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Centring Surprises in Asymmetrical Listeners

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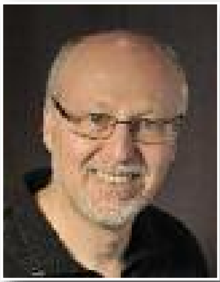

I recently received a great honour. I was informed that I was being audited by my provincial government program for prescribing too many binaural hearing aids, and that this was "way above the rate of binaural hearing aid prescription by my colleagues." Although this did take a fair amount of paperwork and the pulling of almost 200 files it did give me the opportunity to perform a self-review, and this is always a good thing. In fact, many provincial colleges that regulate the profession of audiology do just this, and I have always found this to be a constructive and often enlightening endeavour.

Of the 193 files pulled, indeed the vast majority were for binaural fittings. There were 6 that were "suspect" in the sense that I really didn't know (and indeed indicated this on the hearing aid evaluation form) whether they would benefit from two hearing aids instead of one. My clinical intuition was "let's try it and you always have the option of returning one, or both, at the end of a trial period." We can only predict so much in our clinics. The hearing aid wearer just needs to wear it outside and experience amplified life for several weeks.

Several issues ago, in the *Canadian Hearing Report*, Dr. Wayne Staab was gracious enough to give his perspective on the more general question of "what percentage of people who need hearing aids, actually get them." His response was based on the concept of "hurt." Was a person bothered by their hearing loss and is this not fully predictable from their audiometric measurement? Dr. Staab, and indeed most of the clinicians I know, stated that it was fine to recommend amplification for someone who had near normal audiometric thresholds, if they experienced communication difficulty, especially in adverse listening environments. This discussion can be extended further to the fitting of binaural hearing aids – I would argue that a binaural fitting is best unless it's not. And the way we know that it's "not" is because the hearing aid wearer feels that there is no benefit from having the hearing aid(s) after trying it in real life environments.

Audiometry is such a gross and simplistic measure yet we rely on it to such a great extent. With the advent of other tests that purport to assess audiometric function, rather than audiometric sensitivity, we are gaining a new appreciation of how to deal with our hard of hearing clients. For example, otoacoustic emission measures become pathological long before one observes and audiometric pure tone threshold shift. In some sense, by the time that one observes a measureable hearing loss using pure tone threshold testing, a lot of cochlear damage has already occurred. And with long standing cochlear damage we are now seeing more central changes that diminishes an individual's communication ability.

So, should our clinical decision to recommend one, two, or no hearing aids be based on audiometric pure tone thresholds – probably not, but more often than not, regulators have nothing more to go on. It is of course more complex than this. For example, is a fitting of two hearing aids a truly binaural fitting or are there more central processing issues that limit the full benefit of binaural summation, phase integration, and synthesis? It is therefore our responsibility as a profession to update our regulators (who have a difficult enough job as is) with current technology, assessment techniques, and clinical philosophy. Preferred Practice Guidelines (or PPGs) are statements of minimal care. Perhaps it's time to have "Optimal Practice Guidelines" as well?

In this issue of the *Canadian Hearing Report* we are pleased to present you with an article by Christopher Schweitzer and Christopher McCarron about some interesting phenomena with asymmetrical listeners that touch on some of these issues. Alberto Behar, in his column Noise about Noise questions the usefulness of audiometric testing, and some of the issues surrounding this. And Calvin Staples in From the Blogs has selected several blog entries from HearingHealthMatters.org about issues surrounding ethics.

Peter Stelmacovich, in his column The Deafened Audiologist continues with the theme that more may be better. We shouldn't restrict what we are able to offer our clients and this includes directional microphones, wireless options, and the use of assistive listening devices such as FM systems – more may be better. For any one client, this may not be the case, but unless they are provided with the opportunity to experience the options that our field can offer, there is no way of predicting who requires what in an apriori fashion.

Gael Hannan continues with the Happy HoH and talks about the many things that a hard of hearing person needs to worry about. And in this issue we have a guest columnist for All Things Central – Irene Hoshko discussed central auditory processing assessment with children in 2012 and where we are now. In Spotlight on Science Lendra Friesen and Samidha Joglekar update us on the Oral vs. Intratympanic Steroid Treatment for Sudden Sensorineural Hearing Loss. From time to time we see clients who wake up with a sudden, unexplained unilateral hearing loss (or even a suddenly deafened client – both of whom stretch our clinical and counselling experience. This is a nice overview of the current state of affairs and what we should be telling our clients.

There is a lot to think about in this issue of the *Canadian Hearing Report* – something to cuddle up with in front of a roaring fire, or at least a fluffy armchair. I hope you are enjoying your fall, and for those of you whom attended the past Canadian Academy of Audiology convention in Ottawa, I hope you also enjoyed meeting new colleagues and re-connecting with old classmates.

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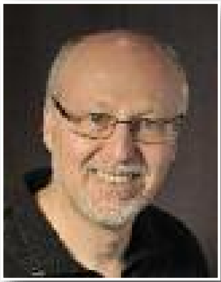

J'ai récemment reçu un grand honneur. On m'a informé que je faisais l'objet d'une vérification par le programme du gouvernement provincial pour avoir prescris beaucoup d'appareils auditifs binauraux, ce qui était " bien au-delà du taux des prescriptions des appareils auditifs binauraux de mes collègues." Même si ça a pris un temps appréciable et l'extraction de presque 200 dossiers, ceci m'a donné l'opportunité de procéder à une auto-révision, ce qui est toujours une bonne chose. En fait, plusieurs collèges provinciaux qui règlementent la profession de l'audiologie font justement ça, ce que j'ai toujours trouvé très constructif et souvent un effort instructif.

Des 193 dossiers tirés, à ne pas en douter, la vaste majorité étaient pour des ajustements binauraux. 6 d'entre eux étaient "suspect" dans le sens que réellement je ne savais pas (et en fait indiqué dans le formulaire dévaluation de l'appareil auditif) si la personne allait bénéficier de deux appareils auditifs au lieu d'un seul. Mon intuition clinique était "on va l'essayer et vous avez toujours l'option de restituer un ou les deux, à la fin de la période d'essai." Nous ne pouvons pas tout prédire dans nos cabinets. Le porteur de l'appareil auditif a juste besoin de le porter à l'extérieur et faire l'expérience de la vie amplifiée pendant quelques semaines.

Dans des numéros précédents de *la revue canadienne d'audition*, Dr Wayne Staab nous avaient donné sa perspective autour de la question plus générale "des personnes qui ont besoin d'appareils auditifs, quel pourcentage d'entre elles effectivement les obtiennent." Sa réponse était basée sur le concept de "préjudice." Est-ce que la personne était dérangée par sa perte auditive et que ceci ne serait prévisible si on regarde de près ses mesures audiométriques ? Dr. Staab, et en fait la plupart des cliniciens que je connaisse, ont déclaré que c'était normal de recommander l'amplification à quelqu'un dont les seuils audiométriques étaient normaux, s'il a des difficultés de communications, spécialement dans des environnements d'écoute défavorables. Cette discussion peut aller plus loin, aux ajustements des appareils auditifs binauraux – Je plaiderai que l'ajustement binaural est meilleur à moins qu'il ne le soit pas. Et on sait qu'il ne l'est pas parce que le porteur de l'appareil auditif sent qu'il n'y a pas d'avantages à porter des appareils auditifs après l'avoir essayé dans un environnement de vie réelle.

L'audiométrie est une mesure tellement grossière et simpliste mais on compte beaucoup dessus. Avec l'avènement d'autres tests qui sont supposés évaluer la fonction audiométrique, nous avons plus de mérite pour faire face à nos clients malentendants. Par exemple, les mesures de l'émission otoacoustique sont pathologiques bien avant qu'on puisse les observer et les seuils du son pur audiométrique changent. Dans un sens, le temps qu'on observe une perte auditive mesurée par le son pur, bien des dommages à la cochlée se sont déjà produits. Et avec un dommage continu à la cochlée, nous voyons maintenant plus de changements centraux qui diminuent la capacité de communication de la personne.

Alors, doit on baser notre décision clinique de recommander un ou deux ou aucun appareils auditifs sur des seuils audiométriques de pure son – probablement non, mais plus souvent que pas, les régulateurs n'ont pas autre chose sur quoi se baser. C'est bien sûr plus compliqué que ça. Par exemple, est ce que l'ajustement de deux appareils auditifs est un vrai ajustement binaural ou y a t il d'autres enjeux de traitements plus centraux qui limitent l'avantage total de la sommation binaurale, la phase d'intégration, et la synthèse ? Il est par conséquent notre responsabilité comme profession de mettre à jour nos régulateurs (qui ont un travail assez difficile déjà) avec la technologie actuelle, les techniques d'évaluation et la philosophie clinique. Les lignes directrices préférées sont des états de soins minimes. Peut-être, est-il temps d'avoir "Des lignes directrices de pratiques optimales" aussi ?

Dans ce numéro de *La revue Canadienne d'audiologie*, nous avons le plaisir de vous présenter un article de Christopher Schweitzer et Christopher McCarron concernant des phénomènes assez intéressants avec des auditeurs asymétriques qui touchent à certains de ces enjeux. Alberto Behar, dans sa colonne Noise about Noise se pose des questions sur l'utilité des tests audiométriques, et certains des enjeux entourant cette question. Et Calvin Staples dans From the Blogs a sélectionné plusieurs entrées sur le blog de HearingHealthMatters.org autour des enjeux éthiques.

Peter Stelmacovich, dans sa colonne The deafened Audiologist continue sur le thème que plus peut être meilleur. Nous ne devrions pas restreindre ce que nous pouvons offrir à nos clients parmi les microphones directionnels, les options sans fil, et l'utilisation des appareils d'amplification sonore comme les systèmes FM– plus peut être mieux. Il se peut que ce ne soit pas le cas pour

Marshall Chasin Receives Award

Congratulations to *Canadian Hearing Report*'s Editor-in-Chief Dr. Marshall Chasin who was a recipient of the 2012 Queen Elizabeth II Diamond Jubilee Medal for his volunteer services with the National Youth Orchestra of Canada. The award was presented by His Excellency the Right Honourable David Johnston, Governor General of Canada.

tout client, mais à moins qu'on leur fournisse l'opportunité d'expérimenter les options que notre domaine peut leur offrir, il n'y a aucun moyen de prédire qui exige quoi.

Gael Hannan continue avec le Happy HoH et nous parle des multitudes de choses dont une personne malentendante devrait s'inquiéter. Et dans ce numéro, nous avons une chroniqueuse invitée pour All Things Central – Irene Hoshko se penche sur les évaluations des traitements auditifs centraux chez les enfants en 2012 et où nous en sommes maintenant. Dans Spotlight on Science, Lendra Friesen et Samidha Joglekar nous font une mise à jour du traitement oral de la perte soudaine d'audition neurosensorielle versus les stéroïdes intra tympaniques. De temps en temps, nous avons des clients qui se réveillent avec une perte auditive unilatérale soudaine et inexplicable (ou même un client avec une surdité soudaine) et c'est justement ces clients qui étirent à la fois notre expérience clinique et de counseling. C'est un beau survol de la situation courante et ce que nous devrions dire à nos clients.

Ce numéro de *la revue canadienne d'audition* nous fait réfléchir sur plusieurs thématiques, bien au chaud devant un feu rugissant, ou au moins dans un fauteuil pelucheux. J'espère que vous savourez votre automne, et pour ceux d'entre vous qui avez assisté au dernier congrès de l'académie canadienne d'audiologie à Ottawa, j'espère que vous avez aussi rencontré de nouveaux collègues et reconnecté avec d'anciens camarades de classes.

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By Calvin Staples, MSc
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September is here and for many across the country that means the end of summer and back to school. I teach professional ethics for hearing health care at Conestoga College so I too am back to school. The course outlines the scope of practice and code of conduct for the hearing instrument specialist. I am continually trying to show the students case-based examples with moral and ethical implications. I am sure the argument could be made that every decision we make in our clinical practices has a moral or ethical consequence, as we work in health care. As audiologists, we pride ourselves in being the "best hearing health care providers" and we are bound to serve our patient population with the highest integrity. And for the most part I think we meet this criteria. I always express to my students that the moment the lines become grey that should be a sign that your decision-making skills have been compromised. Janet Clarke once told me that we should practice like our picture will be on the front-page of the paper. I think there is some real merit in that statement and I decided this blog summary would focus on ethics. I really like these blogs. I hope the readers and you both feel the same. The first one is a real doozie, thanks for the blog Holly!

BUT THAT WOULD STILL BE WRONG: MORAL AND ETHICAL DECISIONS IN HEARING HEALTH CARE

By Holly Hosford-Dunn

A few weeks ago, Hearing Economics ventured into Ethical territory – not a place economists like to visit. Nevertheless, we're back in that quagmire of bad decisions, their effects on practices, and whether they are moral temptations or true ethical dilemmas. The latter surface when there is a clash between two or more moral beliefs, referred to as central values. This post suggests that "Big" carries ethical, if not moral, weight in health care.

CENTRAL VALUE: SIZE MATTERS

Mayo Clinic agreed last week to pay $1.26 million to the federal government for *"knowingly billing Medicare, Medicaid, and other government healthcare programs for nonexistent pathology work."* Mayo Clinic has long been the Gold Standard of American health care. It's a huge organization that covers all specialties. Should our Gold Standard be tarnished just because it has problems in its billing department? Don't we all?

Comment: We've seen banks and companies deemed Too Big to Fail and spared the axe. Now it seems that some health care organizations are Too Big to be Unethical. I'm just guessing that if I got caught billing government agencies for nonexistent services and hearing aids, the State of Arizona would yank my license and never give it back (they're like that). Further, the Government would hit me up with fines that were proportionally huge compared to the measly $1mil+ bill handed to Mayo. I would be out of business, unable to make a living professionally, and out of funds. By contrast, it's business as usual at Mayo except for a one-time dip into petty cash.

Some wit noted that "Corporations are People Too… They're Just Bigger People." You could add to that: "Bigger People Can Assume Bigger Risk." I qualified my projected demise in the previous paragraph by saying *"if I got caught."* Small folks have to think long and hard before doing something immoral like stealing, given the consequences of getting caught. Not so much for Big Mayo, where the odds were good that they wouldn't get caught and the penalties for getting caught were small and fleeting. Mayo took the risk and they're probably still ahead, especially since they don't have to acknowledge blame as part of the payment. This is not an ethical dilemma for Mayo. Not only does this fall in the realm of moral temptation, it falls into a special Big People category I'm calling "Calculated Moral Temptation."

Interestingly, it's the economic view that is not clear cut in the Mayo case, where the economic cost is much larger than the accounting cost of the $1.26 million penalty. This is where the ethical dilemma lurks. If I go out of business because I succumb to moral temptation, there is no harm to the community, other businesses, or most people with hearing loss. The case is simple. But, if Mayo takes the wrong moral path and goes under, the town of Rochester, MN, goes with it. An entire town loses its economic base, professionals lose their jobs, families are displaced, important research is threatened, severely ill patients' lives hang in the balance, and credibility of health care delivery in America suffers. Who wants to be the one who signs off on *that* order? You'd have to go into hiding from The Greater Good who would be out hunting you down.

Economics and ethics join up in the philosophy of utilitarianism, espoused by famous 19th century economist and philosopher John Stuart Mill and encapsulated in his statement:

Actions are right to the degree that they tend to promote the greatest good for the greatest number.

Guess Mayo wins this one, based on the greater good. But their win will probably bring down at least one new government regulation on the rest of us. In that vein, it's worth pointing out that being Big means your actions can be unethical, immoral but NOT illegal. How else to explain Big Finance company MF Global's apparent success in avoiding federal fraud charges for its "loss" of over a billion dollars in customers' monies, on grounds that it was "sloppy" not "criminal." The "Big" Central Value can be rephrased as "It's good to be King." To quote a famous 20th century moral philosopher,

"Steal a little and they throw you in jail. Steal a lot and they make you king." Bob Dylan

There is any number of other ethical dilemmas and moral temptations to consider in hearing health care, especially if you are an audiologist: protection of intellectual property, stealing patients, steering patients, turning away patients, selling hearing aids without providing implied services, deriding colleagues, handling impairments of patients and staff, plagiarism, calculated errors of omission and commission, billing insurances by all the rules … the list just doesn't stop. But I am stopping now.

Philosophy and ethics are hard and confusing because they question decisions made at the margins of behaviour. This blog is in full retreat, moving back next week to the simple world of economics where margins are measureable.

http://hearinghealthmatters.org/hearingeconomics/2012/but-that-would-still-be-wrong-moral-and-ethical-decisions-in-hearing-healthcare/

BUT THAT WOULD BE WRONG: ETHICS OF STEALING AND DECEPTION

By Holly Hosford-Dunn

Previously, Hearing Economics described thefts and deceptions in professional settings. Transgressions were bizarre, some absurd, but all actually happened. Most were illegal; all received some form of punishment. The point was that owners and managers are responsible for imposing and enforcing checks and balances in hearing health care environments in order to protect patients, staff, and assets from theft and manipulation. Indeed, checks and balances are important preventive measures put in place to protect people from making bad choices and create a reliable, trusting environment.

Which brings us to the topic of today's post: Illegal or not, do situations exist in which stealing or deceptions are ethically defensible in hearing health care environments? I think I'm on reasonably firm shifting sand when I say that the Economic view is that all are OK so long as they are not illegal and are done for the good of the firm. Readers are encouraged to send in stories of legal stealing and deception that helped their companies prosper – I'm sure we could all benefit from such information.

While we anxiously await examples, it's worth a minute to define terms. Bad behaviour is often described as "morally and ethically wrong." But seriously, does anyone reading or writing this post know the difference between moral and ethical? Can something be morally right and ethically wrong, or vice-versa? This area has consumed the life of more than one philosopher, so don't look for an answer in this post. However, I was encouraged to dig a little when I discovered that I could ask the Universe on its brand new Twitter account. I haven't heard back from The Universe – making me wonder fleetingly if I am just a speck – but I quickly left that path to seek out more reliable, or at least closer, experts. Somewhat tautologically, it turns out that morals are beliefs and ethics are "advanced expressions of morality" based on consistent reasoning. You have to wonder how consistent rationalizations are handled.

You're in the moral ballgame if your gut tells you that a proposed act is "wrong" (e.g., stealing from the business) or "right" (not stealing). Rushworth M. Killer, deceased ethicist and author of *How Good People Make Tough Choices* calls these "right-wrong" decisions **moral temptations**: clear-cut decisions about behaviours that are widely "understood to be wrong" and provide excellent career opportunities for televangelists. Dealing with what Dr. Killer calls "right-right" decisions moves you up to the big leagues of **ethical dilemmas**, where choices set one central value (not stealing is good) against another (taking money from the wealthy to feed the poor serves the Greater Good) "in ways that will never be resolved simply by pretending that one is wrong." So much for rationalizing… ethics requires honesty in one's thinking.

How about those transgressions in health care mentioned previously? Were they moral temptations or ethical dilemmas? What is the economic view? Below are a few examples, grouped according to the aforementioned Central Values pitted against the good of the firm.

CENTRAL VALUE: FAMILY MATTERS

The poor accountant last week embezzled $16 million, but her motive– only now revealed – was pure. She used that money unselfishly to prop up her son's failed ambulance business. The big picture emerges: A mom helping her son, a family business, ambulances saving people's lives, the world a better place. Ethically, how can you blame the woman for repurposing that money to such a worthy cause?

A close-knit family business in Long Island employed 11 family members who provided special ed. services to disabled toddlers. In the process, the business is accused of falsifying records and overbilling about $2 million. But hey, the kids got (some) services, the family prospered, and $2 mil is a drop in the bucket in the program's $2 *billion* budget.

"Your office manager confesses that she stole money from the office account to buy medicine for her ailing father. Her father has died, and she offers you a check from the insurance proceeds to pay you back. After you cash the check, do you fire her or forgive her?"

Comment: With notable exceptions (Robin Hood, Soprano family) most of us will see these examples as moral temptations rather than ethical dilemmas. It is wrong to steal.

On the other hand, it is not only OK to steal but stealing is a cornerstone of Robin Hood and Tony Soprano ethics – one ethic says it's for the Greater Good of the Family of Man, the other's ethic says it's for the Good of The Family. Not stealing (or not doing other wrong things) would be an ethical dilemma for those bound by oath to organizations such as these.

The economic view is clear cut for the three cases, unless the Sopranos go into health care. Stealing from the firm raises costs, which reduces supply, raises price, and cuts demand. Not good for the business. Not good for consumers. Separate the transgressors from the business and get the stolen funds back, using legal means if necessary. Beyond that, any punishments are the purview of the courts.

In general, professions are not well served by instances of moral and/or ethical failure. The ripple effects of such failures tend to reach consumers, who react by complaining. Complaints get the attention of agencies, which in turn react by applying scrutiny to the profession. Life gets really rough when government agencies move from scrutiny to regulations and investigations of the profession and its members. Just ask Tony Soprano, who practically lives with the Feds in his house. He'll tell you: it's a lot easier and far more profitable to police your own organization than have the government step in or, worse, take over.

http://hearinghealthmatters.org/hearingeconomics/2012/ethics-of-stealing/

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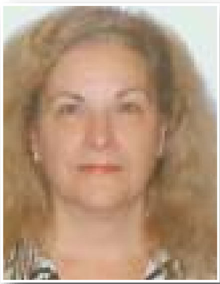
Pediatric (Central) Auditory Processing Assessment In 2012: Where Are We?

By Irene M. Hoshko, M.Sc.(A) Aud(C) OOAQ



In diagnosing central auditory processing dysfunction ([C]APD) the audiologist's focus shifts from sensory end organ to the challenging arena of the auditory brain. (C)APD clinical practice guidelines and position statements are now in development by associations of communication professionals in North America. Educational audiologists recognize the heavy premium placed on the correct interpretation of classroom auditory information before children achieve proficient reading skills. The introduction of electronic multimedia technology to pedagogy requires children to integrate auditory and visual information from disparate sources in real time, accelerating the processing challenge.

ASHA defines (C)APD as "difficulties in the perceptual processing of auditory information in the CNS and the neurobiologic activity that underlies that processing and gives rise to electrophysiologic auditory potentials."[1] The true prevalence rate of (C)APD though uncertain, is estimated at 7%.[2] The goal of (C)APD assessment is to provide insight into, and delineate by deficit profiling, areas of strength and weakness in the operation of multiple auditory processes. This objective is realized by simulating in the test booth, the disadvantageous reception conditions children encounter in their everyday listening environments and by observing when and how the processing breakdown occurs. This knowledge is used to direct a remedial effort.

A generation ago, (C)APD in children was diagnosed by excluding other contributory factors. In 2012 the diagnostic process is more rigorous. Yet, as Allen notes, (C)APD test selection remains difficult as no "gold standard" exists to evaluate the effectiveness of our diagnostic tools.[3] There are many such "hot topics" in (C)APD assessment and intervention today with only modest consensus established in their treatment by researchers and reflective practitioners. At issue are the following and this list is by no means exhaustive:

1. The selection and number of criterion-referenced tests to include in a comprehensive battery.

2. The diagnostic value of using two test procedures to assess a single auditory process when the deficit suspicion index is high.

3. Optimizing test battery diagnostic power and cost effectiveness by balancing sensitivity, specificity and clinical efficiency while avoiding effects of fatigue, attention and motivation.

4. What criteria to use for failure.

5. Facilitating differential diagnosis by including materials with limited language load.

6. Managing language confounds in assessing speech-sound disorders in multilingual children.[4]

7. Ensuring that selected tests are appropriate for a child's language development level and maturational and chronological age.

8. Treating co-morbid conditions in assessment and in interpreting test results, such as, evaluating the impact of disorders of attention, language, learning, global cognition, memory and motivation.

9. Establishing if supramodal tests (e.g., measuring the visual analog of auditory tests or using instruments specifically designed to evaluate attentional status) contribute to differential diagnosis or if auditory intra/intertest comparisons are sufficient.

10. Determining which formalized conceptual model best diagnoses and categorizes (C)APD deficits and targets therapies: the Buffalo, Bellis/Ferre or Spoken Language Processing Model.

11. Quantifying the value and reliability of an expanding array of

electrophysiological potentials to (C)APD pediatric assessment.

12. Customizing a child's intervention plan and specifying what metric(s) to use in gauging therapeutic response.

13. Investigating the appropriateness and outcome efficacy of computer-assisted therapy programs. Defining what constitutes an adequate therapeutic trial. Comparing phonemically-based "bottom-up" interventions; executive-level "top-down" metacognitive/metalinguistic management strategies and concurrent use of both approaches for sustained therapeutic effect.

14. Examining the importance of fostering self-advocacy in remediation and determining at what age it can be taught.

15. Determining if all (C)APD candidates benefit from evaluation in psychology and speech-language pathology. Approximately one-third of children presenting with learning disabilities also evidence (C)APD.[5] Kelly cautions that the dual-deficit child's response to educational and therapeutic programs designed for just one diagnosis may be poor.[6]

16. Studying the impact on intervention plan design of nonlinearity between deficit and functional effect. Children diagnosed with the same deficit profile and magnitude of (C)APD involvement may experience a differential disability impact due to individual differences in mobilizing personal compensatory resources; the presence/absence of secondary disabilities and the availability of appropriate familial and academic support.

STRATEGY FOR (C)APD ASSESSMENT

A multidisciplinary perspective facilitates (C)APD assessment. Before diagnostic testing, the audiologist analyzes assessment results submitted by professionals in other areas of expertise. For example, demonstrated problems with vowels, the consonants *f,r,* and *th* and a reported Performance/Verbal IQ differential are classic potential (C)APD signatures. However, professionals in other disciplines may arrive at a different diagnosis based on test interpretation. To illustrate: psychologists interpret the WISC-III's Freedom from Distractibility Index as measuring attention and concentration. In contrast, the audiologist views the short-term and working memory demands of this task as integral to many auditory processes.[7] Research supports the audiologist's view.[8]

The audiologist carefully reviews results and anecdotal comments from screening instruments and behavioural inventories completed by instructional personnel and parents, such as The Buffalo Model Questionnaire[9]; Children's Auditory Performance Scale (CHAPS)[10]; Listening Inventory for Education (LIFE)[11]; Children's Home Inventory for Listening Difficulties (CHILD)[12]; Screening Instrument for Targeting Educational Risk (SIFTER)[13]; and the Conners' Scales.[14] A detailed case history including pertinent medical, developmental and academic information is gathered. The verbal and nonverbal parent-child interaction patterns in the waiting room are observed. The audiologist converses informally with the child; judges their comfort level in the clinical setting; determines what motivates them and establishes rapport.

Peripheral testing evaluates pure tone hearing status complemented with distortion-product otoacoustic emissions (to evaluate efferent function); immittance; acoustic reflex thresholds (to rule out auditory neuropathy spectrum disorder) and speech discrimination in quiet comparing monaural and binaural performance with that obtained at competitive signal-to-noise ratios. Numerous signs and behavioural indicators signalling (C)APD high risk status may emerge during test. Other observations suggest medical referral as a hyperacusic child may benefit from a neurological consult.

The audiologist assesses the sequential unfolding of diagnostic impressions and uses clinical decision analysis to identify the best auditory diagnostic strategy for (C)APD testing if candidacy is indicated. Using a hypothetico-deductive strategy,[15] a short list of potential (C)APD subtype diagnoses is formed and progressively refined using ongoing clinical test results. Suspect skills requiring measurement are identified and a battery is built around them, strategically selecting from among tests of binaural separation and integration; temporal, frequency and intensity resolution; auditory discrimination under degraded conditions and temporal sequencing.

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Phonak Quest

The Hearing Loss Worry-Wart

By Gael Hannan
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Over the years as I have morphed into a "hearing health advocate," I have been immersed in positive hearing communication strategies. Thanks to my peers and my hearing health providers, I've been dunked, dredged, and baked into a confident and assertive advocate for people with hearing loss.

However, that's not to say I *practice* all these strategies at all times. I certainly know what I should be doing, but on occasion, cracks appear in my polished, hand-crafted suit of communication-and-advocacy armour.

I still have bad hearing moments and full-on crappy hearing days. It's at these very times that we're supposed to intone the following mantra: *Above all, to live successfully with hearing loss, I will keep my sense of humour.*

But what if you don't have one? What then is a poor, humourless hard of hearing person supposed to do? My sense of humour, although reasonably sound, doesn't always rise to the occasion, on demand, especially during a hearing loss moment. While I can tell funny stories about embarrassing hearing *faux pas*, I can also guarantee they weren't hilarious at the time – at least not to me, although other people might have had a laugh or two at my verbal non-sequitur. Not only is hearing loss not particularly funny, growing up with it can turn you into a worry-wart, or a complete bundle of nerves.

Now that I'm older, I worry about new things I had never considered. And, I'm not sure that hearing health professionals are fully aware of this aspect of their clients, because most hard of hearing people wouldn't like to talk about this stuff in public.

"Hearing" people worry when they actually *hear* something go bump in the night. But at least they can figure out how to react, like grabbing a frying pan or whatever to fight off the thing that goes bump. We *don't* hear bumps in the night – but we know they must be out there, because other people say they are. So, I start to worry – what am I not hearing on a given night? What's happening out there in the dark – a bump, a crash, a yell, a smash? I hear nothing – and trust me, this can keep you awake, wondering what you're *not* hearing. The bags under my eyes are not hereditary; they *grew* on my face out of worry.

What else does a HoH worry about? Oh, just about everything, but here's a partial list. I worry that

- My shake-awake alarm will stop vibrating before I wake up.
- The battery people will go on strike; my hearing aids and assistive devices are all battery operated!
- Next year's flu season will be bad and everyone will wear surgical masks instead of lipstick. Can you imagine the hell this would cause for speech readers like me?
- My hearing aid will feed back when I hug somebody – so I hug with my neck stuck out at a weird angle.
- When crossing a busy, noisy street, I won't hear the sound of a car about to hit me.
- ALL the captioners quit, and we're left to depend on speech-to-text, voice-recognition software. I know that live captioners aren't perfect, either; in recent TV coverage, the "Archbishop of Canterbury" and "Queen Victoria" were captioned as the Arch Bitch of Canterbury and Queen Vicious. But with imperfect software, that's what we would get *all* the time!
- My husband's lips will lose their ability to move. Or he'll get tired of repeating himself and will get a new wife who CAN hear through walls.
- My grandchildren will have high squeaky voices. Their moms will say, "Face Nana when you talk to her, sweet pea, she has a hearing loss," and they will respond, "Tough s--t!"
- My friends will start going out without me, saying, "We didn't invite you to the new restaurant, darling, because we know how much noise bothers you. But we brought you back some of the paté." I hate paté.
- My ear hole will close up and I won't be able to wear a hearing aid.
- After I buy my newest $5000

hearing aids, they'll go on sale at 50% off.

- That new study linking hearing loss to dementia proves to be true! Apparently, for every 10 decibels of hearing loss, the risk of dementia increases by 20%. With my 70 dB loss, I reckon I've got about 20 minutes before I lose my mind completely.
- I have missed an important, life-changing opportunity because I didn't hear the phone ring.
- The worst of all – I worry that I will lose my vision. (This one truly keeps me awake.)

These may sound stupid or paranoid to you and I admit I'm not really that much of a mess, although I do have my moments. Being cut off from perfect communication is stressful. And when I read that people with hearing loss are prone to depression, anxiety, and social withdrawal – it's enough to make a hard of hearing person crawl under a rock!

So what to do? One option is to dust off the sense of humour (even though it's not scheduled to come back on until tomorrow at 7 am), and get out there and enjoy! Another option is to tell our audiologists about our concerns; they might be able to help because they *understand* what we're going through. Right?

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Hearing Loss from Both Sides of the Sound Proof Booth

By Peter Stelmacovich
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As an audiologist with hearing impairment, I routinely wear both the hat of a clinician and the hat of a patient. This allows me to see hearing loss from both sides of the sound proof booth. Interestingly the knowledge I have obtained from these two perspectives is different yet complimentary.

Being an audiologist has taught me much about how the auditory system functions, how to assess auditory function, and how to properly prescribe and fit hearing aids, cochlear implants, and wireless remote microphones such as FM systems. As a hearing impaired person, I have learned firsthand what it is like to live with significant hearing loss. Moreover, I know what it feels like to struggle to communicate, especially in the presence of background noise.

We know as audiologists that the two main problems of sensorineural hearing loss are

1. Loss of Audibility
2. Loss of Clarity

We manage the loss of audibility quite well as audiologists. If our patients cannot hear well, we provide them with amplification of varying amounts of gain. Today's hearing aids intelligently provide different amounts of amplification as a function of frequency as well as the original intensity of the signal. Scene analysis in hearing aids optimize gain and frequency response for different environments. As the hearing loss increases we provide increasing amounts of amplification. Should this not restore audibility we now have non-linear frequency compression techniques available to restore audibility of high frequency consonants. Finally if this is not sufficient, we can refer our patients for cochlear implantation.

We all know that loss of clarity means that when there are other noises present, people with hearing impairment will have a very hard time communicating. Just like amplification, we need to provide our patients with greater signal to noise ratios as the hearing loss increases.

The two tools we have at our disposal for improving the signal to noise ratio are directional microphones and wireless remote microphones, with FM systems being the most common example of the latter. Directional microphones provide about a 4 to 5 dB SNR improvement. This amount of improvement is sufficient for adults with mild to moderate degrees of hearing loss. But once we get to a moderate-severe degree of hearing loss (around 60 dB HL), the directional microphone won't be enough. And this is where we start to fail to meet the needs of our patients.

So who should get a directional microphone? In my opinion, every person with a hearing loss, regardless of degree of loss would benefit. Yes there are times when omni-directional microphones are better so we need to provide options for manual switching or an intelligent hearing aid that knows when to appropriately switch based in the environment. But people with moderate-severe, severe, and profound hearing loss must have an FM system if they wish to communicate in noise. FM systems provide about a 15–20 dB SNR improvement which is what people with significant hearing loss will need to communicate in noise. Yet what percentage of these patients actually have an FM system? It is far too low. Perhaps this is area in which I differ most from my normal hearing colleagues. I know firsthand how hard it is to communicate in a noisy environments like a restaurant, bar, cafe, or car. I cannot imagine functioning without my FM system. As such, I will make sure I offer this technology to all patients with moderate-severe losses or greater.

I recognize the reasons why more patients do not use remote wireless microphones are varied. But after over 20 years' experience as an audiologist and 48 years experience of living with hearing loss, I remain convinced that the number one reason most adults do not use this technology is because the technology was never presented to the patient I get frustrated with my audiology colleagues for failing to introduce this technology. Similarly, I get frustrated by my fellow people with hearing loss for rejecting technology that will be of such benefit to their lives. So here are my pleas:

TO AUDIOLOGISTS AND HEARING INSTRUMENT PRACTITIONERS

1. For adult patients, please ensure that you select a hearing instrument that can use an wireless microphone system such as an FM system, even if you do not think they need it right away. The FM system can be used with direct audio input, a telecoil, or in some cases a streamer. Make sure the patient knows how to get to the correct program in their hearing device that can use an FM system. Activate the telecoil at least. I know you also need to keep things simple, but try not to limit the patient's options too.

2. Please introduce the concept of an FM system at least to patients with moderate-severe losses or greater. At this degree of hearing loss, only an FM system can provide them with the required signal-to-noise ratio needed to understand speech in a noisy environment.

3. For pediatric patients, please double check to make sure the FM + M program has been activated. Too often I trouble shoot FM problems in schools, and find this as the cause.

TO PEOPLE WITH HEARING LOSS

1. Please don't always go with the smallest possible hearing aid, especially if you have more than a moderate loss of hearing. You likely won't be able to use an FM system and that seriously limits your listening options. But, the hearing aids that can use an FM system are still quite small! And, FM systems are small now too.

2. Please understand that the hearing aid is but one device that will help you hear better. You can hear better in noise if you add another device such as an FM system.

3. Please don't say the problem is that everyone else mumbles. It's not true …you need help. Your audiologist would be delighted to get you all the help you need.

It is crucial as hearing health care professionals we address both the problems of audibility and the problems of hearing in noise. If all we do is restore audibility, we are only doing half our job.

Peter Stelmacovich has a regular blog entitled Deafened But Not Silent: How to live life to the max with hearing loss. http://deafenedbutnotsilent.wordpress.com/

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Oral vs. Intratympanic Steroid Treatment for Sudden Sensorineural Hearing Loss (SSNHL): Important Information for the Clinical Audiologist

By Lendra Friesen PhD, and Samidha Joglekar, MClSc (C), Audiologist, Reg. CASLPO
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Sudden sensorineural hearing loss (SSNHL) is a common affliction that promptly poses a threat to the quality of life of those patients who experience it. SSNHL refers to a unilateral sensorineural hearing loss of 30 dB or greater over at least three contiguous audiometric frequencies with onset and development over 72 hours.[1–3] SSNHL is a complaint that is commonly encountered in audiologic and otolaryngologic clinical practice and thus, it is necessary that the clinical audiologist be aware of the possible etiologies, characteristics, and treatment options for this condition.

Current epidemiological data related to SSNHL estimates an incidence of between 5 and 20 cases per 100,000 people per year.[2] The true incidence may be higher than these estimates, as individuals who recover quickly and spontaneously do not often seek medical attention.[2] While individuals of all ages may be affected, the peak incidence of SSNHL is between the fifth and sixth decade of life with equal incidence in men and women.[2,4,5]

In their review article entitled *Sudden Sensorineural Hearing Loss: A Review of Diagnosis, Treatment, and Prognosis*, Kuhn and colleagues provide a thorough literature review, along with a comprehensive table, of identifiable causes of SSNHL organized into the following main categories: (1) autoimmune, (2) infectious that includes Lyme disease, mumps, and toxo-plasmosis, a treatable parasitic infection commonly contracted due to contact with cat feces or the ingestion of undercooked meat, (3) functional, that includes malingering and conversion disorder, (4) metabolic that includes diabetes and hypo-thyroidism, and (5) neoplastic that includes vestibular schwannoma and cerebellopontine angle tumour.[6] The most common bacterial infections to cause SSNHL in the U.S. are Lyme disease and syphilis.[6] Besides mumps, which is the leading viral cause, other viruses implicated in the etiology of SSNHL include herpes simplex, varicella zoster, entero virus, and influenza.[6,7] Vascular pathologies that decrease blood supply to the cochlea and reduce intra-cochlear oxygen levels are also a possible cause.[6] Approximately 5% of patients who initially present with SSNHL are ultimately diagnosed with some other otologic disorder as the condition manifests over time. In some cases the final diagnosis is Menière's disease, but it may also be fluctuating hearing loss, otosclerosis, or progressive SNHL.[2,6,7]

Despite an overwhelming amount of research in the area, controversy remains with regard to the etiology and appropriate care of patients with this condition, mostly because recommendations vary greatly between publications.[2,4,7] The prognosis of SSNHL depends heavily on identifiable etiology, disease process and duration, specific impact on cochlear structures, and possible treatment options given these other factors.[6] However, the majority of patients with SSNHL have no identifiable cause for their hearing loss and thus these hearing losses are classified as *"idiopathic."*[4,6] While many of the known causes of SSNHL cause permanent hearing loss due to cochlear and hair cell damage, it has been documented that 45 to 65% of patients with idiopathic SSNHL may regain some pre-loss hearing thresholds without therapy.[2,6,8,9] However, prognosis also depends heavily on a variety of risk factors including age at onset of hearing loss, duration of deafness, the presence of associated symptoms (such as vertigo and/or tinnitus), audiogram characteristics, and the time between onset of the hearing loss and treatment from a physician.[6,7]

According to a recent study by Rauch et al., the current standard of treatment for idiopathic SSNHL is a tapering course of oral corticosteroids (either prednisone or methylprednisone).[2] Over the last 15 years, intratympanic corticosteroid treatment by direct injection into the middle ear has gained wide popularity.[2] A theoretical advantage, documented in guinea pig studies, is an increased drug concentration at the target organ.[10] Another potential benefit of intra-tympanic steroid treatment over oral steroid treatment is reduced systemic steroid exposure.[2] Rauch et al., conducted a multi-centre, randomized trial in order to investigate the effectiveness of oral prednisone compared to intratympanic methylprednisone for principal treatment of idiopathic SSNHL.[2] The study took place over almost five years and across 16 academic community-based otolaryngology practices. Participants were followed for six months and received doses of either oral prednisone or intratympanic methylprednisone over 14 days.[2]

Overall, their findings showed that the efficacy of both treatments was comparable. The mean PTA at 2 months was 56.0 for the oral-steroid group and 57.6 dB for the intratympanic group and recovery of hearing at 2 months was 2 dB greater for oral-steroid treatment compared to intratympanic treatment.[2] The investigators concluded that from the standpoint of comfort, cost, and convenience, oral steroids are better than intratympanic steroid treatment. However, there were no significant differences found between either method in terms of therapeutic impact on SSNHL and hearing loss recovery.[2]

Although most cases of SSNHL are idiopathic, a number of treatable conditions can underlie SSNHL and thus a medical referral should be made immediately in suspect cases so that efforts can be directed towards establishing a medical diagnosis and, most importantly, ruling out an identifiable underlying cause of the hearing loss.[4,6,7] Patients who experience SSNHL should be cautiously counselled regarding prognosis, as hearing recovery depends on a multitude of factors.[6,7] Standard pure tone audiometry provides the criteria for diagnosis of SSNHL and also has prognostic value, as many patients undergo a series of audiograms to document recovery, monitor treatment, guide aural rehabilitation, screen for relapse, and to rule out hearing loss in the contralateral ear.[2] Although many cases of SSNHL spontaneously improve without treatment, the current evidence-based standard of care is directed therapy against identifiable causes of SSNHL, and a ten day to two-week course of either oral or intratympanic corticosteroid therapy for idiopathic SSNHL.

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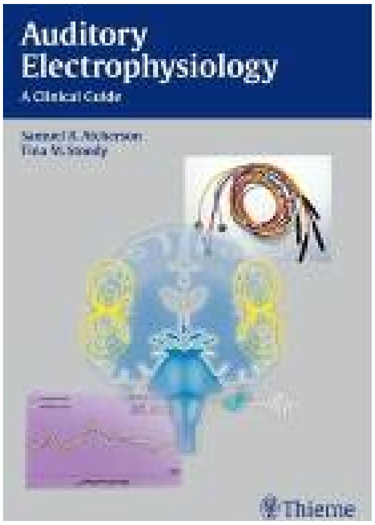

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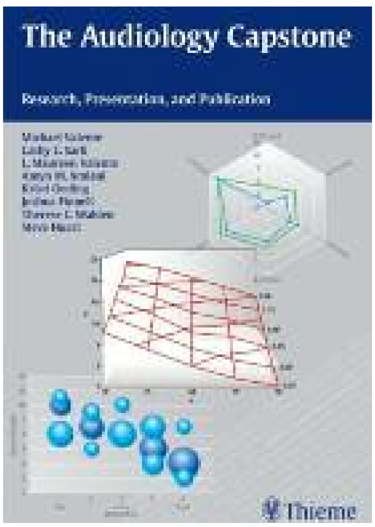

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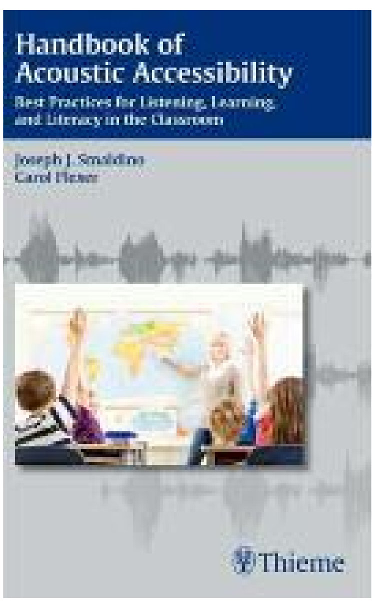

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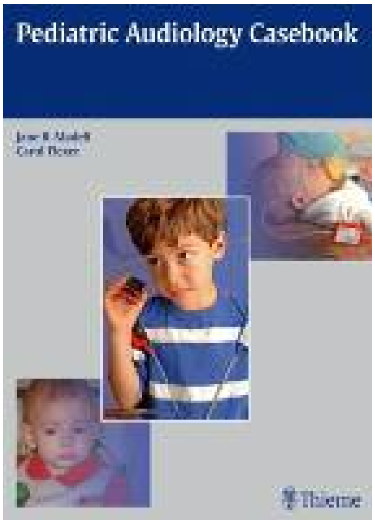

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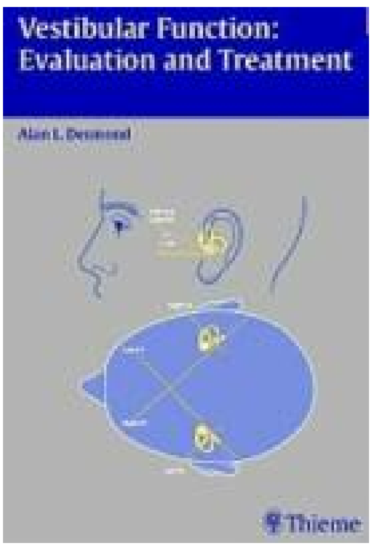

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Acoustical Factors Affecting Hearing Aid Performance: A Retrospective Review

Reviewed by Neil S. Hockley, MSc, Aud(C)
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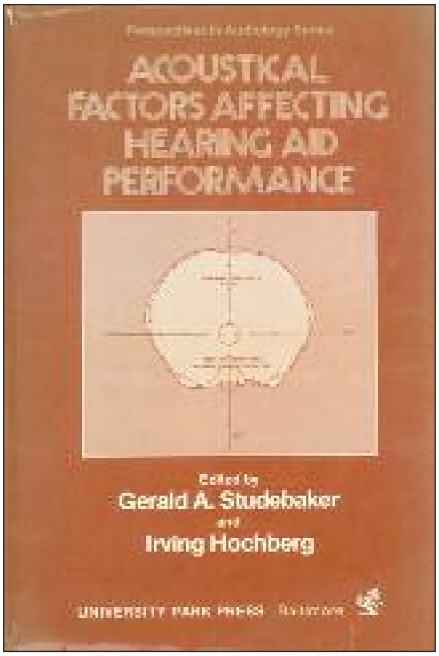
When I was finishing up my thesis for my MSc in the mid 1990s, Dr. K. K. Charan, one of the pillars of the School of Communication Sciences and Disorders Program at McGill University, had at that time recently retired (I met Dr. Charan by chance, a few years after I graduated, in a clinic where I very nervously tested his hearing. He remarked to me part way during this test that I should not try to use any masking that day because even Ira Hirsch from the CID could not mask his hearing loss properly.) and he had left behind a pile of unwanted books in his former office. I was a student who wanted to expand his audiological library inexpensively and so I accepted the administrator's invitation, one hot Montreal summer's day, to have a look through his books. I was given permission to take what I wanted and spent a couple of hours in this dark office picking up and putting down many books from Dr. Charan's private library. I ended up with a small pile of books that included an autographed copy of *Experiments on Tone Perception* by Reinier Plomp from 1966 (including a very worn free vinyl demo disk), and a first edition of Diana Deutsch's 1982 book *The Psychology of Music*. Along with a few books on musical instrument acoustics, there was also the book that I am going to write about in this short review: *The Acoustical Factors Affecting Hearing Aid Performance* edited by Gerald A. Studebaker and Irving Hochberg. If we jump forwards a few years to the present (2012), this 32 year-old book has ended up being the most likely to disappear from my bookshelf for extended periods of time, and in the next few paragraphs I hope to explain to you why this is the case.

The Acoustical Factors Affecting Hearing Aid Performance is a compilation of presented papers and discussions from a conference that was held in New York City from June 14–16, 1978. It was published in 1980 as part of a series of books entitled *Perspectives in Audiology* by University Park Press out of Baltimore MD, edited by Lyle Lloyd. The list of contributors to this volume reads much like a "who's who" of researchers on acoustics and audiology working during the 1970s, some of whom are still very active today. Researchers such as Jozef Zwislocki, Robyn Cox, Norman Erber, Mead Killion, Harry Levitt, Margo Skinner, and Edgar Villchur were involved. The book covers many topics and so it is divided into a number of sections. The first section is entitled "Acoustical Effects of the Environment" with chapters on room acoustics and reverberation to name but two. The second section moves on to present some basic acoustics in a section entitled "The External Ear, the Earmold, and the Earphone." The third section is entitled "Modeling Techniques" and introduces a topic that is very important today in the discussion of real ear measurement and hearing instrument fitting software. The fourth section "Frequency Response Selection Techniques" examines techniques for selecting hearing instruments with regards to gain and frequency response, and includes discussions on master hearing aids. Tacked on to the end of this section is a chapter with some summaries of the conference discussions, where some interesting insights are made that resonate still within the realm of hearing instrument research. This list of topics is not dated and could have been written yesterday; perhaps this explains why this book is a corner stone within the hearing instrument literature and one of Marshall Chasin's favourite books.

I will now go on to describe some of the chapters in the book within each of these sections that I found especially interesting.

ACOUSTICAL EFFECTS OF THE ENVIRONMENT

This section contains 5 chapters. The highlight of this section, in my opinion,



Pictured above: the original book jacket from my copy of this book.

is Chapter 2 entitled "Effects of room acoustics on speech perception through hearing aids by normal-hearing and hearing-impaired listeners" by Anna Nabelek. (Dr. Nabelek's recent work has been on the development of the Acceptable Noise Level (ANL) Test that is a very powerful clinical tool to guide the fitting and ultimately the rehabilitation needed when prescribing hearing aids.) Nabelek begins by describing the sounds that we perceive as a mixture of three components:

1. The original or direct sound;
2. The early reflections occurring shortly after the direct sound; and
3. The later more diffuse reflections.

The two groups of reflected sounds (2 and 3 above) produce different perceptual effects. The earlier reflections "colour" the sound; in contrast, the later reflections are responsible for the prolongation of sounds, which is more commonly called reverberation. Nabelek goes on to describe the effects on speech intelligibility. For example, if the direct sound is quite soft then the early reflections will improve intelligibility (with no reverberation). While reviewing a number of studies, Nabelek states that reverberation generally reduces speech intelligibility but this has many factors including room size, distance from the source, type and amount of masking, monaural versus binaural listening, individual factors, and whether or not the listener is wearing hearing aids. In general though, wearing binaural hearing aids in moderately reverberant rooms is not that different than in anechoic conditions. Reverberation is a complex phenomenon which can make perceiving speech quite difficult and it is still a challenge for today's hearing instruments.

THE EXTERNAL EAR, THE EARMOLD, AND THE EARPHONE

This, the largest section of the book is comprised of 6 chapters. The highlight of this section describes some very important work completed in Canada, included in Chapter 6: "The Acoustics of the External Ear," written by Edgar A.G. Shaw.

Edgar Shaw worked at the NRC research laboratories in Ottawa beginning in the early 1950s after emigrating from the United Kingdom. He did a lot of work which generated many patents and publications on topics such as probe microphones and headphones. He even served as president of the Acoustical Society of America in the 1970s,[1] and devised a number of experiments to measure the acoustics of the external ear canal using probe microphones.[2,3] Any probe microphone measurements made today can be traced to Shaw's pioneering work. As clinical audiologists, we take probe microphone measurements for granted. Edgar Shaw's work was incredibly detailed and required the utmost precision and patience to collect the data. In Chapter 6, he summarizes the acoustical transformation of SPL in the free field to the tympanic membrane. He began with presenting the external ear from two points of view, firstly as an efficient sound collector especially above 2 kHz, and secondly as a filter of complex and uncertain characteristics. Shaw stated that it is hardly surprising that the external ear is "an acoustical factor affecting hearing aid performance" and that we need to be conscious of its effects as we fit hearing instruments. Shaw goes on to describe the elements of the external auditory system starting with the concha, then the external ear canal, and finally the tympanic membrane. This brief chapter summarizes a huge amount of work mostly performed by Shaw himself. The details about the acoustical effects of the different anatomical parts of the external ear are really fascinating, and are something that we as clinicians deal with every day.

At the end of this chapter, Shaw says the following with regards to improving the S/N ratio:

> *…we can imagine a hearing aid in which relevant parameters, such as frequency response and the directionality, are adjusted, perhaps from moment to moment in an adaptive fashion, to maximize the information content of the sound that reaches the seriously impaired inner ear (page 124).*

34 years after this was presented at the New York conference, this goal is still being pursued by hearing instrument manufacturers worldwide.

MODELING TECHNIQUES

The modeling of the hearing instruments and the associated acoustic transforms are an important aspect of today's hearing instrument technology. Models of the acoustic performance of hearing instruments are essential in order to have software control over the hearing instrument. In this section of the book, there are two chapters on modeling. My favourite of the two is Chapter 13 by David P. Egolf and is entitled "Techniques for Modeling the Hearing Aid Receiver and Associated Tubing." If you look at all the parts of a hearing instrument that can affect the sound, each of these parts can be described mathematically. Mathematical descriptions of the microphone, receiver, acoustic coupling methods, etc. can be made and linked together to provide an accurate picture of the hearing instrument behaviour when it is worn on the ear. Egolf is specifically looking at the receiver and the tubing effects, and describes the effects mathematically. Egolf then goes on to describe how a computer model can be compared with probe-tube measurements within a real ear. One example is that of tubing length. Basically, the longer the tubing is, the lower in frequency the first resonance peak. The tubing length is beyond the control of the hearing instrument software but can potentially be measured with probe microphone equipment. Mathematical modelling techniques play an important role in hearing instrument and software design, in order to obtain an accurate picture of all of the variables involved in the path from the free field to the tympanic membrane. Cross calculations within these mathematical models are an essential method to verify that the transformations have been correctly implemented.

Clear definitions are needed when acoustical transformations are employed so that clinicians, researchers, and developers can know that they are talking about the same thing. Modelling is an incredibly important part of hearing instrument design.

FREQUENCY RESPONSE SELECTION TECHNIQUES

The final section of this book is concerned with frequency response selection techniques. There are four chapters dedicated to this topic, along with a final discussion chapter on a variety of subjects pertaining to the four sections of this book. I did not find the chapters in this section to be as relevant to today's hearing instruments as the previous chapters due to the fact that hearing instrument selection techniques have changed greatly since the time of the New York conference. Clinically, non-linear fitting rationales designed for complex compression algorithms such as NAL NL2[4] and DSL m[i/o][5] in addition to the many proprietary fitting rationales, are applied across the hearing instrument industry today. However, I found the last discussion chapter, Chapter 18, to be very interesting. It consisted of very detailed minutes of the discussions that occurred after the presentations of the topics (summarized as the chapters in this book) along with the speaker's name. The summary of each discussion gave me the impression of being a "fly on the wall" at this historical event. Some of the comments concerning acoustic feedback, for example, are not relevant today with the use of phase cancellation feedback systems. Some other comments mentioned, such as those on flexibility of the acoustical coupling to affect the overall amplification and frequency response of the hearing instrument, could however have been brought up just yesterday. I have read conference proceedings in the past, but none of them have been as interesting as the discussions documented in this book.

STRENGTHS AND WEAKNESSES OF THIS BOOK

This book has many strengths. The material is both interesting and easy to read. The individual chapters are very concise. There are many diagrams and graphs to make the material more easily understood. This book really has no weaknesses, other than the fact that it has been out of print for a number of years.

WHY DOES THIS BOOK STILL DISAPPEAR FROM MY BOOKSHELF?

With any book review there is often a statement about who should buy this book. The trouble is that *The Acoustical Factors Affecting Hearing Aid Performance* is now long out of print, and is probably quite difficult to track down. If, however, you ever find one in your favourite used book store (or online supplier), I recommend that you buy it. It would be well worth owning a copy. Perhaps it too will disappear frequently from your bookshelf like mine. This book is useful for students, researchers, and developers who need to immerse themselves in the acoustics of hearing instrument fittings. It could be useful in understanding some fundamental concepts and it could be of historical interest. I find this book to be a treasure trove of information and it has given me a sense of appreciation for the complexity of the acoustical knowledge needed to amplify signals to alleviate the negative consequences of hearing loss. History teaches us a lot, and this book does indeed accomplish this.

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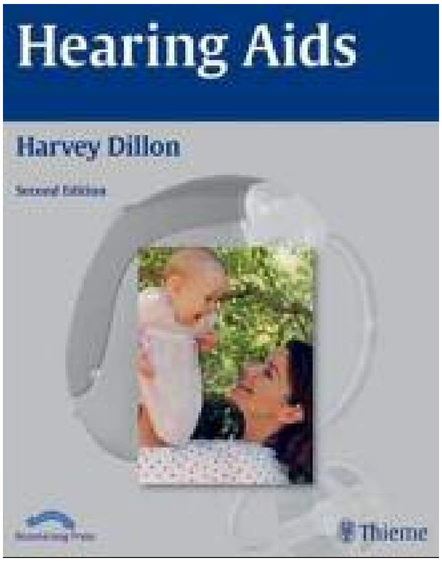
About the Author

Neil was in the second last class of students to graduate from McGill University in Audiology. He often jokes (perhaps too frequently) that the reason why the program was closed in the mid 1990s was due to the massive effort required by the faculty and staff to teach him!



HEARING AIDS BY HARVEY DILLON, 2ND EDITION

Thieme Publishers
2012
ISBN# 9780957816817

REVIEW BY MARSHALL CHASIN, AuD, AUDIOLOGIST

As the editor of the *Canadian Hearing Report* it is my duty to send any new books that we receive for review out to a person who is interested in reviewing it. However, I am shirking my duty because I want to do the review myself. The first edition has quickly become a classic and is becoming the most cited text books found in reference sections of peer reviewed hearing aid related articles. And this second edition is continuing in this tradition. There are a few corrections and additions to this second edition, namely the inclusion of open mold non-occluding fittings — a timely addition.

Each chapter begins with a one-page synopsis that clearly summarizes the content, and if that is not enough, vertical blue lines are printed in the margin to alert the reader to the more important elements. All references for all chapters are printed clearly at the back of the book by author. Personally I feel that this is a more accessible format where the bulk of the research by each author can be easily seen in some form of chronological order. I would also be remiss if I didn't mention that the font is quite accessible, especially for those of us who wear bi-focal or progressive glasses. It is nice to be able to sit back (with a glass of wine) and still see the print clearly from 18′′ away.

The textbook has 17 chapters, ranging from basic concepts to the more esoteric and clinical aspects of fitting hearing aids. Each chapter has a nice balance of clinical, technical, and academic content.

Chapter 1 discusses basic concepts such as critical bandwidth, but only those concepts that are directly relevant to hearing aids and hearing aid fittings. This chapter finishes with a stroll down memory lane and takes us from ear trumpets to wireless communication devices.

Chapters 2 and 3 review the various hearing aid components (chapter 2) and hearing aids (chapter 3). There is also an up to date discussion of the various assistive listening devices that a hearing aid can be coupled with.

Chapter 4 is appropriately titled "Electroacoustic Performance and Measurement" and indeed touching on everything relating to this topic. This chapter ranges from a hearing aid performance in a hearing aid test box and 2 cc couple, to the use of probe tube microphones in the assessment and verification process. Real ear to coupler transforms are discussed and how these can be used when prescribing and fitting hearing aids. This is continued in Chapter 5 with how earmolds, and other coupling systems may alter the output. There is even a section in Chapter 5 on earmold maintenance such as tubing changes.

Chapters 6, 7, and 8 review the various advanced features of hearing aids such as the effect of different non-linear compression schemes, directional microphones, and adaptive technologies that seek to minimize microphone noise, acoustic feedback, and a nice discussion of frequency lowering technologies.

The remaining chapters (9–17) bring the client into the picture and steps away from technology long enough to realize that we are dealing with people and not ears. Chapters on assessing hearing aid candidacy (chapter 10), and the prescription and the verification of gain and output (chapters 11 and 12), are followed by chapters on counselling and outcomes measures (chapter 13 and 14).

The textbook finishes up with a discussion of some of the current issues with binaural hearing aid fittings (chapter 15), a chapter on issues for fitting children (chapter 16), and finally a chapter on the fitting of CROS, BICROS, and implanted hearing aids (chapter 17).

This is a textbook on hearing aids and not on hearing. It is not intended to replace other textbooks that deal with the education and intervention of those who are Deaf or deafened. However, if you would like to be kept up to date on many of the hearing aid issues and technologies relating to our field, I cannot think of a better text.

Canadian Hearing Report 2012;7(5):29.

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ACA

CAA wishes to thank all our delegates, sponsors, and exhibitors for making the 15th Annual Conference and Exhibition a success. We now look forward to our next 15 years!

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Is Audiometric Testing Necessary?

By Alberto Behar, PEng, CIH
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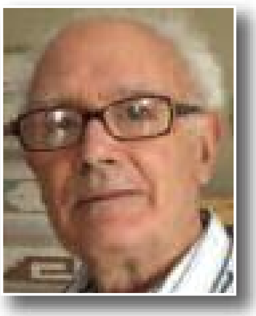

Well, well, well! I see eyebrows lifted in surprise. What a question to be asked! Everyone who has something to do with hearing conservation will answer is: "Yes, of course!" Isn't it the first test to be performed to examine the state of the hearing system? Naturally, there are many other tests that aim at different aspects of hearing. There is the audiologic test battery, as well as the otologic test battery, the vestibular battery, and so on. But, the pillar of any examination is the modest audiometric test.

So, here, we have the answer to our question, but, also, we may very well define the audiometry as a part of a health check and as such related to any other test in the health maintenance field.

WHAT ABOUT THE TESTERS?

Do audiometric technicians have to be qualified? Isn't it sufficient with reading the manual provided by the manufacturer, since, in summary a screening audiometer has only two controls: signal's sound level and frequency? (Yes, of course, there is also the "left" and "right" ear). Even more, when using a computerized audiometer, just the "on" button will do the trick. Does it mean that anyone off the street can perform industrial audiometric screening. The answer here is a resounding no!

There are other things than moving the dials of the audiometer. To start with, there is the everyday's biological test of the audiometer. Then, there is a need for periodic electroacoustical calibration as well as a quiet room to carry out the test. When the person to be tested comes in, the objectives and procedures have to be explained. Following are the instructions on what to do and how to respond to the signals. Finally, once the test is over, there is the going over the results and explaining their meaning to the subject. Not to forget the discussion on the wearing of hearing protectors if used in the workplace. In some sense, the audiometry is only an excuse to begin the education of the worker – it is an important excuse, but only the beginning.

DO TESTERS NEED TO BE TRAINED?

And what about the testers: do they have to be trained? No doubt they should be knowledgeable on noise, the hearing mechanism, noise effects on the exposed individuals (auditory and non auditory), occupational hearing loss and hearing protection and protectors. Finally, they should know about the reasons for, and limitations of air conduction pure tone audiometry.

DO TESTERS NEED TO BE CERTIFIED?

Now we are getting to a very sensitive issue: certification: does it has to be done, who should do it, need for re-certification, etc. Let's start from the first question: do they have to be certified. Certification, in general, is a way of confirming that the person has the necessary knowledge to perform. We can discuss the extension of the word "necessary," but the bottom line is that when somebody applies for the position, he should be able to show that he has the knowledge to perform it properly. That is, the meaning of the certification. Details on the training program, its duration and content can be discussed, as well as the qualification of the training institution. The same applies to the re-certification. What shouldn't admit discussion is the need for certification.

WHAT IS THE SITUATION IN ONTARIO?

Here we are getting to a sore point. The Province of Ontario contains probably the largest workers' population in any Canadian province. Here, there are thousands of industrial establishments where hearing tests are performed (using own or retained testers). However, there are no requirements for audiometric testers, nor there are training facilities nor there are courses (exception should be made with respect to teaching institutions and Universities, where such a training is a part of graduate and undergraduate courses.) on that subject. Several years ago, the Canadian Hearing Society used to offer a one week – 20 hour course that was discontinued. The old Ontario Hydro (OH) used to have a training course as well as a re-certification course for its nurses that were performing audiometric tests to the noise exposed OH workers. That was a part of the hearing conservation program that included an audiometric review team comprised by the chief medical officer, the head nurse and a member from the occupational hygiene unit.

ISN'T IT TIME TO DO SOMETHING?

And who should do it? Is this something to be done by the Ministry of Labour, the Ministry of Health or some other institution? At this point, we are trying to raise the question and seek some answers. It's a very interesting issue when you consider that the ministry responsible for the effects of occupational noise exposure (Health) has little to do with the prevention of occupational noise exposure (Labour).

Canadian Hearing Report 2012;7(5):31-32.

Auditory Brainstem Response and the Travelling Wave Delay

By Laura Prigge, AuD, Sherrie Weller, and Lynn Weatherby

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ABSTRACT
CE-Chirp is a new broadband stimulus available for the evaluation of auditory brainstem response. The new CE-Chirp optimizes the stimulus so that the energy from the stimulus reaches all regions of the cochlea at approximately the same time. This change in the stimulus presentation offsets the mechanics of the cochlea's traveling wave and results in an auditory brainstem response waveform that is significantly increased in amplitude. The ABR generated by a CE-Chirp has been demonstrated to be as much as two times more robust than the corresponding click ABR in normal hearing subjects. CE-Chirp Octave Bands are additional stimuli that are available for frequency specific threshold estimation. Using the same principle as the CE-Chirp, the CE-Chirp Octave Bands elicit optimal waveforms for frequency specific evaluations.

For over 30 years, threshold estimation in very young or difficult to test patients has been accomplished with auditory brainstem response (ABR). The ABR is an onset response; a large number of neurons must fire at the same time to elicit the response. To ensure this synchronous firing, a short duration stimulus is used. The two most common short duration stimuli are the click and the tone-pip.

The traditional click stimulus is a 100 µs electrical pulse that has a frequency range of approximately 100–10,000 Hz. The broad-band nature of the click provides stimulation of a large portion of the cochlea, which causes a large number of neurons to fire simultaneously. The resulting AEP provides information on the neural synchrony of the auditory pathway.

The tone pip (also called tone burst) stimulus assists in the evaluation of frequency specific performance of the auditory system. The frequency-specific stimulus is achieved by presenting a sine wave for a brief duration. The tone pip stimulus is based on the number of cycles presented. Typically, the rise and fall times of the stimuli are 2 cycles and the plateau is either 1 or 0 cycles. With this approach, the duration of the stimulus varies with frequency, but the energy content of stimulus is consistent for each frequency.

The ABR response to click and tone pip stimuli is highly efficient and results in a clear, repeatable waveform; however, the ABR is limited by the cochlea's travelling wave. It takes time for a stimulus to travel from the high to low frequency regions of the cochlea. Lower stimulus frequencies result in longer response time or longer latencies. When the traditional click stimulus is separated into the different frequency components, the response time of the lower frequencies occurs later than the higher frequencies. This limits the contribution of the lower frequencies to the overall ABR (Figure 1).

SOLVING THE TRAVELLING WAVE DELAY

The goal of overcoming the travelling wave delay in ABR is not a new concept. In the late 1990s, the stacked ABR was introduced as a method of enhancing

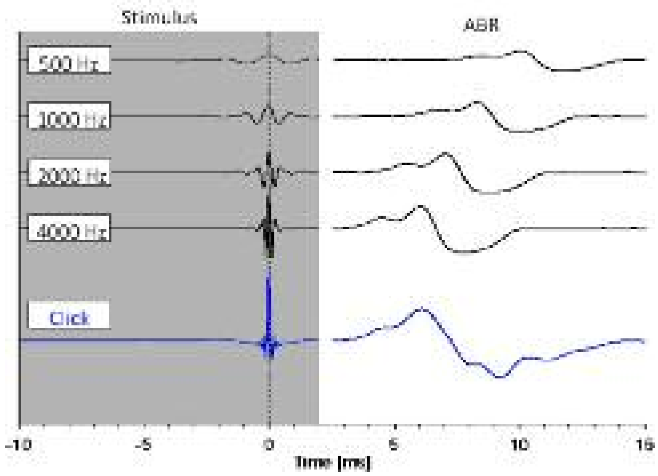

Figure 1. Click stimulus timing and response: Wave V latency is a reflection of cochlear delay.

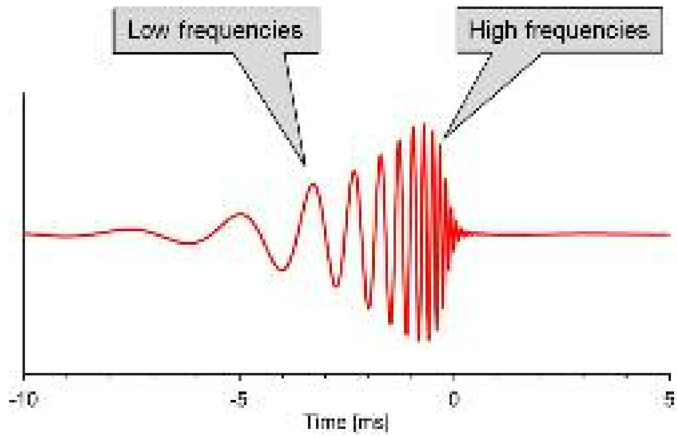

Figure 2. CE-Chirp Stimulus.

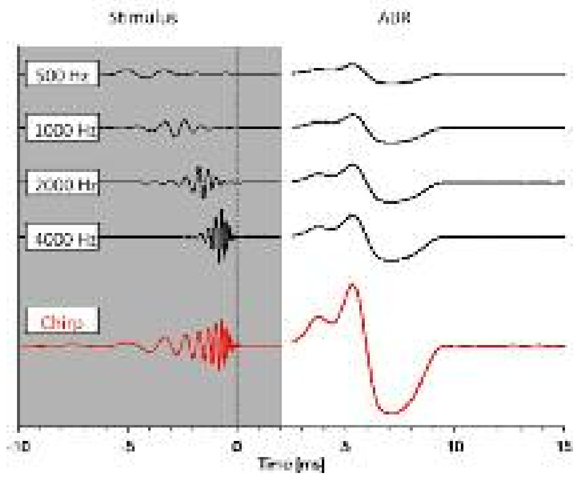

Figure 3. Click Stimulus Timing and Response: CE-Chirp.

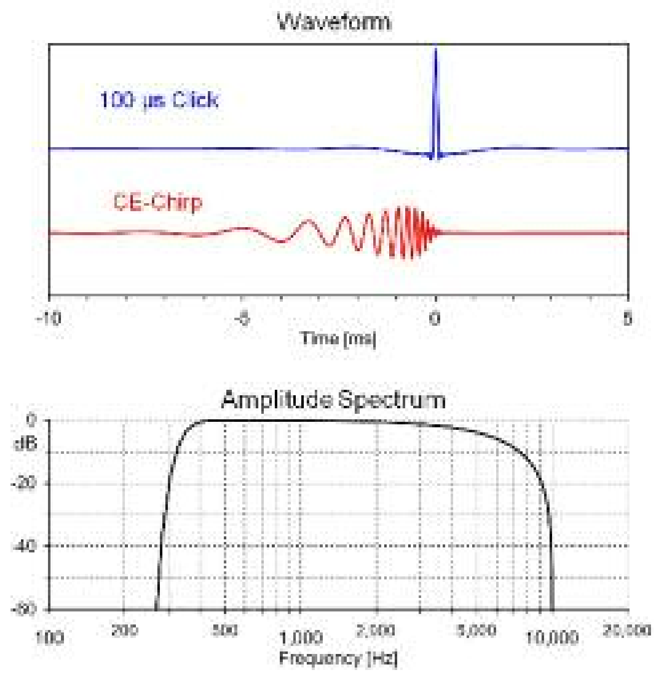

Figure 4. The click and the CE-Chirp have identical amplitude spectra.

Wave V to assist in identifying small acoustic tumours.1 It was theorized that the contribution of the lower frequency activity in the cochlea due to the traveling wave was inhibiting early identification of tumours, especially when the tumours affected the lower frequency region of the auditory nerve. Through a series of filtering and masking, the neural responses to click stimuli were isolated and "stacked" on top of each other to generate a picture of the entire cochlea's contribution to the measurement of ABR. Benefits of the stacked ABR included early identification of small acoustic tumours and larger Wave V. The stacked ABR, however, requires repeated tracings and post-acquisition manipulation to the ABR measurement adding significant time to testing.

There have been a number of early studies to overcome the travelling delay in the cochlea, but the first comprehensive description was made by Dau et al.[2] More recently, a new approach

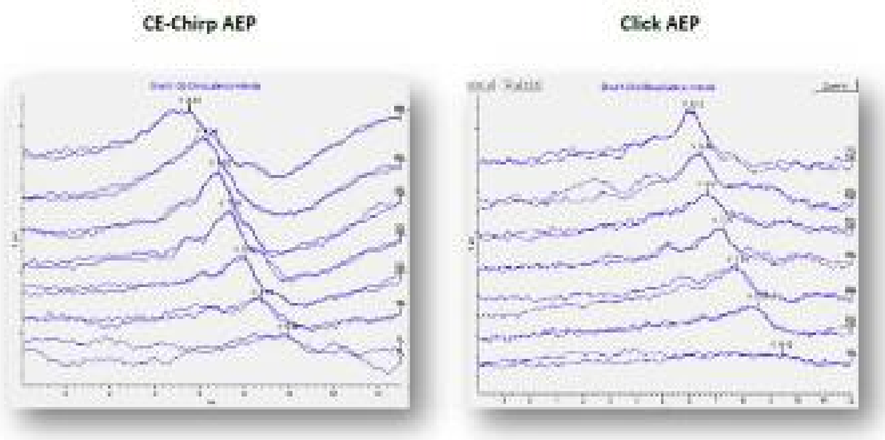

Figure 5. CE-Chirp response follows the expected latency intensity function, but generates a significantly larger amplitude than the Click response.

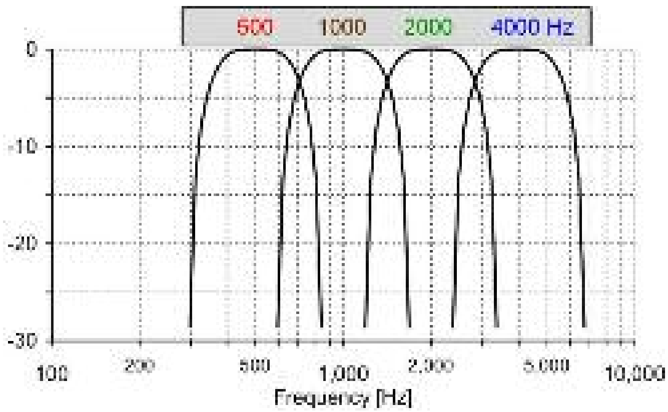

Figure 6. Amplitude spectra of the CE-Chirp Octave Band stimuli.

to improve ABR recordings has been introduced by Claus Elberling and others.[3–5] The CE-Chirp is a new broadband stimulus designed to enhance Wave V of the ABR through adjustment of the stimulus frequency composition. This adjustment counteracts the temporal dispersion of the travelling wave inherent in the cochlea by presenting lower frequency energy before higher frequency energy (Figure 2), resulting in an increased Wave V amplitude (Figure 3). The CE-Chirp frequency adjustment maintains the same frequency content of the click (Figure 4).

The frequency timing, however, maximizes the response of the cochlea, increasing the synchronous neural firings of the auditory pathway. The increased neural firings to the CE-Chirp stimulus have been demonstrated to result in ABR amplitudes that are 1.5 to 2 times greater than ABR amplitudes to click stimuli in normal hearing subjects (Figure 5).

For frequency-specific threshold estimation, the tone-pip or tone burst has traditionally been the most effective stimulus. CE-Chirp Octave Bands are now available for frequency specific threshold estimation. Designed along the same principle as the broadband CE-Chirp, CE-Chirp Octave Band stimuli (Figure 6) elicit optimal waveforms for frequency specific evaluation.

CE-Chirp Octave Bands are derived from the CE-Chirp stimulus; therefore, the latencies of the responses will reflect the timing of the frequencies of the CE-Chirp. Lower frequency CE-Chirp Octave Band stimuli occur earlier in time than higher frequencies (Figure 7).

Therefore, the ABR latencies of the lower frequency CE-Chirp Octave Band stimuli will occur earlier than the higher frequency CE-Chirp Octave Band stimuli. It is important to note that research indicates that for threshold estimation, the absolute latency is not as critical as an identifiable, repeatable response.

IMPLEMENTATION OF CE-CHIRP TO THE ABR EVALUATION

CE-Chirp stimuli are ideal stimuli for electrophysiological threshold estimation. Threshold estimation can be difficult to achieve in a single appointment with challenging patients such as infants and young children. The CE-Chirp and the CE-Chirp Octave Band stimuli have been demonstrated to generate a repeatable and reliable Wave V response that is larger in amplitude than the Wave V elicited by traditional click and tone-pip stimuli. The robust responses are often generated with fewer averages which shorten the time of the evaluation. Additionally, the use of CE-Chirp Octave Band stimuli provides robust and fast frequency-specific threshold estimation for a more thorough evaluation. Although clinical studies are not yet available for neurophysiologic diagnostic evaluation, threshold estimation is an immediate and effective use for the CE-Chirp stimuli.

CALIBRATION AND NORMATIVE DATA FOR CE-CHIRP STIMULI

The International Organization for Standardization (ISO) has recently defined the measurement and calibration of short duration stimuli relative to the effect that temporal integration has on hearing thresholds through the ISO 389-6 standard.[6] ISO 389-6 provides the

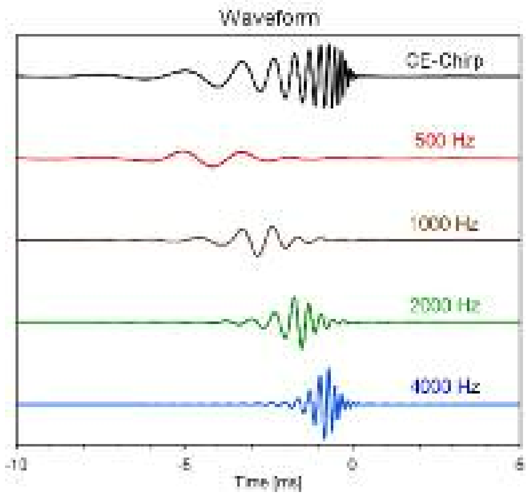

Figure 7. CE-Chirp Octave Band Stimuli derived from the CE-Chirp stimulus.

Recommended Recording Parameters	
Type	CE-Chirp
Polarity	Alternating
Rate	27.1 Hz
Stimulus Level	60dB nHL
High-Pass Filter Settings	30 Hz
Low-Pass Filter Settings	3000 Hz
Time Window	20 msec
Sensitivity	50 µV

Table 1. Sample Protocol for CE-Chirp

reference threshold hearing values for traditional click and tone burst signals while IEC 60645-3 defines how to calibrate click stimuli and the tone burst stimuli. Provided that the click and the CE-Chirp are stored in the test equipment with same amplitude spectrum the internal calibration setting of the click also will apply to the CE-Chirp. The calibration of the CE-Chirp Octave Band stimuli reference values are provided by PTB (Physikalish-Technische Bundesanstalt, Brauschweig, Germany).

As is always recommended for AEP norms, normative data should be collected for the new CE-Chirp stimuli in each clinical environment to ensure appropriate interpretation. When utilizing the CE-Chirp and CE-Chirp Octave Band Stimuli, a protocol similar to the following information outlined in Table 1 is recommended.

SUMMARY

CE-Chirp and CE-Chirp Octave Band stimuli are exciting new additions to the ABR protocol. Available in commercial systems such as the GSI Audera, these new stimuli can help to increase the clinician's confidence and reduce test time for threshold estimation testing. Continued research and publications on the CE-Chirp are likely to enhance the Auditory Evoked Potential clinical applications in the near future.

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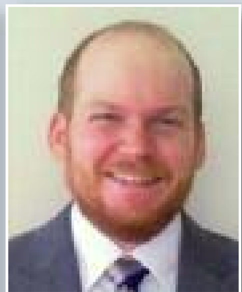
Centring Surprises in Asymmetrical Listeners

By H. Christopher Schweitzer, PhD and Christopher McCarron, AuD



About the Authors

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One of the first activities in the typical audiological assessment is to argue with nature. The right ear gets separated and isolated acoustically from the left. The test proceeds, the individual ear audiometric results are recorded, and quite possibly, even the best clinician gives little thought to the underlying surprises that may lurk below the threshold pattern of the then *dissected* hearing system. In asymmetrical cochlear pathology the surprises may be especially noteworthy. For such asymmetrical clients, with thresholds of one ear significantly worse (e.g., 35 dB or more) than the other, it may not occur to many audiologists to examine the inter-ear differences at common listening levels. However, despite the fact that most common listening experiences are organized around "comfortable" listening levels for broadband signals (rather than pure tones at threshold levels), there is much that can be learned from simple tests of supra-threshold balancing. Having studied nearly 30 such patients, we provide a few examples and commentary.

Simple lateralization tasks were conducted for 29 asymmetrical subjects using a one of two standard clinical audiometers (GSI-16 and Fonix FA-10) calibrated with TDH 39P headphones. The subjects were asked to assist, by verbal report, in adjusting the relative presentation in 5 dB, 2.5 dB, and sometimes 1 dB steps. The characteristic findings represented by two cases for those with known or presumed cochlear impairments are given here.

The first example is for a 49-year-old female with a congenital, severe sensori-neural impairment of the left ear with audiometric thresholds is shown in Figure 1. Note that the plotting on the audiometrics is on a logarithmic scale, so they appear slightly unconventional to standard audiograms, but all values are dB HL standard notations. No masked thresholds were detected at 2 kHz and above. The right ear is essentially normal. The masked air conduction thresholds for the Left as shown are obviously severe. It is evident that she has a threshold *difference* for her left/right hearing threshold levels for frequencies 250, 500, 750, 1 k, and 1.5 kHz of about 60 dB. This subject has worn a hearing aid in the bad ear for over 25 years. Hence, it can be assumed that the impaired side was accustomed to sensory stimulation, a point of some relevance. History, reflex testing, and other differential diagnostic findings strongly support a cochlear site of lesion, of undetermined congenital cause.

A unique element shown on this audiogram (and in Figure 5) is a measured portrayal of the inter-ear levels required to achieve a "center of the head" perceptual experience at comfortably loud sensation levels. To obtain these measures a relatively simple protocol was introduced[1] using standard audiometric headphones. The listener was asked to

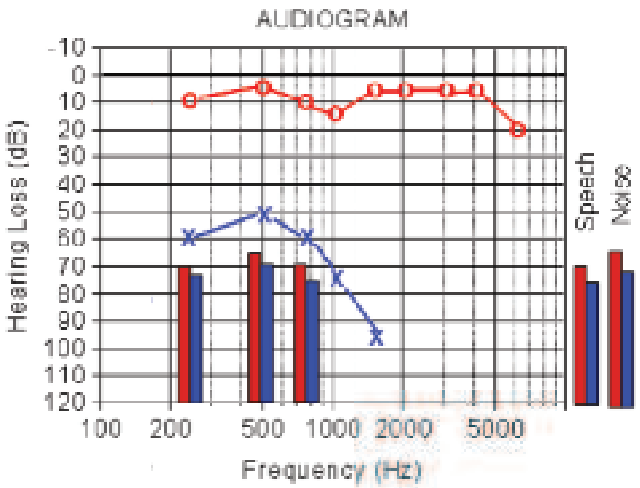

Figure 1. Threshold and plotted examples of levels to achieve balances for selected signals for one asymmetrical listener with presumed cochlear site of lesion (see text).

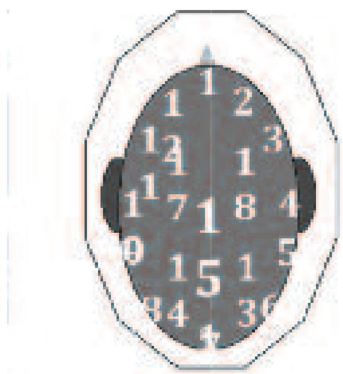

Figure 2. Illustration of the numbering chart used to locate the perceptual experience for the various signals. Listeners were asked have the experimenter adjust the relative left-right levels until the stimulus was perceived in a position as near as possible to number 15.

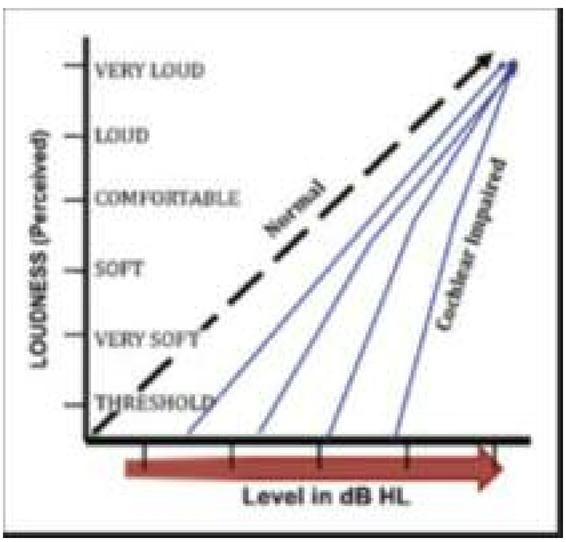

Figure 3. Generalized representation of classical "Growth of Loudness" patterns suggesting steeper than normal function for sensori-neural hearing impairment. Florentine et al.[2–6] have suggested a "softness imperception" aspect of the abnormality, rather than loudness "recruitment."

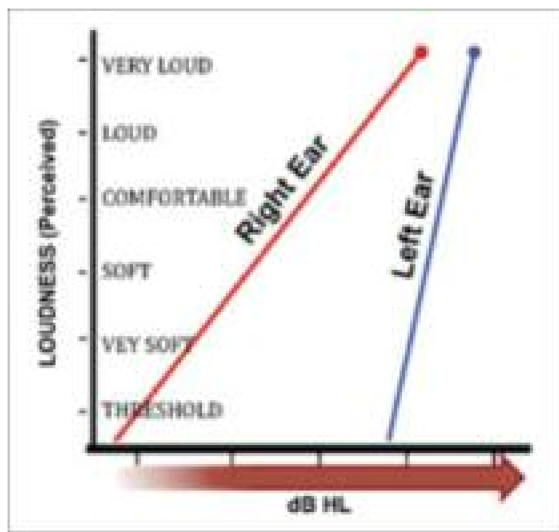

Figure 4. Behaviour pattern for ears of a patient with unilateral sensor-neural impairment (Subject described in text and Figure 1) showing a similar nonlinear loudness discontinuity as in Figure 3. This figure is illustrative rather than strictly data-based.

report the location of the perceived sound using a reference chart shown in Figure 2. Selected signals were manually adjusted to each ear independently by the examiner until the target (center of head) was achieved.

With presentation levels to the better ear set to a "comfortable" setting, interactive adjustments were made to the poor ear level in a bracketing approach until a center-point position of the interrupted (pulsed) tone signals was reported. Three determinations of the levels, with incremental changes as small as 2.5 dB, were done for each stimulus to provide confidence in the measured levels. The initial signals were pulsed tone frequencies of 250, 500, and 750 Hz for this subject.It was not difficult for the listener to reach the desired "center of the head" level relatively quickly and without variation on the three repeated determinations for each signal. The recorded tonal measures are shown as red/blue bars for this subject in Figure 1. It can be seen that the differences at the

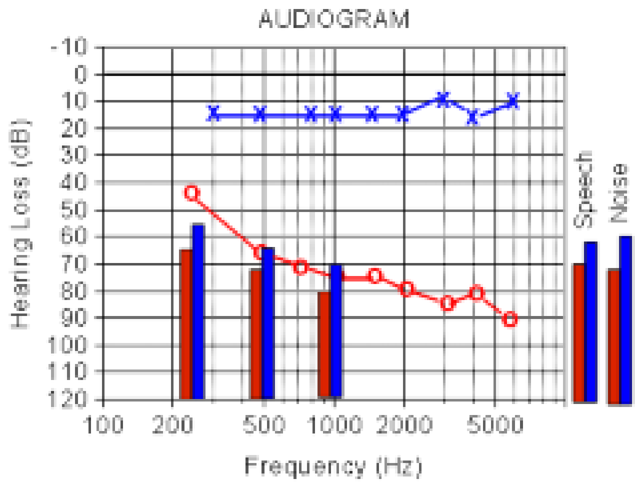

Figure 5.Threshold and plotted examples of levels to achieve balances for selected signals for a male subject with adventitiously acquired hearing loss for the right ear (see text).

two ears converged to substantially reduced values of less than 7.5 dB, in some cases less than 5 dB! A steep pattern of "loudness catch-up" is observed through an assumed combination of possible unmasked cross over and binaural processing. The pattern is somewhat similar to the steep growth of loudness associated with classical sensori-neural hearing loss patterns as compared to normal hearing patterns.

This familiar pattern, and the basis for many amplification assumptions, is shown as a reminder in Figure 3. At any rate, it should be immediately observed from Figure 1 that *the inter-ear differences* greatly constrict at supra-threshold presentation levels – levels closer to normal listening conditions. Moreover, the pattern, when studied at several presentation levels, for this listener looks like that of Figure 4.

An additional method by which speech and music was introduced to collect observations on non-sinusoidal signals was introduce on several of the subjects, including for the subject portrayed in Figure 1. The procedure for these measures follows later in this article.

A second audiometric example is shown in Figure 5. This was a male, age 52, with essentially normal hearing on the left ear and severe loss on the right ear subsequent to a vaccine reaction at age 50.

Some initial spontaneous threshold recovery was observed in the impaired ear for this subject in the first several months post-onset. The stabilized thresholds in the severe range are shown in Figure 5 along with inter-ear difference measure results. This subject had tried amplification sporadically with limited success on the impaired right ear. Distortion of external sounds, and of his own voice, dominated his auditory experience, even with very mild gain values. Currently, he reports help with localization and hearing in quiet with amplification levels far less than standard prescription gain proposals.[9] The balancing tasks were more difficult for this subject due to substantial distortion in the otopathologic ear. He was, however, able to achieve repeatable results shown in Figure 5, including for music.

Once again in Figure 5 we have plotted difference levels for selected signal at which balance sensations were achieved. The results were again striking examples of the previously mentioned "catching up" behaviour for the several frequencies tested. It was clear for this subject, also, that a significantly smaller amount of difference for presentation levels to the two ears was required to achieve a sense of "center of the head" lateralization experience for tones, speech, and music at comfortable listening levels (CLL) than implied by the threshold audiogram. An experience of binaural auditory perception was clearly achieved, both surprising and curiously amusing the subject.

Similar findings were observed for the other participants in these clinical observational studies if cochlear site of lesion was presumed. Clearly the patterns speak to the high value that Nature assigns to the principle of *Balance*, (with regard to audition, rather than to vestibular function), even when injury and medical mishaps conspire to disrupt it. To re-iterate, differences of 50 and 60 dB at threshold were in some cases condensed to 5 dB *or less* at comfortable sensation levels. It is noteworthy that, in several instances subjects reported that the auditory "image" jumped rapidly from right to left, requiring a few moments to engage the adjustments so as to locate the sound within the head. This usually occurred when a long and substantial "ear dominance" made the introduction of sound to the more severe ear particularly unusual.

Another interesting report from several subjects with long-term severe deficits was the experience of a "phantom" image to the bad side perceived briefly when all stimulation was moved back to the better side. Audiograms and notes for two such subjects are shown in Figure 6, and

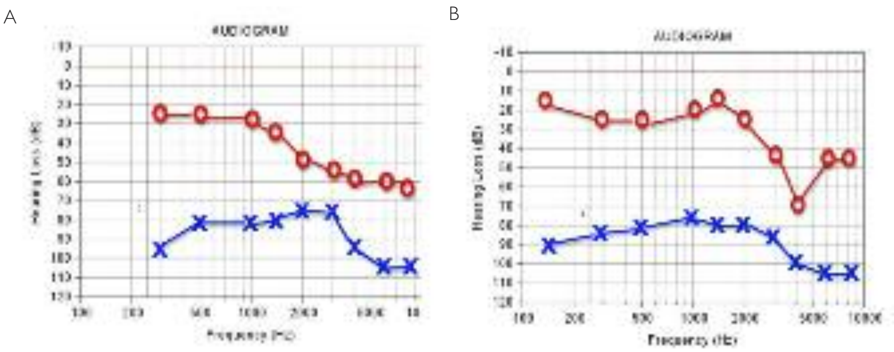

Figure 6. Two additional samples of assymetrical audiograms on individuals (Males ages, 64 & 53) we have studied. They have quite different histories and etiologies, and only one has test data at 125 Hz. However, both had confusions of which ear was stimulated in some conditions, including perceiving a signal in the 'bad'' ear when stimulation had returned entirely to the better ear (Figure 8). Both have worn hearing aids (for different lengths of time) in the worse ear.

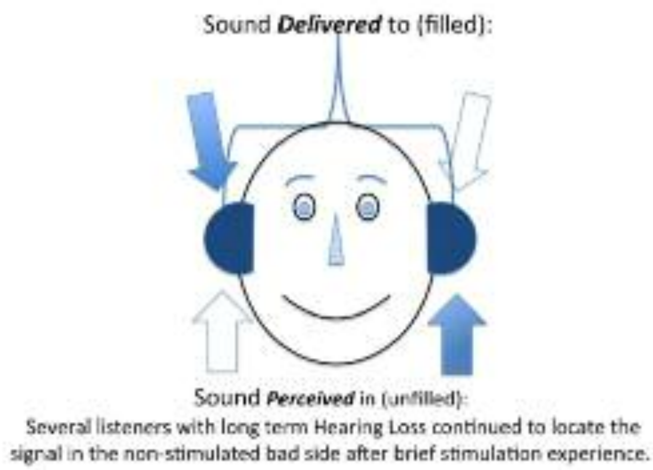

Figure 7. Illustration of cross-head migration of perception observed in several subjects after stimulation of the long-term "bad" ear; subsequent stimulation to the better was reported as still lateralized to the now non-stimulated ear side.

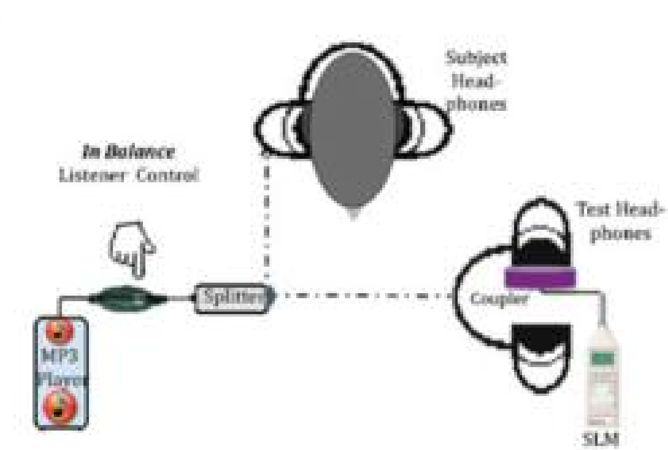

Figure 8. Measurement scenario for determining the relative dB spl differences between headphones when subjects adjusted the music from a digital player to a Center of Head position.

Figure 7 attempts to illustrate the perceptual "cross-over" with an unlikely, but admittedly uncertain, amount of acoustic cross-over given the presentation conditions. It appears that the higher neurological features of the auditory pathway, cortical activity and synaptic pattern tracks associated with these perceptual tasks makes the task complex and sometimes ambiguous for the listener. Established neural pathways may require "new registrations" when stimuli are moved and mixed in the manner described here. Sensitive brain imaging and/or mapping techniques are almost certainly needed for more comprehensive answers.

Generally our observations have consistently shown a systematic reduction of the difference to achieve balance as a function of sensation level. In other words, as presentation levels were increased to the better ear, the amount of *difference* to the injured ear was further reduced as suggested in Figure 5.

It is well-established that large individual differences exist in *loudness growth* patterns among listeners with sensori-neural hearing loss.[4,5] Inter-ear differences, as in cases of asymmetrical hearing sensitivities, present numerous additional uncertainties related to balanced auditory perception. As mentioned above, some of the measured findings for these subjects may be related to classical "cross over" stimulation since classical masking was not introduced for the surpra-threshold measures. However, since the better ear was also receiving simultaneous stimulation of the same signal, it is difficult to sort the interactive aspect. It is also reasonable to speculate that some post-cochlear processes through the brainstem and mid-brain nodal centers may have contributed to the net experience of de-lateralized perception. The report of several listeners

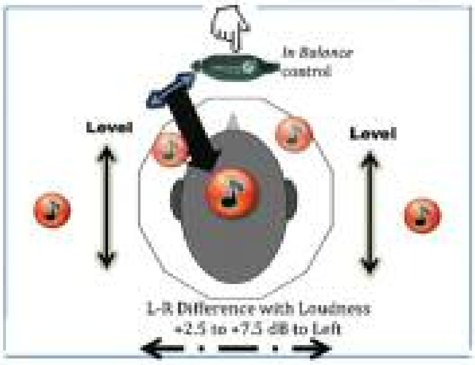

Figure9. Illustration of the use of the In Balance control to achieve a "Center of Head" experience for the music passage. Differences were measured using a steady pink noise as shown in Figure 3. For the subjects described in Figure 2 and several others, depending on the loudness listening level, the differences ranged from 2.5 to 7.5 dB. Not surprisingly the least differences occurred at louder sensation levels in patterns such as shown in Figure 4.

of the "phantom image" in the non-stimulated ear seems consistent with such a conjecture. Conceivably, such post-cochlear pathways may have been the dominant effect, but the clinical research reported here did not have the measurement sensitivity or rigor to inquire deeply into the neuro-physiological mechanisms.

Although most studies of binaural loudness summation[7,8] make use of symmetrical hearing loss subjects, this finding, of an interaction with sensation level, is consistent with studies of binaural loudness summation patterns as a function of level. It further emphasizes the uncertain relation between threshold audiometry and the typical goal of amplification – the delivery of normal speech acoustics to a "comfortably clear level" (CCL), especially when inter-ear differences are present.

NON-CLINICAL SOUNDS

For many of the subjects we extended these studies to the related question of whether binaural perception of signals for unilateral or asymmetrical sensori-neural impairments can still produce 'center of the head' lateralization, or stereophonic listening experiences – at preferred listening levels? In other words, do acoustically dichotic signals (not diotic) of stereo music presented via headphones converge to an enjoyable auditory experience if and when the levels at the two ears can be independently adjusted for ears of dissimilar audiometric sensitivity (threshold)? This was addressed by use of a proprietary In Balance control made by Able Planet, Inc. The listener/subject was able to adjust the Left/Right levels of signals delivered from an MP3 player into a set of consumer audio headphones. The In Balance control uses linear tapering to adjust inter-ear differences by up to 24 dB. The music and some recorded speech data shown in Figures 1 and 5 were obtained by having the subjects listen to a musical passage played into a set of Able Planet NC-200 headphones and adjust the In Balance control. The subjects first adjusted the basic volume for a passage of Bonnie Rait's "Something to Talk About" played at a comfortably clear level (CCL). The 15 subjects in this part of the study indicated the passage (and level) was enjoyable. They adjusted the balance control to reposition the sound until a middle of the head position was achieved. This was usually accomplished in a few seconds after over-adjusting briefly to the worse ear, before converging on the best position. The control was then 'locked' into position with the secure toggle switch.

By splitting the signal to a matched set of headphone's the sound pressure level difference between the individual ear outputs were obtained on a standard sound level meter in A-weighted slow mode secured into a coupler. When the subject reported a position at (or near) the target of Number 15 (Figure 2) position on the head chart, the balance control was locked and a pink noise signal was played through the MP3 device. Measured pink noise output differences in dB SPL (sound pressure level) for the two earphones were recorded as inter-ear level differences (see Figure 8). For the first subject described above those differences ranged from 2.5 dB to 7.5 dB, depending on the level at the better ear as shown in the Figure 1 details. Figure 9 adds further descriptive detail of the adjustment protocol.

SUMMARY

Asymmetrical hearing loss patterns with differences of 35 dB or greater are understood to present diagnostic challenges of masking in order to isolate the more severe ear. They also introduce considerable uncertainty as to inter-ear differences at supra-threshold levels. In cochlear-based asymmetries there is the strong likelihood that *differences* between ear responses at threshold, especially in the case where one ear is essentially normal, will show considerable 'catching up' at supra-lateralization of bilaterally presented sound stimuli such as in the use of headphones for entertainment. Typical listening levels for such purposes are, of course, considerably more intensive than barely audible (threshold) levels. We have described some clinical research that attempts to join audiometrics with commonplace listening experience. The availability of a reliable balance control may notably improve the stereo listening enjoyment of unilaterally impaired, or asymmetrical listeners without much required offset.

Not surprisingly individual differences for the subjects we have observed in this audiometric category were noteworthy. The issues that confound unilateral and asymmetrical sensori-neural hearing loss were operating to make each subject unique in his or her auditory history and inter-ear dissimilarities. Nevertheless, the robust and fundamental binaural processing of signals, even from ears of unequal sensitivities and stimulation histories could be readily observed for all three subjects.

The clinical tradition for hearing assessment is to first separate the two naturally communicating acoustical sensors (ears), and then to measure them independently. Perhaps it is characteristic of the discovery process that sometimes a great deal can be learned about complex systems, such as hearing, from modest changes in protocol and the serendipitous presentation of a few individuals with non-standard hearing patterns. These findings are instructive at several levels of discourse.

These carefully obtained, but admittedly not rigorously researched, observations of a relatively small group of listeners with asymmetrical hearing patterns suggest numerous 'surprises' await the inquisitive and engaged clinician. It is noteworthy that many subjects indicated that being able to re-position the listening experience towards a center of the head position was a desirable feature. In several instances it produced an unprecedented and enjoyable auditory sensation.

The corresponding audiologic findings on these listeners' binaural balancing experience under controlled conditions are of interest of themselves. The present findings, while obviously varied among the members of the small sample size, are patterns uniquely pertaining to sensori-neural type of impairment, presumably reflecting cochlear damage of varying durations. This assumption was supported by tests on two additional asymmetrical subjects with entirely conductive sites of lesion. Their experience was completely different. In both cases it appeared that balanced performance might possibly only occur if the large threshold differences were essentially maintained and carried up to the supra-threshold listening levels. This was both impractical and outside the interest of the present investigation.

While the various differences between the subjects argues against averaging these findings it was tempting to simply compare the Average Threshold difference between 'good' and 'bad' ears with the Average Balanced level difference. Those numbers are: 4**9.2 dB Threshold** versus **7.4 dB for supratheshold Balance** values across all the various signal types and sensation levels. Clearly, something similar to the speculative pattern of Figure 4 was at work. Clinicians are encouraged to consider the potential for significant differences that may occur 'between the ears' at supra-threshold listening levels in these types of patients.

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