the questionnaire (85%). Twenty-one of the 44 respondents were female (48%). Average age of males was 51.7 years (SD = 11.1), while average age of females was 48.7 (SD = 9.9). Average age of participants was reasonably matched across the five groups.

Table 2 shows the numbers of years participants were playing in general and professionally. An analysis-of-variance (ANOVA) determined that the groups did not differ with respect to the length of their exposure.

The majority of respondents reported listening to music through speakers (40). Many also used earbuds with portable

instruments (21). Very few listened through circumaural headphones (5). Participants did not normally limit themselves to only one music listening device. Relatively few respondents reported involvement in noisy activities (9). However, it should be noted that a proper definition of “noisy activity” was not provided.

### Audiometric Results

Figure 2 shows the average audiometric pure tone test results for the musicians. On average the data suggest only a slight to mild mid to high frequency sensory-neural hearing loss in the 4000–6000 Hz region. This is consistent with hearing losses observed with other forms of noise exposure.

### Measured and Predicted Hearing Losses

The ISO 1999 Standard predicts hearing loss at different frequencies for males and females, according to age and number of years of exposure at a given noise level.<sup>2</sup> Figure 3 shows the measured and calculated hearing losses for the group in this study. It may be observed that there are practically no differences between measured and calculated hearing losses at 3000, 4000, and 8000 Hz. Although the difference at 500 Hz is likely due to background noise in the audiometric booth, there is no obvious explanation for differences at 1000 and 2000 Hz. In any case, the differences between measured and predicted losses do not exceed the limits of measurement accuracy.

### DISCUSSION

Pure tone audiometry showed that threshold varied as a function of instrument group and frequency region. Brasses and percussion/basses had the highest thresholds, bordering on clinically significant losses in the 4000–6000 Hz region. These differences across

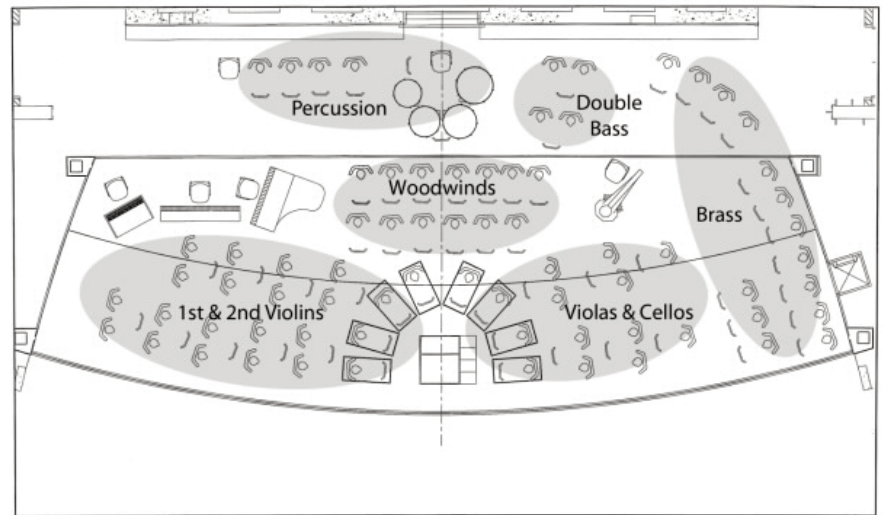


Figure 1: Location of the instruments groups on the orchestra floor.

TABLE 1. NORMALIZED AVERAGE AND STANDARD ERROR NOISE EXPOSURES

Group	Instruments	Average	St. Error
1	Violins	86.5	0.8
2	Viola/Cello	86.8	0.3
3	Woodwinds	89.8	0.8
4	Brasses	92.7	0.5
5	Percussion/Double basses	89	0.5

TABLE 2. YEARS OF PLAYING.

Groups	1	2	3	4	5
Average playing	41.8	35.6	40.4	38.6	32.5
Average playing professionally	26.0	23.9	31.5	29.9	22.8

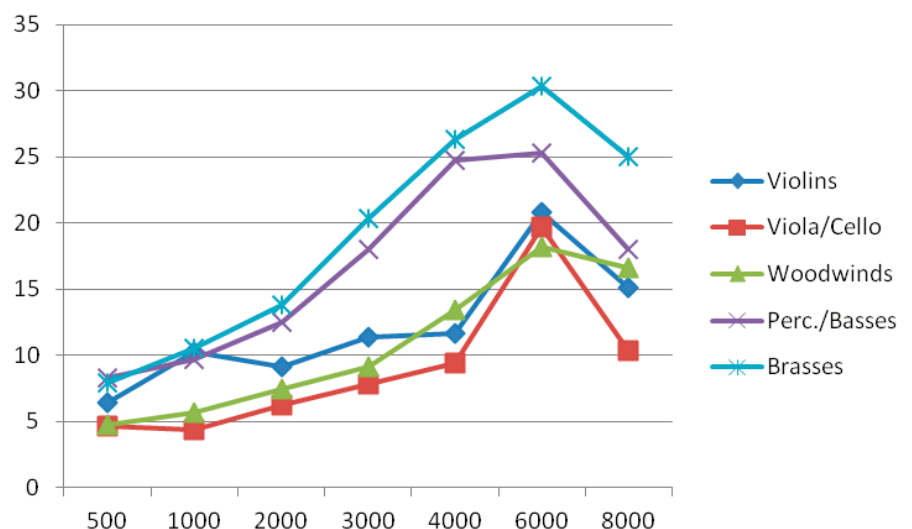


Figure 2. Average hearing loss of the different groups.

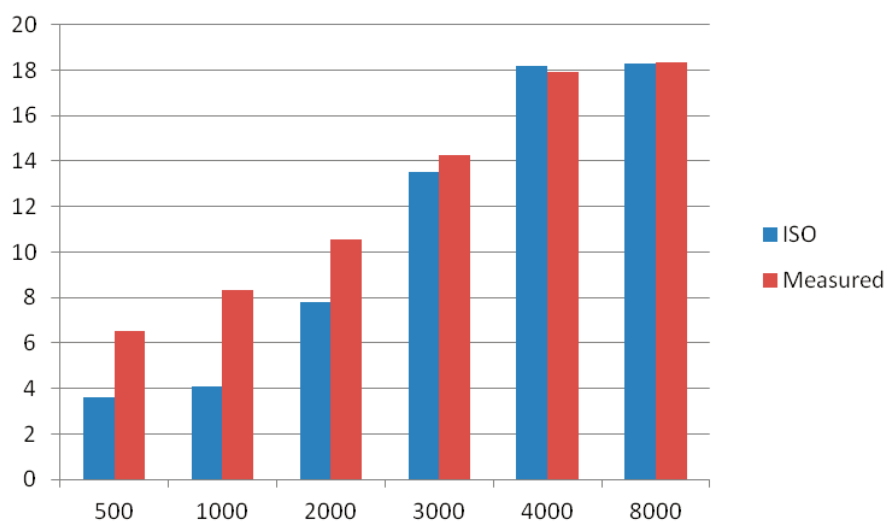


Figure 3. Measured and predicted hearing losses (as per ISO 1999) in dB

groups could not be explained by age, years of playing, or years of playing professionally, and are thus most likely due to individual differences in noise exposure. Brass players had the highest hearing losses (10 dB or greater than strings and woodwinds between 4000 and 8000 Hz). This finding is consistent with other noise-exposure surveys and audiometric investigations which raises some concern about long-term hearing health of brass players. Nonetheless, it is important to acknowledge that at the time of testing, none of the groups had hearing loss that would be considered outside the limits of normal hearing.

Noise exposure levels in the orchestra, normalized to 360 hr/year were below the hazard limit of 85 dBA with the exception of the brasses. Longer playing

times will increase the risk. It seems reasonable to recommend that orchestras comparable to the National Ballet Orchestra adopt a Hearing Conservation Program, and that linear ear-plugs be considered for those orchestra members that are exposed to higher noise levels.<sup>3</sup> On the basis of the current study, it appears that such interventions may be most necessary among brass players.

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Canadian Hearing Report 2013;8(2):40-42.



# The “Epidemic” of NIHL from MP3 Player Use

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## About the Author

Cory Portnuff is an audiologist at the University of Colorado at Boulder.

In the past few years, a wide range of media coverage has declared hearing loss from overuse of MP3 players and other portable listening devices (PLDs) to be at epidemic proportions. Indeed, the MP3 player has become a ubiquitous accessory in for many younger people. Over 342 million Apple iPods and iPhones have been sold across the world, and it's now common to see the white, Apple earbuds in the ears of many teenagers and college students. A 2010 Kaiser Family Foundation survey found that ownership of iPods and MP3 players among children has increased from 18 to 76% in just the past 5 years. While these devices are widely used, the risk of music-induced hearing loss (MIHL) from PLDs is dependent on how people choose to use their music players. So, is it really correct to declare MIHL from PLD use to be a public health crisis?

To help answer this question, we can

look at the literature examining PLD use. First, there is a strong understanding that MP3 players can produce high output levels with any type of headphone, ranging from 102–108 dBA with earbuds, and up to 120 dBA with aftermarket earphones.<sup>1,2</sup> Beyond the output levels, we have to ask how people choose to use their PLDs. We know that people tend to listen at higher levels in background noise.<sup>2,3</sup> In the laboratory, we see that the vast majority of people choose levels above 85 dBA when they're in 80 dBA of background noise. In the real world, the effect of noise is especially clear. For example, on a noisy urban college campus, up to 52% of students reported listening at levels that would exceed 100% of their daily noise dose.<sup>4</sup>

In our lab, we're particularly concerned with looking at the actual listening levels of people in the real world. To look at this, we completed a dosimetry study where we connected dosimeters to the PLDs of a group of 18–29-year-olds for a week. Of our study group, 16.7% exceeded a 100% weekly noise dose, and 20.8% exceeded a 50% weekly noise dose from their PLD use alone.<sup>5</sup> We concluded that a small, but substantial group of listeners are putting themselves at risk for hearing loss from their typical PLD use.

So, let's try a little math to see what the actual risk to the population is. For the purposes of this example, several

assumptions must be made to guess at how people will actually use their PLDs. First, we'll assume that 16.7% of users of PLDs will exceed their 100% weekly noise dose with their typical listening activities. Of that group, let's assume that only the most tender ears (8%) will incur a material hearing impairment (MHI). So, 1.2% of the total users of PLDs will incur an MHI. With 342 million iPods and iPhones on the market, let's assume that half of those devices are still in use (about 170 million). So, if 170 million people are using PLDs, and 1.2% of them will incur an MHI, then a total of 2.04 million people will have hearing loss attributable to overuse of PLDs.

While the example above is not the most conservative estimate of hearing loss caused by PLD use, it does show that there is some cause for concern about MIHL from the current listening habits of young people. Certainly, when compared to the 10 million workers in the United States with occupational hearing loss, 2 million people with hearing loss from PLD use is small. Perhaps PLD use won't result in an *epidemic* of hearing loss. However, it's important to remember that hearing loss from music is *entirely preventable*. In industry, there are jobs where exposure to noise may be unavoidable. The choice to listen to music through a PLD is entirely optional – anyone can choose to listen at safe levels.

For many people, their PLD overuse is a

TABLE 1.

% of Volume Control	Maximum listening time per day		
	Earbud	Isolator	Supra-Aural
10–50%	No limit	No limit	No limit
60%	No limit	14 hours	No limit
70%	6 hours	3.4 hours	19 hours
80%	90 minutes	50 minutes	4.6 hours
90%	22 minutes	12 minutes	66 minutes
100%	5 minutes	3 minutes	16 minutes

Recommended listening time as a function of volume control level. These times reflect exposure to 50% noise dose, NIOSH damage-risk criteria. “Isolator” style earphones are earphones that seal the ear canal, blocking out background noise.

case of a lack of knowledge. If we, as audiologists, can provide good information to the public, perhaps we can influence people to make good choices about their listening levels. A good rule of thumb is the 80–90 Rule – you can listen at 80% of the maximum volume for 90 minutes per day safely (see Table 1 for recommended listening times at varying volume control settings). This rule works well for earbuds and cheaper supra-aural earphones. Some earphones that are designed for high outputs (i.e., earphones for DJs, musicians’ monitors) may require shorter listening times or lower volume control settings.

Research in our lab has also shown that we need to target several specific areas in order to affect change in peoples’ listening behaviour. First, when people feel more susceptible to hearing loss, they will tend to listen at lower levels. Interventions must show people that hearing loss can cause a significant impact on their life, and that their actions can cause them to incur that hearing loss. Second, when people feel fewer barriers to listening at lower levels, they choose those lower levels. So, if people know what levels are safe and how to protect themselves, they will be more likely to make better choices for their hearing.

Without a question, the research shows that a small but substantial percentage of

PLD users choose levels that put themselves at increased risk for hearing loss. As audiologists, the burden of informing the public about their sound exposure falls on us. Even if the amount of MIHL from PLD use is not yet at “epidemic” levels, we have the ability and obligation to inform our patients and the public of how to listen safely. Audiologists are in a unique position to be the experts on preventing hearing loss, both occupational and recreational. Whether it’s outreach to local schools or just talking to your patients, you have the opportunity to make a difference. So, let’s take the next step and put what we know into practice!

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Canadian Hearing Report 2013;8(2):43-44.

## GENERAL RECOMMENDATIONS FOR PLD USE

1. 80-90 Rule: You can listen at 80% of the max volume for 90 minutes per day safely. Listening at higher levels gets less time, listening at lower levels gets more time.
2. When listening in noisy environments, choose earphones that block out background noise. Isolating earphones can decrease noise levels in your ear canal, meaning that you don’t have to turn the volume up as high to hear the music.
3. Be aware of your surroundings. When you’re listening to music, it’s harder to hear warning signals, so be sure to use your other senses to know what’s happening around you.
4. If you’re concerned about your hearing, see an audiologist for a hearing evaluation.





# SIN and SNR: The Unavoidable Importance of Maximizing Signal to Noise Ratio

By Richard Einhorn, BA  
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## About the Author

*Richard Einhorn is a modern classical composer. He graduated summa cum laude and Phi Beta Kappa from Columbia University in New York City in 1975, and studied composition and electronic music with Jack Beeson, Vladimir Ussachevsky, and Mario Davidovsky.*

*His most notable work, *Voices of Light*, premiered in 1994, is an oratorio, scored for soloists, chorus, orchestra and a bell. It was inspired by Carl Theodor Dreyer's silent film *The Passion of Joan of Arc* (1928). In the 1980s, he composed many horror and thriller film scores, including *The Prowler* and *Sister, Sister*. He also contributed to the soundtrack of *Liberty! The American Revolution*.*

*Richard lives in New York with his wife, Amy Singer, and their daughter, Miranda.*

As a composer, I have spent thousands of hours at my piano and computer fashioning sounds, harmonies, rhythms, melodies – trying to write down the music I hear in my imagination. I have also worked equally long and hard as a record producer and engineer, carefully adjusting microphones, mixers, equalizers, limiters, and other professional audio gear to capture the performances of great musicians like Glenn Gould and Yo-Yo Ma with the most beautiful sound quality possible.

Hearing is, by far, my primary sense; it is through sound that I have always aligned myself to the world and to my life. Listening closely to music and the sounds around me are, along with my family life, among my greatest pleasures. I remain a “sound person” even today, as I try to cope with several different kinds of very serious hearing losses, including, three years ago, the complete loss of my right ear from Sudden Sensorineural Hearing Loss (Einhorn 2012).<sup>1</sup> By adapting and extending some

common audio recording techniques that I've used for over 40 years, I've come up with what is apparently a somewhat unusual, but practical, approach to hearing assistance. I'm able to compose music without compromise, participate fully in rehearsals, and enjoy both live performances and recordings. Of equal importance, my approach also enables me to hear speech in noise (SIN) well enough in situations where I would be hopelessly deaf if I had to rely simply on my hearing aid. As a result, I am able to participate fully in nearly all of the activities I was involved in before my hearing loss, musical and otherwise.

I certainly realize that many people struggling with their own hearing problems will not achieve the same level of benefit I get from the techniques I use, and the equipment, while simple for me, might be a bit daunting to someone not comfortable with technology. Indeed, there are trade-offs, and no audio technology I know, including standard hearing assistance devices, will “solve”

hearing loss; it will, at best, only help us cope.

All that said, I believe that through the approach I take in my day-to-day hearing assistance, it is often possible to minimize a considerable number of the audio problems that prevent me – and many others – from hearing as well as we possibly could in many difficult situations.

There is no magic: I simply use high quality audio equipment in a way appropriate to the situation. Fortunately, excellent audio equipment useful for hearing assistance is quite affordable today. And if good equipment is properly used, I have found it is often quite possible to significantly improve my ability to comprehend both music and speech.

## DO WHATEVER IT TAKES TO HEAR

I start my approach to hearing assistance with a simple desire:

<sup>1</sup> Briefly, my right ear has severe recruitment with no speech comprehension; my left ear has roughly a 60 db mixed loss. I have moderate to severe tinnitus in both ears.

*I want to hear.*

Unless I hear the world with understanding, my ability to function in it is vastly diminished. In addition, hearing well enough to take pleasure in the sounds around me – from conversations to environmental sounds to music – is crucial to my emotional and psychological well-being.

A fundamental principle follows that informs my entire approach to hearing assistance:

*I will do whatever it takes to hear as well as my ears will allow.*

There is a corollary to this principle:

*I don't care if my hearing assistance is visible, provided it works.*

Apparently, my reasoning about hearing assistance is quite rare. I have been told repeatedly by audiologists, by otologists, by hearing aid designers, and even persons with hearing loss that those of us with hearing impairments care more about hiding our hearing devices than we do about hearing well. That is why hearing aids are so small, for example.

While I realize this attitude is widespread, I do not understand either the emotions or logic behind it. Why would anyone willingly choose to withdraw from conversations, from music – from life! – merely because they are embarrassed about using a hearing device someone else might notice? I've heard a litany of answers to this – hearing aids are stigmatizing; hearing loss is a signifier of old age and decline; a hearing device projects weakness during business meetings – but none of these makes sense to me, especially if, by using a visible hearing device, I can participate, at least partly, in the conversation.

As I see it, my hearing loss is a disability, no more, no less, and it is pointless for me to try to hide it. Just as I would compensate for a serious walking

problem with a wheelchair – and I wouldn't be embarrassed to use it no matter who saw me – I have no compunctions about using whatever is necessary to hear as well as I can.

There's one important caveat, however. To repeat: I don't care if my hearing assistance is visible, *provided it works*.

Naturally, no one would be willing to use visible hearing assistance if it didn't do any good! Unfortunately, for a lot of everyday situations, many common assistive listening devices, including hearing aids, don't, in fact, work very well. The problem, put simply, is signal to noise ratio.

### MAXIMIZE SNR

Because I have spent my life recording, producing, and composing, I can't help but think of the problem of effective hearing assistance as, first of all, an audio problem. I seek out audio equipment and techniques that will provide me with the best possible sound signal for a given situation. Then, I adjust the equipment to compensate for my medical problem – my hearing loss – but I try at all times to preserve sound quality, just as I would if I were recording a great pianist or cellist.

When I speak about sound equipment and techniques that provide “the best possible sound,” I mean an electronic audio signal with, first and foremost, a very high signal to noise ratio (SNR) and by high SNR, I mean that the audio signal must contain a desired signal source – say, a voice or a musical ensemble – that is significantly louder than the background noise. Therefore, the “best possible sound” is achieved by good equipment appropriately used to maximize SNR.<sup>2</sup> I believe high SNR is essential because, based upon my experience, there is simply no audio signal processing available – digital or analog – that can effectively extract a low gain signal from noise except in the most trivially noisy situations. For example, with specially designed headphones, it is quite possible today to achieve noise

cancellation that significantly lowers the gain of, say, loud jet engines. But that is a relatively easy problem for modern technology to solve.

A far more difficult problem than steady-state noise reduction is improving the intelligibility of a specific voice in the presence of speech babble – say, in a restaurant. It is true that, given sophisticated enough digital signal processing (DSP) – for example, via careful equalization and precise multi-band compression, it is possible in certain specific situations to improve SNR, but often that is not enough to make much of a difference to me and to others with hearing loss. We require a significantly higher SNR than people with normal hearing (see, for example, Killion 1997), and despite considerable experience and experimentation with numerous types and brands of DSPs, I have not heard any processing technology that dramatically and reliably improves SNR in difficult situations.

However, if the SNR is already pretty good, DSP properly applied to a sound source can be very effective. Put another way, the best way to create a significant improvement in the SNR is not to attempt to process a very noisy signal. Instead, it is better to *start* by maximizing the SNR, and *then* process.

On a practical level, “maximizing the SNR” means:

1. If the desired sound source is live, place the microphone (or microphones) as close as possible to the source.
2. If the desired sound source is amplified, try to get a direct audio feed from the originating sound system.

### LIVE SOUND SOURCES

For someone with my level of hearing loss, hearing aids are absolutely essential. They provide me with very convenient general-purpose hearing assistance for a wide variety of situations.

<sup>2</sup> Also important for good sound are other factors, including the SNR for the device's electronics and low total harmonic distortion.

In quiet places, they keep my ear and brain stimulated by ensuring that I hear a constant background of room or outdoor ambience.

However, in many other circumstances, I have found that my state-of-the-art hearing aids are ineffective, despite their extraordinarily sophisticated DSP. In restaurants, at parties, and even in private homes with less-than-optimal acoustics, it is often impossible for me to understand speech; none of the included programs help despite careful programming – and re-programming – by my very committed, compassionate, and patient audiologist. Why?

From an audio producer's standpoint, one answer is obvious: the microphones are simply too far away from the desired sound. Because my hearing aid's mics are placed by my ear (I wear a BTE), they are located, under the best circumstances, at least three feet away from the person I am interested in speaking to, and sometimes farther. If I'm in a very noisy environment, then the SNR – even at three feet! – is much too low for signal processing to do much good. Nor will directional mics on my aids help that much: the pattern is too broad. For directional mics to work well at that distance, the mic pattern, in my experience, needs to be fairly close to hyper-cardioid; however, such a tightly focused pattern would often require more user adjustability than is practical with an ear-mounted mic.

The problem I'm describing is, of course, a classic illustration of the inverse square law – the intensity of an audio signal is in inverse proportion to the square of its distance. Therefore, from an acoustical point of view, the simplest way to improve the SNR is simply to place a microphone closer to a desired sound source (see also Killion in Palmer and Seewald, 2006). From an operational standpoint, it is also essential that the

microphone be easily and unobtrusively moved, to point at a new sound source – say, a second companion at a dinner table.

After a lot of research and testing, I determined that a portable rig based around an iPhone could make a high-quality, affordable, and – most importantly – very effective assistive listening system. It may sound odd to confront a serious condition like hearing loss with a very common consumer product, but in fact, smartphones are increasingly used for important medical purposes (NBC News, 2013). There is no intrinsic reason why such ubiquitous and powerful mobile computer technology shouldn't be used proactively for live hearing assistance.

In fact, as an audio device, the iPhone has very good analog to digital (A/D) and digital to analog (D/A) conversion as well as a small but useful suite of DSP available to app developers. This makes it an excellent platform for hearing assistance.<sup>3</sup> I've discussed my iPhone rig in detail elsewhere (Einhorn, 2012). Essentially, it consists of, in addition to an iPhone, a sound app such as SoundAmp R or Fire 2, a good pair of in-ear-style earphones, and a high-quality stereo cardioid microphone called a "Mikey Digital" from Blue Microphones that snaps onto the power jack of the iPhone 4 or 4S.<sup>4</sup>

Each component in this system is important for high performance and was picked to help maximize the SNR in a difficult hearing situation. The in-ear earphones, because they fit snugly in the ear canal, prevent live sound from directly reaching my ears. Therefore, when using the rig, I hear the world almost exclusively through the iPhone.<sup>5</sup> The attached digital stereo cardioid microphone (which bypasses the analog mic circuitry on the iPhone and connects directly to the A/D) provides

not only an ability to focus the sound on what is directly in front of the unit, but also has better quality audio specs – a flatter frequency response and lower harmonic distortion – than is available via the stock iPhone mic (Studio Six Digital web site, accessed 2013). The app – I use either SoundAmpR or FiRe 2 more or less interchangeably – provides a variety of adjustments for attenuation and signal processing, including equalization, limiting, and compression. I can even record what I'm listening to, for replay later.

While the components of my iPhone rig are extremely important, it is just as critical for maximizing SNR to seek the most optimal mic placement that is practical. At restaurants, I place the unit on the table with the mic as close as possible to and pointed directly at the speaker. I have learned how to quickly and unobtrusively move the device when someone else speaks to redirect the microphone. At parties and other social occasions, I hold the iPhone at slightly above waist-level, with the microphone pointed up directly at the person speaking. While this often places the device farther away from a speaker than the mics on my hearing aid, the Mikey Digital provides superior directionality (and possibly, our clothing and bodies somewhat help block and attenuate the ambient sound). At music rehearsals, I sit as close as possible to the musicians and angle the mic so as to enable me to hear a complete blend of the instruments with as little room reverberation as possible. At live concert, plays, and movies, I also try to sit close (the first row, if practical) and point the microphone directly at the stage or at the speaker under the screen.

In these and many other situations where hearing aids would be inadequate, proper use of my iPhone rig enables me to hear with useful clarity and precision. That said, it is by no means perfect.

<sup>3</sup> Similar set ups are likely possible with other kinds of smartphones, but I have not personally tested them.

<sup>4</sup> I have not yet tested the iPhone 5 to see if an external mic will work in this fashion; the iPhone 5 has a different power jack than the 4S, but it is likely that, with an adapter cable, the Mikey Digital or similar microphones can be used.

<sup>5</sup> It is essential to use high quality in-ear or noise-canceling headphones with an assistive listening device of this sort; the Apple earbuds do not provide acceptable sound or isolation.

In order to use the rig properly, it is necessary to remove my hearing aid and wear an in-ear style earphone. While I have tried to use my iPhone rig with a neck loop and my aid's t-coil, I have found that the sound quality of the neck loops I have tried is very poor (inferior bass response, among other problems). Worse, neck loops are susceptible to severe hum if there is poor electrical wiring present, which is often the case in New York City.

Another problem with the iPhone rig is that the user needs some time to adapt to both the occlusion effect and the audible but slight latency (delay) between the actual live sound and the sound as heard via the microphone. Neither occlusion nor latency have troubled me much, but they are noticeable.

Finally, in especially difficult situations – for example, while dining with another couple in a popular New York restaurant, where the noise level can be considerable – even a powerful cardioid microphone picks up too much ambient noise for comfortable, adequate, comprehension.<sup>6</sup>

Despite these issues, however, in very noisy situations – and again, for people with hearing loss, a lot more situations qualify as “very noisy” than they do for people with normal hearing (Killion, 1997) – I have found that my iPhone rig usually enables me to hear comfortably enough to participate in the conversation, whereas a hearing aid simply cannot provide speech comprehension for me under such difficult circumstances.

There are alternative devices, such as those commonly recommended for hearing assistance. However, I have found them to be of very poor quality, very expensive, hard to use, and/or unreliable for this kind of live hearing assistance.

The relatively inexpensive hand-held “pocketalker” styles of sound amplifiers

usually ship with low-quality earphones and inferior microphones. The models I tried also have a very harsh, unpleasant, and fatiguing sound. Unlike the iPhone apps I use, these devices typically have no user-adjustable parameters besides volume control or, in some models, microphone polarity.

Another feature missing from these portable sound amplifiers is limiting. The failure to include an effective “brick wall” limiter can expose the user to painfully loud audio signal levels if the overall db SPL rapidly changes, as it often does in a restaurant or party when people burst into laughter or applaud. Again, some apps on the iPhone enable the user to switch on a limiter; Fire 2, for example, enables the user to easily choose from two different kinds of limiting and two kinds of output compression.

While the FM wireless systems I've tried can sound quite good, and while the technology could be quite useful to me at lectures and classes, they are expensive. In addition, FM systems cannot be used directly with hearing aids, except for one product which costs as least as much as a pair of hearing aids. In addition, I often find the control panels extremely confusing, bristling with features that may be useful in a classroom situation, but are not that important for use at restaurants, parties, business conferences, and other social gatherings.

There are other issues with FM devices. For example, at least one device has a range of 100 feet, which is very useful in a large lecture hall, but can create problems if a friend wears the transmitter at a restaurant. It would be very easy for her to forget to remove the device if she got up from the table, potentially creating very serious or embarrassing privacy concerns.

Some hearing aid manufacturers make proprietary microphones that interconnect either directly, or more typically, via a streamer device to their hearing

aids (and no other manufacturer's). The mics I've tried sound heavily processed and are fatiguing to listen to for extended periods. In addition, I have found them unreliable, often losing their connection with the streamer device.

At present, therefore, while it is not for everyone (especially if there is some discomfort using technology), I have found a properly configured iPhone to be the single most useful device for hearing assistance in situations where my hearing aids are inadequate. I use it nearly every day. When I do use this rig – or some other visible assistive device besides my hearing aids – my friends and colleagues often report that because I am hearing and participating so well, they forget I have a serious hearing impairment. In other words, by using effective hearing assistance, clearly visible though it may be, my hearing loss disappears.

Of course, the same level of dramatic improvement in speech comprehension may not be possible for every loss. However, by making my primary goal the maximization of SNR, not my personal appearance, I have certainly improved my own ability to understand in otherwise intractable ambiances. And no one cares that I'm wearing earphones, because I'm able to hear, follow, and stay connected to the conversation.

## GOING DIRECT

Whenever possible, I try simply to avoid live sound – i.e., sound heard live in an acoustical space or over loudspeakers – in favour of sound provided directly from the amplified sound source to my hearing aids or other assistive devices. Going direct often has the potential to truly maximize SNR.

Before my hearing loss, for example, I used to compose at my computer, which was hooked up to a high-end speaker system. Although my studio is fairly quiet – by New York standards – today, with my reduced ability to resolve signal from noise, the very soft ambient sound in my studio is very disturbing, and the

<sup>6</sup>The Etymotic Companion Mic, a wireless 4-mic-I-listener personal assistive listening system, is the best and most affordable device I am aware of that can help dramatically in such a situation. Unfortunately, it has been discontinued and a newer model is not yet available as of this writing.

audio from these great speakers sounds smeared, muddy, and indistinct. I need to eliminate the sound of my studio and simply hear what I am composing, with absolutely no live room ambience.

Accordingly, I purchased a top-of-the-line custom-fitted single in-ear monitor which featured four proprietary speakers and – because I now have unilateral hearing – sums a stereo signal to mono. I simply plug the in-ear monitor directly into a high end audio interface connected to my computer. It sounds absolutely fantastic and the custom fit makes it comfortable to wear for hours on end. I'm able to hear with precision and I can compose literally without compromise. For example, one recent work has already been performed several times at New York's Metropolitan Museum of Art.

For telephone calls, I use a neck-worn proprietary streamer manufactured by my hearing aid company. It can receive Bluetooth and transmits via near-field technology into my aid. That way, I never hear a phone call through the air. The streamer can be unreliable, refusing to pair with my phone, and I have never successfully paired it to my computers. The sound quality of the streamer-plus-hearing aid is more than adequate for phone calls, but I don't find it acceptable for serious music listening because it is grainy and harsh, with virtually no bass response. For music listening, I take my hearing aid out and use my custom in-ear monitor or a high quality in-ear earphones. The improvement in sound quality over the streamer is dramatic.

For listening to a TV – which is nearly impossible for me now via live room speakers, I use an induction loop system attached to the audio output of the TV and switch my hearing aid to t-coil. I used to use proprietary wireless technology manufactured by my hearing aid company, but I found it unreliable (again, pairing issues) and unpleasant sounding. Induction loop technology, when set up properly, delivers very clear, crisp sound. In fact, my home TV loop

system is often so loud that I have to turn my aid down, a very happy situation for someone with a serious hearing loss!

Induction loops are a critically important technology for people with hearing loss, not only in the home but in many public places, from audiologist's offices to concert halls. Loop advocates such as David Myers, Juliette Sterkens, Linda Remensnyder, Janice Schacter, and myself are seeking to install more loops in the US, as very few public spaces in the US use this important assistive technology. This is unfortunate, because the present infrared (IR) or FM public assistive listening systems are not often properly maintained. Worse, the venues typically provide uncomfortable, poor-sounding headpieces that are so aesthetically undignified that even I am embarrassed to wear them! Furthermore, these headpieces leak sound; whenever I use them, the people near me inevitably complain. A loop system used with a t-coil-equipped hearing aid has none of these problems, and a loop receiver can accommodate people without hearing aids just as well as IR or FM systems can.

Because public assistance can be so inadequate, I often break my rule about using direct audio wherever possible when I go to a live concert, a movie, or a play. Instead, I sit as close as I can and use my iPhone rig, pointing the microphone directly at the stage or the speakers. It's not perfect, but I often get better sound from my rig than I do from the public IR assistive listening system.

## CONCLUSION: DSP IS NO SUBSTITUTE FOR HIGH SNR

I've spent most of my life working with professional audio equipment, and I've played with some great toys – as expensive sound gear is affectionally known by everyone in pro audio. DSP has truly awesome power. I have on my home computer professional spectral audio processing software that is so powerful it can, with the click of a button, eliminate annoying fret squeaks

from a guitar recording, remove loud coughs from a live lecture recording, or clean up a 78 so well that only experts could tell the recording was made in 1940 – all without audible artifacts. Yet as powerful and flexible as this software undeniably is, there is one kind of processing that is nearly impossible to do reliably and well.

If there is too much of the wrong kind of noise – speech babble, in particular – a spectral processor, let alone multi-band compressors, limiters, noise gates, and eq, often cannot effectively extract a speech signal from the background. Even in less extreme circumstances, the DSP available in professional audio can only provide some, not much, improvement.

The same holds true for the DSP in hearing devices, which uses many of the same processes – multi-band compression, limiting, different kinds of eq. While this DSP is just as powerful as it is in pro audio, it, too, has the same set of limits. Given a poor enough signal to noise ratio, especially where the “noise” comprises significant amounts of speech babble, even the most precise and sophisticated DSP algorithms will meet their match. Unfortunately, in a lot of real world environments, people with hearing loss regularly encounter exactly that kind of poor SNR.

DSP, at best, can provide an incremental improvement in SNR when compared to the dramatic improvement obtained by close-mic techniques. This can easily be verified by anyone with normal hearing simply by listening to a conversation recorded outdoors in a typically noisy urban background by a microphone at the ear versus the same event recorded by a microphone a few inches from the sound source. If you manipulate the “ear-microphone” recording using DSP, you may get some improvement in speech to noise comprehension, but what is achieved pales in comparison to the recording made by simply placing a microphone closer. Furthermore, the close-miked, high-SNR signal is much

easier to process to improve SNR. Since often, DSP without good SNR provides only incremental assistance, that leaves only two truly effective approaches for those millions, like myself, who experience serious difficulty in extracting speech from noise. We can try to close-mic the desired sound sources or, whenever possible, we can find ways to provide the hearing devices we're wearing with direct audio input.

I understand that most people with hearing loss do not, at present, understand how to use the equipment available to improve the signal to noise ratio for themselves. I am also very sensitive to the undeniable fact that many people with hearing loss would much prefer to hide their hearing problems if coping with them means they would have to use technology that would be visible to others.

Nevertheless, people can learn, and resistances can change. What cannot change are the chaotic acoustics of our very noisy world. By altering the way those of us with hearing problems approach our hearing assistance, by using high quality equipment and using it properly, it is possible for many of us to dramatically improve our ability to hear in many circumstances. Millions of people can benefit from a higher quality of life if a more effective approach to hearing assistance can be found. We need easier and more affordable devices to use, and we need help in learning how to use them, but the potential of present day audio and hearing technology to improve SNR and thereby improve our hearing, is considerable.

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## Alberto Behar is the Recipient of the 2012 Award of Merit from the Canadian Standards Association (CSA)

Alberto Behar, BA Sc, P.Eng

Alberto Behar is the recipient of the 2012 Award of Merit from the Canadian Standards Association (CSA). The CSA is a not-for-profit membership-based association serving business, industry, government, and consumers in Canada and the global marketplace.

This award, now in its 15th year, has been given out since 1997 to individuals who have served on a CSA Group Committee in the realm of standardization, demonstrated leadership, and have published and presented on related topics.

Alberto is a well-respected engineer, hearing conservationist, and noise control specialist who has spear-headed, and chaired, many noise-related standards committees over the years. He has always been willing to answer questions and to clarify misconceptions that are in the field, especially my own. I

have spent many an hour with Alberto over pie and coffee (much to the detriment of my waist line) trying to grasp the subtle differences between sound pressure and sound intensity and when one should be used over the other.

Alberto has been involved in several influential publications over the years including *Noise Control*- a primer (2000, Singular Publishing Group, with myself and Dr. Margaret Cheesman as authors).

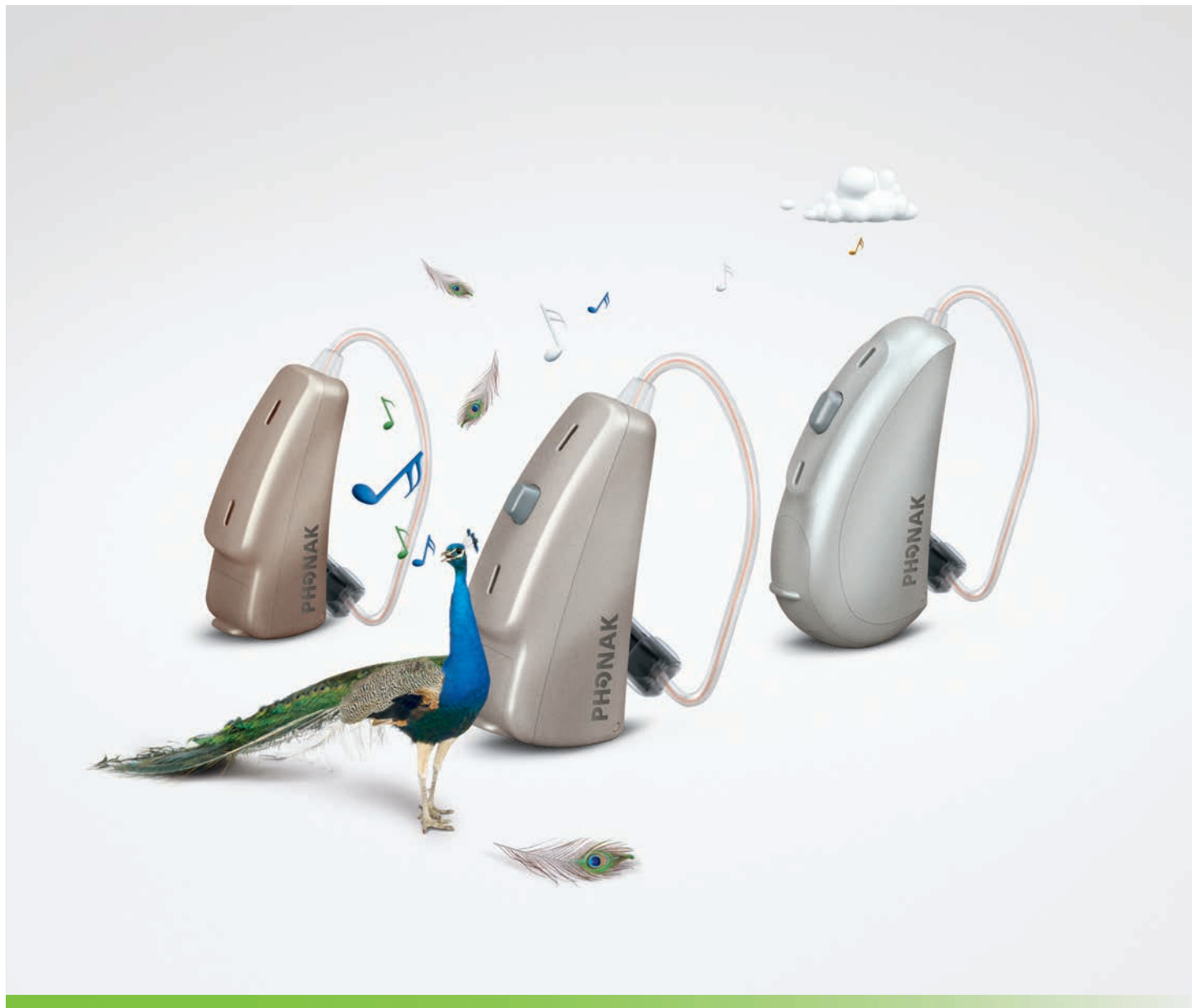
Alberto was a Fulbright Scholar who came to Canada during the military dictatorship era in Argentina, and loved it so much, that he decided to stay. Canada and Ontario Hydro (where he worked in the field of noise control), are beneficiaries of his engineering talents.

During his "retirement", Alberto has worked with Professor Hans Kunov in the acoustics laboratory of the

Department of Biomaterials and Biomedical Engineering at the University of Toronto for many years and is now working with Professor Frank Russo at the Ryerson University in Toronto. Among his other "retirement years" volunteer activities, Alberto is active in the National Hearing Conservation Association (NHCA) in the United States, the Occupational Hearing Association and the Canadian Acoustical Association, and is a columnist "Noise About Noise" for the *Canadian Hearing Report* – the official publication of the Canadian Academy of Audiology.

I can think of no better person to receive the Award of Merit from the Canadian Standards Association. Congratulations Alberto!

*Submitted by Marshall Chasin, AuD*



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