A Research Career Turned Towards a Focus on Hearing Loss

By **Bill Martens**

As a cochlear implant (CI) recipient with a long career in hearing science, I have been asked to share some personal reflections on what has brought me to where I am in my career, particularly since I experienced a sudden and complete single-sided hearing loss in 2018. Let me begin by sharing a bit of my personal story regarding my experiences during the first six months after that unexpected sensorineural hearing loss (apparently due to a viral infection). Throughout those six months, I experienced nearly incapacitating tinnitus, in just my left ear, until I received a cochlear implant (CI) on that same side. Although a standard audiogram revealed normal hearing in my right ear, I did not adjust so well to the unilateral hearing loss, as I continued to have difficulty with spatial sound localisation (the ability to tell which direction sounds are coming from), and I experienced everyday fatigue due to the effort required for my understanding of speech in noise. But there is a silver lining to the cloud: having normal hearing in my right ear enabled me to embark on a program of research directly comparing my auditory experience via electric versus acoustic hearing. Unfortunately, I now am missing the pleasure of hearing binaural recordings, such as that of my own violin sound (shown in the picture), and any other stereophonic music for that matter. Before continuing with that story, I should introduce myself.

Images: Supplied.

A violin performance in an anechoic chamber in which Bill Martens personally captures the binaural sound of a violin at close range using in-ear microphones along with a close-mounted instrument microphone (for use in evaluation of simulated stage acoustics).

Who am I?

I am a perceptual psychologist with more than 40 years of experience in auditory research, but virtually all that work was focussed on the perceptual abilities of normal-hearing listeners. While the many and varied results of that research were reported in technical journal articles ranging in publication dates from 1980 to 2020, my work for the last 5 years has been focussed on the perceptual consequences of hearing loss. As my own sudden hearing loss has given me some first-hand experience of these perceptual consequences, I have embarked on this new direction for my research that is informed by my lived experience as a single-sided deaf (SSD) listener. There's a great deal to say about that, but first I'll recount the initial experiences I had with my CI. To begin with, I will share some text that I sent to friends on 20 February, 2019, the day that my left-ear CI was switched on:

"I'm happy to say that I had immediate good results. As soon as the CI was switched on, the horrible tinnitus in my left ear disappeared! Soon after the first test of its operation, I paired the CI's external processor with my iPhone, and the audiologist called me on my iPhone from another room. I had good 'open-set word recognition' during my first mobile phone call. To test my word recognition, she asked me what colour my shoes were, which I heard clearly enough to repeat the question and respond. I thought that this result was not bad for my first day!"

Thinking back to 2018, I remember a time when I felt devastated by the sudden sensorineural

hearing loss that rendered me Single Sided Deaf (SSD), but it was actually the tinnitus that was the most severe consequence at that time. My tinnitus, which I can characterise as a constant, loud "waterfall-like" rushing sound, happily was greatly reduced every time I powered up the CI I use for my deaf left ear. Before receiving the CI, I tried to deal with some of the difficulties associated with the left-ear hearing loss through the use of a Contralateral Routing of Signals (CROS) hearing aid system, which transmitted sound arriving at the ear-canal entrance of my deaf left ear to a receiver located inside the ear-canal entrance of my normal-hearing (right) ear.

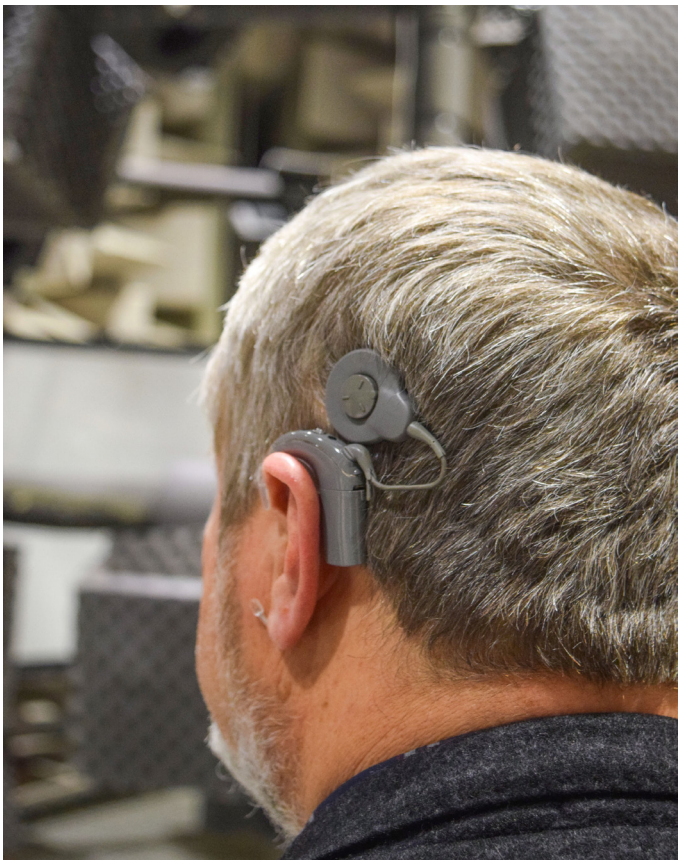
Research on the perceptual consequences of the use of a CROS system?

Interestingly, the CROS arrangement did enable a surprising level of sound localisation performance in laboratory-based studies under conditions in which I had collected experimental data as a normal-hearing binaural listener only a few months before I lost hearing in my left ear. Against my expectations, I still was able to discriminate well between sound sources arriving from front versus rear locations, and also between sound sources arriving from locations above versus below my ear level. The only directional discriminations that were strongly degraded by my hearing loss were between sources that shifted to the left or right. In fact, with my eyes closed, I could clearly discern the spatial path taken by a Latin percussion instrument called a cabasa while a colleague shook it and moved it in a circular pattern within a plane offset to my left (moving up from a frontal starting point, then to the rear, then down below, and returning to the front). Hearing the pattern quite clearly, I would smile with delightful recognition. I was delighted because I could clearly hear the movements of the rattling sound (of the cabasa) even though I couldn't tell whether it was positioned to the left or right side of my head! This particular confusion resulted because the cabasa was always heard to be positioned to my right, regardless of the side on which it was actually positioned. It's also true that powering up the CI for my deaf left ear has enabled some complementary research that has been quite revealing.

Research enabled by unilateral CI use?

While the majority of my earlier research had been focused upon audio signal processing and spatial sound reproduction for normal-hearing listeners, the many years of emphasis on the perception of musical sound and stereophonic imagery have provided a foundation for the follow-up studies of the impact of cochlear implantation on the appreciation of music. My recent studies have looked at the character and quality of the sound of musical instruments presented for comparison between my cybernetic (implanted) left ear and my remaining normal-hearing right ear. The musical instruments sound different to my differently hearing ears, of course, but when two instrument tones are heard as entirely different when they are both presented to more normal-hearing ear, those same tones may be indistinguishable when they are both heard via my CI.

In addition to this, I have focussed on the difficulty of segregating the sound of simultaneously heard musical instruments when listening with a single normal-hearing ear. The loss of my ability to perceive the stereophonic soundstage in reproduced music was truly devasting to me, as I had greatly enjoyed listening to and recording stereophonic music for many years. Having served as the Chair of a world class sound recording program within the Schulich School of Music (McGill University), I had become a highly trained music listener using the same technical ear training programs as those employed to train sound recording students. Five years ago, I embarked upon a program of laboratory research that included an investigation of the effects of auditory training on the spatial hearing abilities of SSD listeners (like me). But perhaps just as interesting as that story are some stories regarding my lived experiences over the last 5 years.



Experiences in the Café?

Although there are many experiences that might be recounted, I focus here on some personal reflections to highlight a few points. If I were to choose always to enjoy my coffee only by myself in the typical café, and never try to converse with another person, the typically loud clatter and surrounding speech babble would not be so objectionable. According to current fashion, many of the cafés I visit have hardwood flooring and most interior surfaces are highly reflecting for the ambient sound. Indeed, the reverberation within such cafés boosts the measurable noise level by as much as 15 to 20 dB. So, since speech intelligibility is known to be dependent on the signal to noise ratio in these reverberant little spaces, it should not be surprising that a deficit would be predicted for patrons with some bilateral hearing loss that can be measured in quiet. But for SSD listeners without much hearing loss in their one good ear, the problem is nonetheless exacerbated by the environmental sound. What I have found here is that most binaural listeners will fail to appreciate that the slight increase in hearing difficulty they experience in a noisy, reverberant café is associated with a great increase in hearing difficulty for SSD listeners. And it's not just the struggle to hear another person's speech that is disappointing for SSD listeners, as for me I am frequently distressed by the resulting fatigue that comes from the extreme effort required to follow such café conversations.

Experiences in the Workplace?

There certainly is some value in being present for group discussions in the workplace, in which I typically would like to participate. I have recently been very happy to be able to report to work in a building that was designed to support interaction and collaboration for groups of researchers like myself. In fact, the "Breakout Room" in which I often find myself on my working days has been retrofit with acoustical treatment (using sound absorbing panels) designed to reduce listening effort for regular conversation. Indeed, these acoustically treated workspaces are much less acoustically hostile than they would have been had they been left untreated. Nonetheless, acoustic communication difficulties can still arise in such spaces during larger meetings or workshops, especially if and when a facilitator directs the participants to work in several small teams to address specific challenges that require group discussion (simultaneously, for each team). When those teams all meet in the same large space, the noise level registered during these dreaded "Breakout Groups" will quickly exceed the limit for what SSD listeners can manage. The main difficulty here is that SSD listeners cannot use the advantage afforded by binaural hearing (i.e., listening with two ears) for selective attention to a particular talker's voice. Perhaps it would be easier for a binaural listener to grasp what this scenario might be like for the SSD listener by imagining what it would be like if the sound of many simultaneous voices were captured using a single mobile phone and then sending

the single-channel "air-mix" of all those voices to be reproduced elsewhere for presentation at a single ear. Now, if the talker of interest were to use a Mickey Mouse or Donald Duck voice, it might be easier to segregate that voice from the mix, but segregation would be much easier were the voices to be distributed across a spatially extended auditory scene (in binaural listening).

Another potential surprise for talkers with normal binaural hearing is the choice to speak directly into my ear at very close range gives them only a 50% chance of their voice being heard at all. If within a "Breakout Group" scenario I wear no hearing assistance gear on either ear, the talker won't be able to tell which is my deaf ear. If they guess wrongly, the sound of the talker's voice near my deaf ear will be undetectable (rather than merely unintelligible). Occasionally, I might seem to be consciously choosing to ignore the talker at my ear.

Experiences in the Clinic?

While there are those who have been single-sided deaf (SSD) from birth, I have very little personal experience with such clients, so my recent focus has been less upon the hearing difficulties of those who are congenitally SSD, as instead I am focussed more upon the social and emotional consequences for those listeners who (like me) have experienced a sudden single-sided hearing loss. While it is generally acknowledged that SSD listeners have difficulty understanding speech in noisy environments, especially in group conversations, it should not be surprising to learn of the strong negative emotional impact that SSD can have. Indeed, there is potential for feelings of confusion and social ineptitude, which could lead to social isolation and the associated loneliness. Unsurprisingly, their clinical treatment journey often results in SSD clients feeling neglected or ignored, due to the lack of adequate treatment options available via health services. So, there are problems here that need solutions, since in the clinical treatment journey for SSD clients, there is poor consensus on the best path that should be followed to achieve an improved quality of life, in terms of physical, social, and emotional well-being. The search for these solutions begins with a recognition of the unmet needs of these clients, and I hope to participate in the promotion of better awareness of these needs and how some better solutions might work for them. I have proposed programs of training like those that aided me in dealing with some of my sound localisation difficulties. I hope to continue in these efforts, so I'll end by encouraging my readers to please watch this space.

In Conclusion

The above image presents me as one who currently plays violin, recording its sound in an anechoic chamber, and so I would bring this article to a close by noting the following: Honestly, it was a devastating loss that life dealt me in 2018, with so many stereophonic sound mixes waiting to be artfully turned out, which certainly would require two ears to complete properly (as I can only imagine in my "mind's ear" the sonic results which I can no longer craft through my single-ear listening). But that bit about the "silver lining" that I wrote earlier in this article was not just the politically correct statement that it might have seemed. Again, honestly, I regard the hearing loss as a gift, as I am poised to make lemonade from the lemons that life has dealt me.