

Journey into Silence

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Political activist and author Helen Keller (1880-1968) was no stranger to adversity. At age 19 months, she lost both her sight and hearing to meningitis or scarlet fever. She went on to become the first known blind and deaf college graduate, earning her Bachelor of Arts degree from Radcliff in 1904. Her oft-quoted comment on the loss of two senses is both succinct and profound: "Blindness separates us from things but deafness separates us from people."

I want to share my feelings about hearing loss with this small community that includes the preponderance of my friends. I also want to discuss this issue with that band of technical practitioners who might be able to help medical science prevent or reverse this sensory loss in others who will follow me.

My battle with diminished hearing is longstanding; it began in my early twenties. An act of personal stupidity rendered both of my ears totally useless for several months. Good fortune was mine, and my hearing slowly returned to normal (save an occasional bit of tinnitus). In fact, for most of my life my hearing has been quite acute and discriminating. I took great pleasure from listening to music and always sought superior reproduction equipment, because I could hear the difference that better technology, particularly speaker technology, provided.

I built my first (monophonic) high-fidelity amplifier and speaker system while in college. Thereafter, my stereo listening system was always state of the art and upgraded quite regularly. This always seemed a good investment in the quality of life. Today, the cheapest AM radio is a more-than-adequate source of sound for the remaining discrimination of my ears.

Good hearing was a major asset in my professional work. Understanding how and why a structure vibrates is often aided by listening to and touching the thing you will need to measure or model. The mathematics always takes on more meaning when it reflects characteristics personally sensed from the structure with hand, eye and ear; I can no longer do that.

In my early college days, I developed an interest in firearms and target shooting. My fiancé gave me a bolt-action rifle built upon a military-surplus 1917 Enfield action and firing the powerful .30-06 cartridge. Her father, my friend and an old "peacetime Army" marksman, and I traveled to the Blue Trail Range to sight the rifle in. We enjoyed a half hour's sunny top-down New England summer ride in my mother's 1961 Oldsmobile convertible. Life was good until we arrived at the range and I discovered I

had forgotten my new Clark hearing protectors. In that era free of the now-ubiquitous liability lawsuit, the range was not required to demand shooters wear eye and hearing protection, nor did they rent such equipment. They simply sold me some targets, gave us brief "rules of the range" instruction and assigned us to a shooting point on the 100-yard range. Sid had his field-proven ear plugs with him; I stuffed some tissue paper into my ears. We moved out onto the firing line.

The 100-yard range was an unsophisticated outdoor facility under control of a range officer who issued instructions through a very loud PA system. The firing line was a concrete pad with wooden seats and bench firing points every eight to 10 feet; it was covered by a flat roof of corrugated steel. About every 15 minutes the range officer would command a "cease fire" and, after assuring all rifles were unloaded and open, allow shooters to walk forward 300 feet to hang new targets on the wooden frames in front of a substantial earthen backstop.

We took our designated place between two serious riflemen firing magnum-caliber weapons. There were about a dozen total shooters on the line, all firing serious center-fire calibers. In short, I took position between two nearly parallel highly reflective surfaces bounding a dozen loud impulsive sound sources without effective ear protection and prepared to spend some 'quality' time; it was a very hostile acoustic environment. We spent about two hours tuning the rifle and enjoying the result. About a hundred or so rounds later we exited the range and returned to the car. I was totally unaware that my hearing and life itself had just changed.

I was enjoying the bright sunshine and pleasant breeze as I piloted our sleek 4200-pound, 325-horsepower ride toward home. My reverie was interrupted by Sid slapping my right thigh several times to get my attention. Surprised, I turned toward him and immediately thought he was clowning around, although this would have been most uncharacteristic. He was gesturing toward the radio and apparently shouting something, though I heard nothing. Then I realized he was demanding I turn the radio down; it was too loud. I didn't know the radio was on. I hadn't heard a word he said. In a heartbeat, I realized I didn't even hear the rush of the wind as we motored grandly in the open car at 60 mph. I simply looked at him and said, "I can't hear anything." And I couldn't – not even the sound of my own voice. It was a very sobering moment.

Of course I hoped this was a temporary

condition. But hours turned into days without improvement; the only thing I heard were whistles and ringing artifacts generated within my own head. I was totally without hearing. I saw our family physician and then an otolaryngologist. I was informed that I *might* recover *some* amount of hearing, but there was absolutely no guarantee. I learned that I had damaged my cochlea, the cornucopia-shaped, three-chambered, fluid-filled sound sensor of the inner ear. The damage probably included a combination of breaking off or uprooting some fine hair-like cilia and inflaming the nerves their roots excited. While the nerve inflammation might subside, leading to hearing recovery, ripping out or breaking cilia produces a permanent hearing loss.

Several depressing weeks passed with no change; I was isolated. That is the immediate effect of deafness – you are suddenly trapped alone and apart from all other human beings. Being unable to receive spoken communication from others is frightening. Realizing that this separation is permanent is terrifying. Then a miraculous thing happened, I began to sense some sound again. At first, it was not enough to allow me to understand speech, or to identify from *where* the sound emanated. Bit by bit, my ability to process spoken language returned, in part because I was learning to infer and interpolate for the words or phrases that I missed hearing clearly using surrounding words and the speaker's expression and gestures.

At first, I began to understand male speech while the higher-pitched female voice remained unfathomable. Then some higher frequency sensitivity returned. I found it very discordant to hear overtones without a related fundamental note. This caused me to avoid music in general and whistling in particular for well over a year. I continued to enjoy a slow but progressive remission of symptoms, and much of my hearing returned to near normal. Like many exposed to excessive percussive sound, I suffered a permanent "4 kHz notch" in my hearing. I had the exceptional good fortune to regain a functional level of aural acuity. I was again able to function as a member of the human race, not merely a detached observer of it.

In the blink of an eye, 20 years passed. I was now in my mid-forties, the father of two daughters and living in my fourth house with my second wife. I worked for myself in my home basement office/laboratory/workshop. I had previously enjoyed working as a helicopter dynamics engineer, an automotive structural analyst, a signal processing applications engineer and the president

of a small instrumentation manufacturer. Now I worked alone and performed various consulting activities including preliminary product design, prototyping, marketing and documentation for various firms with interest in vibration analysis and control. I was listening to a favorite FM station while typing on my Macintosh when a strange sensation washed over me. It took a second for me to realize that my right ear was no longer hearing anything and that I was suddenly dizzy. It was just as though a switch had been thrown in my head. While the left ear still heard normally, the right had shut down completely in an instant. There was no pain involved with this transition. I was now a monophonic animal with no ability to discern the direction from which a sound came.

Over the next few days I had several medical exams. Our family physician referred me to a local otolaryngologist who, in turn, sent me on to a big-city inner-ear specialist. I was treated to hearing tests, blood tests, head X-rays, and a CAT scan. This latter imaging was relatively new and shockingly expensive. But it was deemed essential in this case, since the “switch-like” change in hearing with accompanying loss of balance was a strong indication of a potential tumor. Of course, I was very relieved to hear that there was no tumor growing inside my head. But I was disappointed that a definitive diagnosis was not forthcoming. I was told that this was *possibly* a “vascular event” akin to a mini-stroke in the inner ear, but there was no way to substantiate this hypothesis. Further, there was no indicated course of treatment and no way to predict if any of that ear’s performance might return. Most frighteningly, there was no way to forecast if the *other* ear might suffer a similar event, and no prescribed course of treatment or behavior to avoid this possibility.

This second event was quite mysterious. There was no percussive noise exposure involved; I hadn’t fired a firearm in nearly a decade. However, this was not the only time my cranium was subjected to a lot of medical imaging and conjecture as well as a bit of mystery. Entering my mid-thirties I fell victim to *cluster headaches*, a nasty form of vascular headache related to migraines, but far more intense, of shorter duration, occurring multiple times-per-day for a month or two. For those of you unfamiliar with them, these headaches are really painful and debilitating; sufferers have been known to commit suicide in desperation. When I got my first one I thought it was a stroke. The throbbing pain was concentrated on the left side of my head; the left side of my face sagged and tears flowed from my left eye. For the next 10 years I would have two to three of these every day during the months of August and February. The diagnosis was a “good news – bad news” kind of thing. Good, in that a stroke or tumor was eliminated. Bad, in that very little is really known about the cause of cluster headaches, and medication was typically ineffective at re-

lieving the symptoms. My physicians could only assure me that I would outgrow them in my early forties, which I did. But no one was subsequently able to tell me if there was any relationship between having vascular headaches and suffering a “vascular event” that destroyed the hearing/balance of an ear. Nor could they tell me if the shooting indiscretion of my youth had predisposed me to either occurrence. Many aspects of the human body and its degradation simply remain mysterious.

My sense of balance returned relatively quickly (or my body found new ways to use the remaining dynamic input available to determine equilibrium). Within two weeks I was able to navigate without fear of falling. However, I remained monophonic for nearly a year. It took several more for any semblance of binaural hearing to return. In the interim, my life took several turns, including a really unpleasant divorce, and a couple of less-than-satisfactory jobs. I was 54 when I took the second of these. My hearing had returned to a functionally useful level. While my hearing acuity was less than typical for age, I had regained source-locating ability and an acceptable semblance of normal speech interpretability. However, the new job required that I fly coast-to-coast every month. I soon noted that my hearing “took a hit” whenever I spent the day on transcontinental jets. For the first few years, this flying-related hearing loss seemed temporary, lasting only a few days. Then I began to realize that the damage was actually cumulative and nonreversing. I had reached a point where conducting product-application lectures (a significant part of my job) was a problem; I could no longer hear student questions clearly. Management was not at all sympathetic to this health issue. When I finally refused to fly every month, I was sacked in a corporate layoff along with several other “expensive” older folks.

Since the 21st century market demand for 60-odd-year-old engineers is modest, at best, I elected to return to private practice working from my home. This was a tough start-up, forcing a lot of belt-tightening. One of the things I had to give up for several years was medical insurance. While working without an insurance net, I had a second right-ear shut-down event that rendered me monophonic again. While I sought medical aid, I was restricted in what I could afford to seek.

I was subsequently fortunate in many ways. My right-side hearing partially returned over the course of a year. A business upturn enabled me to enroll in an HMO. A *third* right ear “switch-off” event in 2005 sent me to the young primary-care physician whose careful diagnostic testing saved me from having a heart attack. While my right ear remains useless, and the left now loses acuity daily, the sudden hearing loss actually led me to care that spared me from a vascular event of the most serious type. Joining that HMO saved me from a “killer”

fiscal event as well; they paid the lion’s share of the six-figure bill for my sextuple bypass surgery.

Having a close personal brush with a life-threatening medical problem is an eye-opener. I now take personal health monitoring and maintenance far more seriously than ever before. My weekly routine includes three visits to the “geriatric gymnasium” to torture myself on treadmill, stationary bicycle and weight machine, and I treat these visits as sacrosanct. I am on a first-name basis with *several* physicians, and I visit them all quite regularly. I have also stumbled down many strange avenues in search of a solution to my eroding hearing. None has shown me a cure.

I now make every effort to treat my hearing carefully. I am acutely aware of my atypical reaction to loud situations – I lose a little hearing whenever I am exposed to a loud circumstance such as a boisterous party or loud concert. If I exit the situation immediately, the loss is minimal and temporary. Prudence has dictated a number of socially awkward exits that I regret, but they were absolutely necessary to preserve what little remaining hearing I have. I’m afraid I am on my way to a very solitary place, and I have no desire to hasten that journey. Few hearing-competent people have any concept of the isolation of deafness or the concern it causes. I cannot count the number of times a cashier, waitress or secretary has responded to my saying something like, “I’m sorry, I don’t hear very well,” with a glib, “Oh, that’s OK.” I used to upset such young people by responding with, “No, damn it, there is nothing OK about being deaf!” Now I have just become a quieter old curmudgeon and simply accept their inappropriate response with a nod and a sneer.

I now find my ability to understand speech is much better over a telephone than in face-to-face conversation. The earpiece masks out background noise at my location, and the phone’s narrow bandwidth approximately matches that of my injured ear. Digital readouts on television sets make it easy to monitor the erosion of your hearing – you simply note the day-by-day increase in the volume setting you need to understand the evening news. It will eventually become necessary to learn how to invoke the closed-captioning option your TV set provides. At this point you will learn how poorly supported the real-time needs of the hearing-impaired community really are. You will also come face to face with the limited vocabulary and poor spelling of the typical network transcriber-cum-typist. You will also learn that digital cable service does not include closed captions; you must use the support of the originating RF broadcasters and your television receiver. This means connecting the set to the service box with a single RF cable, *not* an HDMI cable or a bank of five RCA-to-RCA cables.

I’m hoping a few very bright young folks in our readership will recognize a place where they can make a real contribution

to humanity and acoustics; let me identify the problem for you. Think how difficult it is to understand the multiple functions of the cochlea; it is only available for study by dissecting someone who no longer needs his. Even the chemical and geometric arrangement remains a mystery. Did you know that each of the three spiral chambers of this mysterious sensor contains a *measurably different* liquid and no one knows why they are different? A physician cannot study a live cochlea nor observe its response to sonic inputs. While he or she can measure the dynamic pressure *input* exciting a human's hearing sensor, the *output* of this organ is currently elusive and immeasurable.

In 2010, you will not meet anyone who understands how the vibration of the *tympanum* is encoded as electrochemical pulses traveling through the *eighth nerve* to the brain. We need to answer this question to understand the cochlea and hearing.


Wouldn't it be a wonderful experience to show a team of physicians how to measure and understand the nervous output of a living cochlea without injuring its host? Imagine their wonder and gratitude if you were able to directly sense the nervous

system's response nonintrusively and mathematically relate that output to the measured sound pressure monitored within the outer ear? Hearing acuity could suddenly be characterized by simple frequency response and coherence functions! Can you envision a single more important contribution to medicine by an acoustician than that? It is my hope that one of our readers might find the way to decipher aural output from an array of encephalographic scalp electrodes, or by demodulating a light beam reflected from an eye, or by detecting microwave emission using a small antenna inserted into the nasal cavity, or by doing something else equally improbable in the present.

I am suggesting a very basic area of research into one of the most baffling functions of the human body. I'm defining a technical problem screaming for attack by teams of bright, inquisitive and experimental people who have no fear of failure or of crossing disciplines in their search for truth. I would be very proud to know that my challenge excited that person who will eventually provide a breakthrough in the understanding of the human ear.

Aging may polish and refine a bottle of fine

wine or a side of well-marbled beef; it has almost the diametrically opposite effect upon a human being. Most of us lose function and grace as we pass into our final years.

There is a certain irony about the "finishing" of the two old friends who routinely produce this magazine. The top guy, a runner for 28 years, has trouble sufficiently vibrating the air he expels to produce speech; his second banana, a recently reformed couch potato, can barely detect the resulting sound! While Jack has triumphed over an extremely rare laryngeal cancer, and I am rapidly losing the last vestige of my hearing, we continue to enjoy a long-standing joke. When I call S&V after normal working hours, I know who will answer the phone. A soft raspy voice says, "Sound and Vibration," to which I reply, "... not much sound!" This is met with, "Yeah, but I'm vibrating like crazy!" And two old guys share a laugh. Crazy or not, old habits and friendships die hard. And despite our limitations, we're still having fun forging new issues of *Sound & Vibration*. 

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