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Canadian Hearing Report

CAA Canadian Academy of Audiology Heard. Understood.
Academie canadienne d'audiologie Entendus. Compris. ACA

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Vol. 4 No 3

Revue canadienne d'audition

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Another issue and another season. To date, the *Canadian Hearing Report* has been published four times a year. However, I suspect that once a season is too sparse. In attempt to keep the *Canadian Hearing Report* under your nose (or in your favourite reading spot, whether it's the beaches of Calgary or the bars of downtown Halifax) starting in January 2010 we will be moving to six issues a year – 1.5 times a season, or every other month. This will allow us to bring you even more current information and articles based on sound (if you'll excuse the pun) basic science.

Beginning in this issue we are introducing a new column called "E" is for Engineering where our engineering colleagues will be discussing topics of interest to audiologists. This will provide some unbiased insight into why certain technical innovations are implemented in a certain way and the strengths and limitations of the innovations. Questions that may be addressed in future issues may be why a certain hearing aid component is designed the way it is and how does that impact on internal noise, and what are the advantages (and disadvantages) for performing digital calculations in the time domain versus the frequency domain? In short, this column will function as a bridge between the audiologist and the engineer in hopes of increasing two-way communication.

Our Audiology News section will help keep everyone abreast of the latest news and changes in our field. Of interest, and of great sadness, we have learned about the closing down of one of Canada's gems – the acoustic and signal processing group of the National Research Council in Ottawa. This group was made up of world-class luminaries such as doctors E.A.G. Shaw, Michael Stinson, Tony Embleton, and Gilles Daigle, who performed basic acoustic research such as the first work on transfer functions of the outer ear.

And I am pleased to welcome Lendra Friesen back to the *Canadian Hearing Report*. Lendra had written a "From the Labs" column in a previous issue and does research in the area of cochlear implants. She is our newest member of our edito-

Un autre numéro et une autre saison. A jour, *la Revue Canadienne d'Audition* est publiée quatre fois par an. Toutefois, je sens qu'une fois par saison n'est pas suffisant. Dans l'effort de garder *La Revue Canadienne d'Audition* sous vos nez (ou dans votre coin de lecture favori, que ce soit sur les plages de Calgary ou les bras du centre ville de Halifax) à partir de Janvier 2010, nous allons passer à six numéros par an – 1.5 fois par saison, ou tous les deux mois. Ceci nous permettra de vous fournir une information encore plus récente et des articles basés sur le bon sens (si vous me passez l'expression) de la science fondamentale.

Avec ce numéro, nous allons présenter une nouvelle colonne qu'on a appelée "E" qui est pour l'ingénierie, et à travers laquelle nos collègues ingénieurs vont discuter de sujets d'intérêt pour les audiologistes. Ceci fournira des avis impartiaux sur la mise en œuvre de certaines techniques d'innovation ainsi que les points forts et les limitations de ces innovations. On pourra répondre dans les prochains numéros aux questions telles, certains éléments des appareils auditifs sont conçus d'une façon et pas d'une autre et l'impact de ceci sur le son interne, et les avantages (et inconvénients) sur les calculs numériques dans le domaine temps versus le domaine fréquence? En bref, cette colonne sera un pont entre l'audiologiste et l'ingénieur dans l'espoir d'augmenter la communication bidirectionnelle.

Notre section des nouvelles de l'Audiologie permet à tout le monde de rester à l'affut des dernières nouvelles et des changements dans notre domaine. Avec intérêt et grande tristesse, nous avons appris la fermeture d'un des joyaux du Canada- le groupe pour le traitement du signal et l'acoustique du Conseil National de Recherches du Canada à Ottawa. Ce groupe était composé d'imminences de renommée mondiale tels les docteurs E.A.G. Shaw, Michael Stinson, Tony Embleton, et Gilles Daigle, qui a exécuté de la recherche acoustique fondamentale tel le premier travail sur le transfer de fonctions dans l'oreille externe.

Et j'ai le plaisir souhaiter la bienvenue à Lendra Friesen qui est de retour à *la Revue Canadienne d'Audition*. Lendra a rédigé la colonne "Des laboratoires" dans des numéros précédents et fait de la recherche dans le domaine des implants cochléaires. Elle est notre nouveau membre de notre comité de rédaction, et amène une richesse en information. Lendra va rédiger la colonne "Spotlight on Science" dans les prochains numéros. J'ai écrit celle de ce numéro et c'est une

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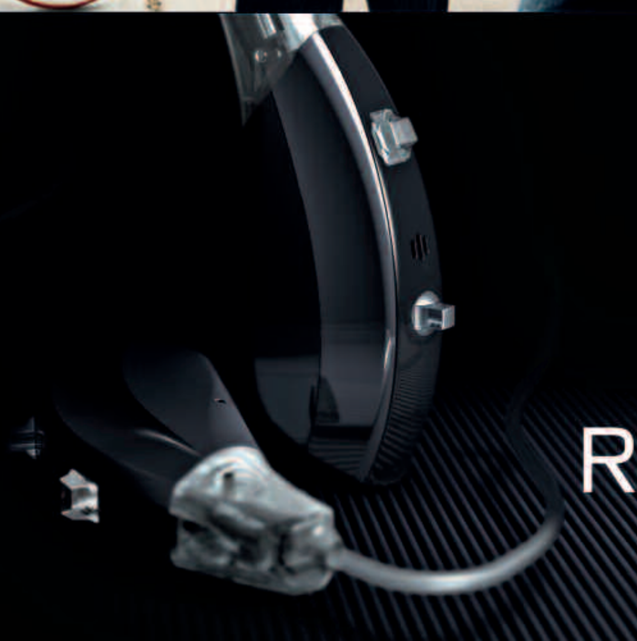

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rial committee, and brings with her a wealth of information. Lendra will be writing "Spotlight on Science" columns in future issues. The one in this issue was written by me and it's a review of an excellent article that appeared in *Ear and Hearing* on genetics.

The content of the *Canadian Hearing Report* needs to come primarily from its members. After all, this is the official organ of the Canadian Academy of Audiology. Articles for submission do not need to be long – just interesting and well written … or at least interesting … we have a wonderful editorial board that checks "speling" mistakes and can help in wordsmithing when required. Articles of a clinical orientation are always welcome and this includes interesting cases and how they were handled.

By the time this issue comes out we will be in convention mode and I'll be there with two hats on – one is to learn new material and the other is to surreptitiously sneak around and try to encourage the presenters to submit their material for publication in the *Canadian Hearing Report*. I must admit to a slight bias in that I have always learned the most from the poster sessions. Many of these are by students and reflect the blood, sweat, and tears of months (if not years) of research. If you are planning to attend the Canadian Academy of Audiology conference take some time and browse through the poster sessions – I think that you will be impressed.

And most importantly, when at the convention, if you didn't already know, it is official CAA policy to buy the editor-in-chief of the *Canadian Hearing Report* a beer (or two)…

Best regards,

Marshall Chasin, AuD, MSc, Reg. CASLPO,
Doctor of Audiology
Editor-in-Chief

révision d'un excellent article publié dans *Ear and Hearing* en génétique.

Le contenu de *la Revue Canadienne d'Audition* doit essentiellement parvenir de ses membres. Après tout, c'est l'organe officiel de l'Académie Canadienne d'Audiologie. Les articles à soumettre n'ont pas à être longs –juste intéressants et bien écrits …ou au moins intéressants …nous avons un conseil de rédaction qui vérifie " les fautes d'ortographes" et peut faciliter le choix des mots quand nécessaire. Les articles aux orientations cliniques sont toujours les bienvenus et ceci comprend les cas intéressants et leur prise en charge.

A la sortie de ce numéro, nous serons dans le mode congrès et j'y serai avec deux chapeaux- pour en savoir plus sur le nouveau matériel et pour me faufiler afin d'encourager les conférenciers à soumettre leur travail pour publication dans *la Revue Canadienne d'Audiologie*. Je dois admettre une certaine impartialité dans le fait que j'ai toujours appris le plus lors des sessions d'affichage. Plusieurs affiches sont le travail d'étudiants et sont le reflet du sang, de la sueur, et de larme versées après des mois (sinon des années) de recherche. Si vous avez l'intention d'assister à la conférence de l'Académie Canadienne d'Audiologie, prenez le temps de naviguer à travers les sessions d'affichage– Je pense que vous allez être impressionnés.

Et plus important, quand vous serez à la convention, au cas ou vous ne le saurez pas encore, c'est un règlement officiel de l'ACA de payer une bière (ou deux) à l'éditeur en chef de *la Revue Canadienne d'Audiologie* …

Meilleures salutations,

Marshall Chasin, AuD, MSc, Reg. CASLPO,
Docteur en Audiologie
Éditeur en chef

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What is CAA?

For the past week I have been struggling with this question and this column. What is the Canadian Academy of Audiology? I mean, I can give you the pat answer that:

> The Canadian Academy of Audiology is a professional organization dedicated to enhancing the profession of Audiology, the provision of quality hearing health care and education to those with, or at risk for, hearing and/or vestibular disorders.

But we are so much more than that. I tried to think of what it is that defines us. Is it our conference? Is it our advocacy? Is it our education? Then it struck me. What defines us, what makes us different from everyone else? Our members.

Many years ago I was in my last year of an American audiology program. I planned to move back to Canada to do my final placement and I knew no one in the field here. Thankfully around that same time a group of Canadian audiologists got together and decided to form the Canadian Academy of Audiology (CAA). That same year they held their first conference and I was there. A shy, (yes I did say shy stop laughing) determined audiology student at her first professional conference. (Even though I had attended school in the states I did not attend an AAA conference until two years after I graduated.) The CAA conference was the gold standard against which I compared all others and it did not disappoint. Sessions offered were wonderful, the networking was invaluable but what I remember the most is the people. They were dedicated, they were supportive, and they were helpful beyond my wildest expectation. But the thing that really stood out for me was the passion that I saw in those in attendance; it was awe inspiring.

Thirteen years later I am still inspired by the audiologists in Canada. They are a dedicated group who work together and individually to improve the quality of hearing health care and the field of audiology across the country and around the world. We all know them. The clinician who also helps with the summer theatre camp for kids who are hard of hearing or Deaf. The professor who pushes their students to challenge themselves, to make new dis-

Qu'est l'ACA?

Ca fait une semaine que je me penche sur cette question et cette colonne. Ce qu'est l'Académie Canadienne d'Audiologie? Je veux dire, je peux vous donner la réponse d'à propos qui est:

> L'Académie Canadienne d'Audiologie est une organisation professionnelle dédiée à rehausser la profession de l'Audiologie, la provision pour des soins de santé de qualité de l'ouïe et la formation de ceux ou celles avec, ou à risque de développer, des troubles auditifs et/ou vestibulaires.

Mais nous sommes beaucoup plus. J'ai essayé de réfléchir à ce qui nous définit. Est-ce notre conférence? Est-ce notre art de plaider? Est-ce notre formation? Puis ca m'a frappé. Ce qui nous définit, ce qui nous rend différents des autres? Nos membres.

Il y'a plusieurs années, j'étais à ma dernière année d'un programme d'audiologie américain et j'avais planifié de retourner au Canada pour faire mon dernier placement mais je ne connaissais personne du secteur ici. Heureusement, au même moment, un groupe d'audiologistes canadiens se sont réunis et ont décidé de créer l'Académie Canadienne d'Audiologie (ACA). La même année, ils ont organisé leur première conférence et j'étais parmi l'assistance. Une timide (oui j'ai bien dit timide, arrêtez de rire) étudiante en audiologie déterminée à sa toute première conférence professionnelle. (Même si je faisais mes études aux états unis, je n'ai assisté à une conférence de l'AAA que deux ans après mon diplôme.) La conférence de l'ACA était la norme d'or à la quelle je comparais toutes les autres et elle n'a pas déçu. Les sessions offertes étaient superbes, le réseautage de très grande valeur mais ce dont je me souviens le plus est l'assistance. Des personnes dévouées, offrant leur soutien et leur aide au-delà de toutes mes espérances. Mais la chose qui m'a vraiment frappé est la passion que j'ai trouvée dans l'assistance; une vraie inspiration.

Treize ans plus tard, je demeure inspirée par les audiologistes du Canada. C'est un groupe dévoué dont les membres travaillent ensemble et individuellement à améliorer la qualité des soins de santé auditifs et le secteur de l'audiolocoveries to advance the fields of hearing science and audiology. The individuals who work together to bring audiological services, supplies, and training to those in developing countries who might otherwise live in silence. The corporations who promote audiology and hearing health care around the world every day. These are the people who will inspire the next generation of audiologist, but only if they hear about them. So how do we ensure that their songs are sung to the masses?

The Canadian Academy of Audiology presents annual awards to audiologists and those in related fields who have made a significant contribution to the profession. What we need from you is nominations. Help us to publicly recognize the good work that we do as a profession. There are five awards for which you can nominate someone. The following awards are available:

- The Moneca Price Humanitarian Award
- Paul Kuttner Pioneer Award
- Jean Kienapple Award for Clinical Excellence
- Richard Seewald Career Award
- Honours of the Academy

(see the CAA website, www.canadianaudiology.ca, for more details on these awards)

The call for nominations went out earlier this year and the response was fabulous. Each year, these awards a given to individuals whose peers have centered them out as being exceptional. These awards are presented at the President's Luncheon and I hope that you will be there to help us honour these outstanding award winners. I also hope that our winners this year will inspire you to nominate someone you know who has made a significant contribution to audiology. Help us let the world know what audiologists can do.

Carri Johnson
President
Canadian Academy of Audiology
president@canadianaudiology.ca

gie à travers le pays et dans le monde. Nous les connaissons tous. Le clinicien qui aussi offre son aide au camp de théâtre d'été pour enfants malentendants ou sourds. Le professeur qui incite ses étudiants à se défier, à aller à la recherche de nouvelles découvertes pour faire avancer les secteurs de la science de l'ouïe et de l'audiologie. Les personnes qui travaillent ensemble pour faciliter l'accès aux services audiologiques, l'approvisionnement et la formation de ceux dans les pays en voie de développement qui autrement vivent dans le silence. Les entreprises qui, chaque jour, font la promotion de l'audiologie et des soins de santé audiologiques à travers le monde. Ce sont ces personnes qui vont inspirer la prochaine génération d'audiologistes, mais seulement s'ils savent qu'elles existent. Comment donc pouvons-nous nous assurer que leurs chansons sont chantées aux masses? L'Académie Canadienne d'Audiologie présente des prix annuels aux audiologistes et à d'autres travaillant dans des secteurs affiliés, qui ont eu une contribution significative à la profession. Nous avons besoin de vos mises en candidature. Aidez nous à reconnaitre publiquement le bon travail que nous faisons comme profession. Il y'a cinq prix auxquels vous pouvez proposer un lauréat. Voici les prix disponibles:

- Prix Moneca Price pour activités humanitaires
- Prix du pionnier Paul Kuttner
- Prix Jean Kienapple pour l'excellence clinique
- Prix professionnel Richard Seewald
- Honneur de l'Académie

(Pour plus de détails sur ces prix, veuillez visiter le site web de l'ACA, www.canadianaudiology.ca)

L'appel pour les mises en candidature a été lancé plus tôt cette année et la réponse a été fantastique. Chaque année, ces prix sont remis à des personnes dont les collègues ont vanté l'exceptionnalité. Ces prix sont remis au Diner du Président et j'espère que vous serez présents pour nous aider à honorer ces récipiendaires exceptionnels. Je souhaite aussi que les lauréats de cette année vous inspirerons à mettre en candidature quelqu'un que vous connaissez et qui a eu une contribution significative à l'audiologie. Aidez nous à faire savoir au monde ce que les audiologistes peuvent accomplir.

Carri Johnson
Présidente
L'Académie Canadienne d'Audiologie
president@canadianaudiology.ca

NATIONAL AUDIOLOGY WEEK

This year, National Audiology Week will be during the week of October 19 to 25. In this edition of *CHR* you will find this year's poster.

We encourage all audiologists to participate at that week to help our profession become better known by the public.

Cette année la Semaine Nationale de l`Audiologie aura lieu dans la semaine du 19 au 25 octobre. Dans cette édition de la *RCA* vous trouverez une copie de l`affiche pour cette année.

Nous encourageons tous les audiologistes a participer à cette semaine pour mieux faire connaître notre profession au public.

"A Giant in Pediatric Audiology" Retires

By JB Orange and Marlene Bagatto, School of Communication Sciences and Disorders, and Program of Health and Rehabilitation Sciences, Faculty of Health Sciences, University of Western Ontario

Dr. Richard C. Seewald retired on June 30, 2009 from the School of Communication Sciences and Disorders and the National Centre for Audiology in the Faculty of Health Sciences at the University of Western Ontario (UWO). His well-earned retirement came 40 years after he earned his baccalaureate degree in speech pathology and audiology from Ithaca College in 1969. During his 40 year career as a world-renowned audiologist, most noted for his meticulous work on developing and advancing the Desired Sensation Level (DSL) Method used by audiologists to select and to fit hearing aids for their pediatric clients, Richard showed unfailing devotion to the profession of audiology and to infants and young children with hearing loss.

Dr. Richard C. Seewald

Richard's career in audiology began in earnest after he was awarded his master's degree in audiology in 1974 from the University of Minnesota. In the mid-1970s, he moved to Canada to work as a clinical audiologist in the Nova Scotia Hearing and Speech Clinic in Halifax. An unexpected rubella outbreak in Nova Scotian children and their ensuring hearing problems galvanized Richard's resolve to devote his career to paediatric audiology. In order to best meet the needs of children with hearing loss and to satisfy his desire to learn how to help them more effectively, Richard completed his doctoral degree in 1981 in audiology under the sage guidance of Professor Mark Ross at the University of Connecticut at Storrs. After a brief stint as an assistant professor in the Department of Speech Pathology and Audiology at Ithaca College, Richard returned to Nova Scotia in the early 1980s to take up a faculty position in the School of Human Communication Disorders at Dalhousie University at Halifax. During his time at Dalhousie as an assistant professor, Richard published a report on the use of computers and mathematical formulas to guide audiologists in the selection and fitting of hearing aids to infants and children with hearing loss.

In 1986, Richard and his wife

Carol moved from Dalhousie University to the University of Western Ontario at London Ontario where Richard took up a faculty position in the Department of Communicative Disorders. Richard's research career blossomed over the 23 years he spent at Western. His scholarly work on a software-based hearing aid selection and fitting procedure surged with the development of the DSL Method and its evolving, more sophisticated versions. The DSL software provides audiologists with easy access to evidence-based calculations so their young clients with hearing loss will have the best access to sound through their hearing aids in order to develop speech and language skills. This was a pioneering translation of laboratory research directly to the clinic. It is this type of knowledge transfer activity on which Richard worked throughout his career and which he will continue to pursue during his retirement.

Richard worked diligently, methodically and collaboratively for many years refining the DSL Method. His scholarly work attracted the attention of multiple industrial and peer-reviewed funding agencies that helped support his research. Moreover, Richard recruited multi-talented graduate students and research associates to his laboratory, with each adding new dimensions and perspectives to his foundational work in pediatric audiology and to the DSL Method in particular. During his time at the University of Western Ontario, Richard acted as wise and respected mentor to dozens of research audiology students, learned teacher to budding clinical and research audiologists, and trusted colleague to fellow faculty. He was instrumental in the early development and advancement of the Hearing Health Care Research Unit at the UWO that later evolved into the internationally acclaimed National Centre for Audiology. Richard also championed the development and implementation of the Ontario Infant Hearing Program (IHP), a service that screens the hearing of every infant born in Ontario and has resulted in the earlier detection of and appropriate remediation for infants and children with hearing impairment. The IHP has been the model program of choice used in many countries the world over to screen and to assess the hearing of infants and children and to provide appropriately-fitted hearing aids to those infants with hearing loss using the DSL Method. His role as consultant to the IHP has been instrumental to its continuing successes.

Richard's seminal research and academic work was noticed and acknowledged by university officials, research foundations, and clinical and research colleagues. Starting in 2002, Richard held the Canadian Institutes of Health Research Canada Research Chair in Childhood Hearing. The federally funded chair position provided protected time and resources for his focused research. He was awarded professor status in 1997 which was then advanced to the prestigious level of distinguished university professor in 2008, a title bestowed on only a select three or four outstanding faculty at the UWO each year. Richard's numerous research awards include, but are not limited to, the Richard Seewald Annual Award for Childhood Hearing, named in his honour by the Hear the World Foundation. In addition, he received the Career Award from the Canadian Academy of Audiology, the Lifetime Achievement Award from the Canadian Association of Speech-Language Pathologists and Audiologists, the International Award in Hearing from the American Academy of Audiology, and an honorary doctorate of laws, honoris causa from Dalhousie University.

A review of Richard's career accomplishments shows that he achieved the status of "giant" in pediatric audiology. In addition to being an accomplished scientist, he also demonstrated tremendous artistic talent and creativity, especially in his photographic arts which adorn the walls in many buildings at the UWO. It is clear that he is finely attuned to exquisite sensory stimulation – both auditory and visual. Those of us working in the area of human communication disorders, particularly in the profession of audiology and the discipline of hearing science, are indebted to Richard for his sound research, his uncompromising collegiality, and his humble leadership. Moreover, we acknowledge and thank Richard for being a leading, international figure whose highly creative and original work will continue to influence researchers, clinicians, colleagues, policy makers, families, and those with hearing loss throughout the world for decades to come.

The Richard C. Seewald Entrance Scholarship in Audiology will be awarded annually to a full-time student entering the first year of the audiology program in the School of Communication Sciences and Disorders at The University of Western Ontario, who demonstrates a strong professional commitment, as well as academic excellence. Preference will be given to the student who demonstrates all-around academic excellence and exceptional potential relating to the practice of clinical audiology. To contribute to the scholarship or for further information, please contact Catherine Dorais-Plesko, The University of Western Ontario, at 519-661-2111x85199 or cdoraisp@uwo.ca.

Dr. André Marcoux Named Head of CHHA National Advisory Committee on Science and Industry

Dr. André Marcoux, professor of audiology at the University of Ottawa has been appointed to head the Canadian Hard of Hearing Association's (CHHA) new National Advisory Committee on Science, Health and Industry. In a recent announcement, Carole Willans, the national president of CHHA, stated that "its role is to provide the CHHA National Board of Directors with advice on relevant and current issues and initiatives related to science, health, and industry."

This is Dr. Marcoux's first experience with this consumer-based group and it promises to be quite fruitful. Dr. Marcoux stated that he has urged CHHA over a number of years to become more vocal on issues relating to science and this appointment will help for this to occur. When one thinks of organizations such as CHHA, one thinks about accessibility, and this new scientific thrust spearheaded by Dr. Marcoux will add a much needed scientific component for providing access for the hard of hearing.

Dr. Marcoux stated that CHHA is an excellent organization with which to become involved. He states that "it is well organized and provides no direct service other than support and education to its members. As such it will be well positioned to influence decision makers in a wide range of industries and governments."

A Canadian Chapter on Acoustics is Closed

By Jim Ryan

The National Research Council's Acoustics and Signal Processing Group played a key role in the acoustics research community for 60 years, from its inception in 1929 to its recent closure earlier this year.

Acoustics research at NRC was first established in 1929 as the Acoustics Section of the Division of Physics. The effort grew into three separate laboratories: one focused on ultrasonics, another on building research and a third which became the Acoustics and Signal Processing Group. This group became part of the Institute for Microstructural Sciences in 1990.[1]

Over the years, the members of this group made significant contributions in many different areas of acoustics. Of particular note to those involved in audiology are the contributions to ear canal modeling (Stinson and Daigle[2]), external-ear acoustics (Shaw[3]) and the impact of physiological noise on audiometry (Shaw and Piercy[4]).

Influence of the group's activities was felt internationally. Members of the group received numerous awards and accolades over the years and three members of the group became president of Acoustical Society of America: G.A. Daigle (2007–2008), T.F.W. Embleton (1980–81) and E.A.G. Shaw (1973–74).

Although the group has now been disbanded, its members have made a lasting contribution both to Canada's expertise in acoustics and our international reputation.

1. Shaw EAG. The Acoustics Section: A Profile of the Laboratory. Acoustics and Noise Control in Canada 1981;9(2).
2. Stinson MR, Daigle GA. Transverse Pressure Distributions In a Simple Model Ear Canal Occluded By a Hearing Aid Test Fixture. The Journal of the Acoustical Society of America. 2007;121(6):3689–702.
3. Shaw EAG. Diffuse Field Response, Receiver Impedance, and the Acoustical Reciprocity Principle. The Journal of the Acoustical Society of America. 1988;84(6)1988:2284–87.
4. Shaw EAG, Piercy JE. Physiological Noise in Relation to Audiometry. The Journal of the Acoustical Society of America 1962;34(5):745.

2009 CASLPA Clinical Research Grant Recipients

Congratulations to Marshall Chasin and Mojgan Owliaey (co-recipient Benoît Jutras), who each received a grant of $2,500.

Of the many differences between languages, subject-object-verb (SOV) languages such as Korean have post-positions which tend to have lower intensity than English (or SVO) prepositions. Marshall Chasin's research will test the hypothesis that compression circuitry should be set to yield more gain for low level inputs for Korean than for English.

Mojgan Owliaey along with Benoît Jutras will focus their research on auditory processing. The research questions they will investigate are the following: How do children with an APD benefit from hearing in noise training, in terms of neurophysiology and auditory behaviours? Does therapy impact on the social participation of children with an APD?

CASLPA would like to thank AON for their generous sponsorship and support of clinical research in Canada.

More information is available at: http://www.caslpa.ca/english/profession/clinical_research_grants_winners.asp

17th Annual Conference on Management of the Tinnitus Patient

September 24–26, 2009

FOR PATIENTS AND PROFESSIONALS: SPONSORED BY THE DEPARTMENT OF OTOLARYNGOLOGY – HEAD AND NECK SURGERY, DEPARTMENT OF COMMUNICATION SCIENCES, THE UNIVERSITY OF IOWA

This conference is intended for otologists, audiologists, psychologists, and nurses who provide clinical management services for patients with tinnitus. The conference will also provide information to patients who have tinnitus, their family and friends, but it will NOT include individual diagnosis and treatment. The purpose of this conference is to provide a review of current evaluation and management strategies for the treatment of tinnitus. Upon completion of the program, the participant will be able to discuss the management of tinnitus and the tinnitus patient.

The guest of honour is Paul Van De Heyning, MD – Electrical Stimulation of the Cochlea and the Auditory Cortex for the Treatment of Tinnitus

For more information please visit: www.uihealthcare.com/depts/med/otolaryngology/conferences/TinnitusBrochure2009.pdf

Canadian Academy of Audiology Appoints Tate Marketing as Agency of Record

The Board of Directors of the Canadian Academy of Audiology (CAA) announced Tate Marketing Inc. has been appointed its new agency of record. The GTA-based shop was shortlisted with six other agencies during a nationwide review process that began in early June.

Carri Johnson, CAA President, was exuberant. "Tate provided CAA with a top of the line plan of what they would want to achieve over the course of the next 3 years, and was the only agency that suggested showing and testing its creative concepts at the CAA Conference October 28–31 in Toronto. Tate was very in tune with all the activities and projects the CAA has been involved in the past, and exhibited a confidence that they would be able to execute a national branding program for CAA."

"From my perspective as an audiologist, CAA needs to do more to let the public know what we do" says Ronald Choquette, Chair of the CAA PR & Visibility Committee. "With Tate's experienced and creative help, a proactive marketing plan and creative materials will be developed to promote our profession".

Tate Marketing already has plans underway, but details have not yet been released.


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Fundamental Differences between Analog and Digital Hearing Aids

By Jim Ryan

About the Author

Jim Ryan is the manager of the DSP algorithm development group at Sound Design Technologies. He has been with Sound Design Technologies (a spin-off company of Gennum Corporation) since 2000 and is responsible for four generations of hearing-aid DSP products. Prior to joining Sound Design Technologies, he was a Senior Research Officer at the National Research Council of Canada. Jim holds a PhD in electrical engineering from Carleton University (1999), Ottawa, Canada with a specialization in DSP for audio and acoustics.

Perhaps the most important trend in hearing aid design over the past decade has been the rapid shift from analog circuit technology to digital. Today, over 90% of all hearing aids sold in North America are digital instruments.

The shift to digital technology has brought about many important design innovations which would have been difficult or impossible to achieve with analog circuitry. Features such as adaptive noise reduction, feedback cancellation and adaptive directional microphones are all common place today due to digital technology.

While digital hearing aids perform the same functions as analog ones, there are some fundamental differences in their characteristics that the practicing audiologist should be aware of when fitting such devices. This article describes three of the most readily observed differences between digital and analog hearing aid performance. These include: audio bandwidth, input dynamic range, and time delay.

Digital Amplifiers

Every digital hearing aid contains an integrated circuit known as a digital amplifier, or digital signal processor (DSP). A DSP is a high-speed computer that manipulates the audio signals in a hearing aid numerically. In order to perform its function, the DSP relies on the conversion of signals from their real-world, analog format to digital format for processing. This function is performed by the analog-to-digital converter (ADC) and the reverse by the digital-to-analog converter (DAC). The analog-to-digital conversion process requires that continuous-time analog signals be sampled at discrete time intervals and converted into a stream of numerical values, or samples. This process is illustrated in Figure 1.

It is the conversion between analog and digital signal domains that leads to most of the differences between analog and digital hearing aids. This is described in more detail below.

AUDIO BANDWIDTH

To ensure an accurate digital-signal representation, the rate at which the analog signal is sampled (the sampling frequency) must be at least twice as high as the highest frequency component in the audio signal. This is a fundamental limitation of digital signal processing. Failure to obey this limitation results in an unrecoverable signal distortion known as aliasing.

To avoid aliasing, the incoming signal is filtered to restrict its bandwidth to less than half of the sampling frequency. This filtering process results in a sharper high-frequency cutoff for a digital hearing aid as compared to an analog hearing aid. This is illustrated in Figure 2. The green curve represents the frequency spectrum of the microphone signal. The orange curve represents the filtered signal that is presented to the ADC. For minimal

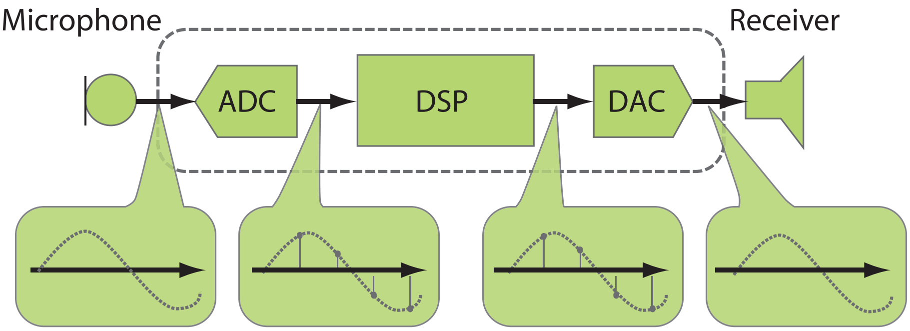

Figure 1. Block diagram of a digital hearing aid showing the analog-to-digital converter (ADC), digital signal processor (DSP) and the digital-to-analog converter (DAC).

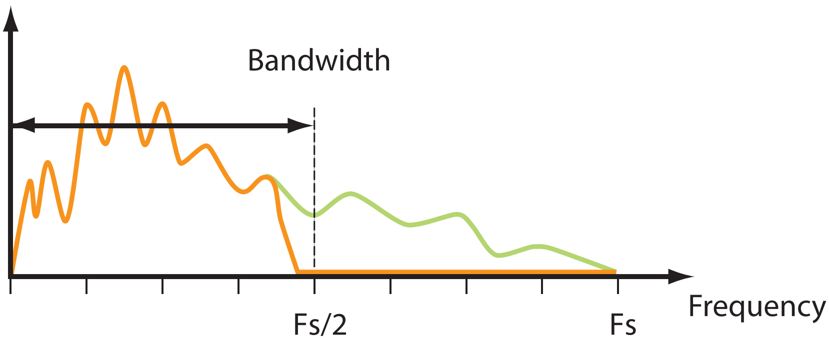

Figure 2. Illustration of the bandwidth restriction inherent in a digital hearing aid.

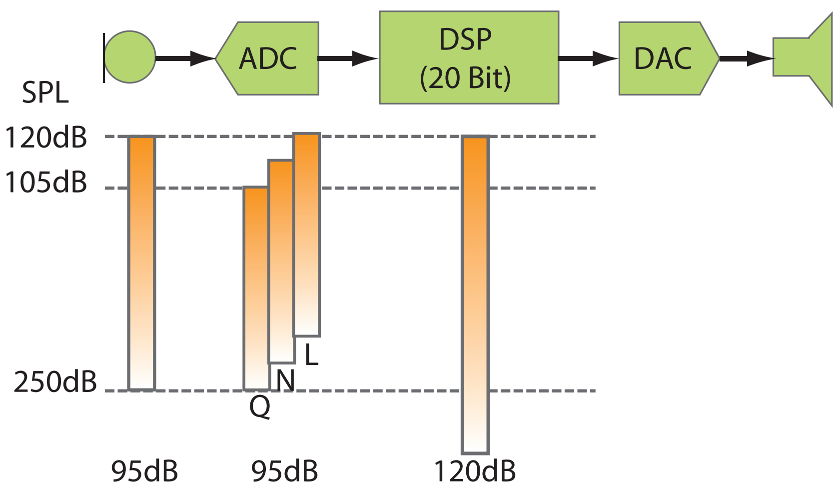

Figure 3. Illustration of dynamic range limitations in a digital hearing aid. The limited dynamic range of the ADC can be adjusted for quiet (Q), normal (N) and loud (L) input signals by adjusting the gain of the microphone preamplifier.

aliasing distortion, the filtering process removes all the signal energy above half the sample frequency (Fs/2).

Of course, the audio bandwidth of a DSP can be extended by simply increasing the sampling frequency. Unfortunately, a higher sampling frequency requires a faster DSP to handle the increased rate of audio samples and to allow for advanced features. A faster DSP, in turn, consumes more battery power which is undesirable in a hearing aid. As a result, there is a trade-off between signal bandwidth and battery current. Often, designers of digital hearing aids will reduce the audio signal bandwidth to the minimum required for processing speech signals in order to minimize battery consumption. This can lead to poor performance for music, since the bandwidth of music signals can easily exceed that of speech.

INPUT LIMITING LEVEL AND DYNAMIC RANGE

In addition to the time sampling described above, analog-to-digital conversion also requires amplitude sampling. The continuous-time analog waveform, sampled at discrete time intervals, is converted into a series of numbers by the analog-to-digital converter. The accuracy of the amplitude sampling is governed by the precision of some sensitive analog circuitry in the front end of the DSP.

Increasing the dynamic range of the conversion process requires higher precision analog circuitry. Typically, however, this requires an increase in the power consumption which is disproportionate to the increase in dynamic range. As a result, the dynamic range of a hearing aid ADC is usually limited to roughly 80 dB. This was a major limitation of early digital instruments since the dynamic range of the best analog instruments was greater than 90 dB.

Input range is increased by providing a programmable-gain amplifier in front of the ADC. This allows the ADC performance to be tuned for specific situations by adjusting the fixed gain of the preamplifier. For instance, the ADC can be adjusted for quiet (Q), normal (N) and loud (L) situations by adjusting its input range as shown in Figure 3. This method allows an 80 dB ADC to cover the same dynamic range as a 95 dB microphone.

Of course, the numerical precision of the subsequent DSP also affects the system dynamic range. To understand why, consider that a DSP manipulates audio signals through digital computations using the binary number format. In the binary system, numerical precision is measured in binary digits, or bits. A well-known rule of thumb is that each bit of numerical precision represents approximately 6 dB of dynamic range. Thus, a 16-bit digital word, as used in the CD audio format, results in a dynamic range of approximately 96 dB.

When two numbers are multiplied within a DSP, the product contains twice the number of bits compared to the multiplicands. Since the number of bits cannot grow beyond the DSP's native word length, the product precision must be reduced through rounding. The rounding process introduces a small error in the signal representation that is manifested as a noise added to the audio signal. For repeated operations on the same signal, rounding error accumulates increasing the noise by the same amount each time. For each doubling of the number of rounding operations, the noise increases by 3 dB reducing dynamic range by the same amount.

If one were to apply a 16-bit DSP to the output of an analog-to-digital converter with a 96 dB dynamic range, the dynamic range of the system would be reduced by 6 dB after only four rounding operations. Restricting the DSP to only four rounding operations would not allow very complicated algorithms to be applied to the signal.

Consequently, modern hearing-aid DSPs offers native word sizes in excess of 16 bits. A 20-bit DSP, for example, results in a dynamic range of 120 dB. This means that over 200 additional rounding operations can be applied to the audio signal while maintaining the same quantization noise. This is sufficient to support many of the signal processing algorithms in hearing aids today.

TIME DELAY

Time delay in a digital hearing aid arises due to both the analog-to-digital conversion processes (ADC and DAC) and the signal-processing algorithms. This type of delay is not present in analog hearing aids and it represents one of the more noticeable differences between analog and digital instruments.

Most of the analog-to-digital converter delay arises due to the aggressive low-pass filtering that must be applied to the analog signal in order to restrict its bandwidth for digital sampling (as shown in Figure 2). In a typical high-quality audio converter, time delays of several milliseconds can arise, owing to the nature of the filtering used. Such delays must be minimized for a digital hearing aid since conversion delays reduce the amount of time left to implement signal-processing features.

Signal-processing delays are influenced by two factors: the filter bank that decomposes the audio signal into its constituent frequency components, and the need to reduce computations to minimize power consumption.

The filter bank algorithm forms the core of many advanced audio features, such as adaptive noise reduction. For maximum effectiveness, such algorithms can require a narrowband filter bank. Unfortunately, there is a fundamental relationship between filter-bank frequency resolution and time delay. A filter bank with many, narrow-band filters necessarily incurs a longer time delay than one with fewer, wide-band filters.

As mentioned above, DSP power consumption is directly related to the number of computations required for each audio sample. More complex signal-processing algorithms typically require more computations per sample leading to increased power consumption. To overcome this, hearing-aid engineers can spread the computations over a wider time interval but this can also result in longer time delays.

Evolution in integrated-circuit technology is helping to reduce hearing-aid time delays.

With each new technology generation, transistor feature size and power consumption shrink by half. This means that more transistors can fit within the same silicon area and power budget. More transistors mean higher DSP computation rates, allowing more complex system designs and lower time delay.

While early digital instruments exhibited time delays in excess of 10 ms, time delays on the order of 4–6 ms are now the norm, even though algorithm complexity has actually increased.

Summary

The adoption of digital technology has resulted in a major change in hearing-instrument design. Compared to their analog counterparts, digital hearing aids possess a sharper high-frequency cutoff, exhibit longer time delay, and may have a reduced dynamic range.

With each successive generation of digital circuit technology, transistor feature size and power consumption will continue to shrink. With more transistors available for the same size and power budget, engineers can consider more complex design options. This will lead to continued innovation of new hearing-aid features and to continued improvements in the system specifications described above.

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By Marshall Chasin, AuD, MSc, Reg. CASLPO, Aud(C), Editor-in-Chief

Konings A, Van Laer L, Van Camp G. Genetic Studies on Noise-Induced Hearing Loss: A Review Ear and Hearing 2009;30(2):151–59.

If there was one article that anyone should read this year it is called "Genetic studies on noise-induced hearing loss: a review" by Annelies Konings, Lut Van Laer, and Guy Van Camp.

If you are like most audiologists, our knowledge of genetics and how they may affect certain pathological processes in the cochlea is limited. The most that I know about genetics (having last studied it 30 years ago) is how to tell a boy chromosome from a girl chromosome … you pull down its genes…

In this study the authors note that noise induced hearing loss (NIHL) is a complex disorders and is related to both environmental and genetic factors. They also point out that people have different susceptibilities two people who were both exposed for 30 years at 100 dBA may have as much as an 85 dB HL loss and as little as a 35 dB loss. The authors attribute, at least part of this difference, to genetic factors.

The authors admit that "little is known about the genetic factors that influence NIHL" but by using animal models and, more recently, association studies on candidate genes, more specific information can be obtained.

The authors talk about three main areas where genes may play an important role in NIHL. These include the following:

1. Oxidative Stress: Because of the cochlear metabolism, reactive oxygen species (ROS) are naturally produced when oxygen is metabolized to water. In cases of NIHL, ROS are produced in greater quantity and unless mitigated by antioxidant enzymes, can cause damage to DNA, proteins, and membranes. An association study of 58 workers indicated that the gene *GSTM1* was implicated in those workers who had lower susceptibility to NIHL. However, caution should be exercised since the power of the test was low. In another study of 94 workers, the genes *PON1*, *PON2*, and *SOD2* also showed significant association with NIHL; however, the authors again caution about definitive conclusions due to a small sample size and possible confounding factors such as smoking that could not be controlled for.
2. K-recycling pathways: These refer to genes that potentially disrupt the normal K^+ ion pathways when high noise levels are present. K^+ is quite important for a healthy cochlear metabolism as evidenced by the large number of both syndromic and non-syndromic hearing losses resulting from genes that alter the K-recycling pathways in the cochlea. Of interest is the gene *KCNE1* where the p.85N allele was only detected in those workers who were susceptible to NIHL. This variant of the *KCHE1* gene caused K^+ channels to open more rapidly than normal and also the normalized current was higher. The authors do caution that these findings are only preliminary.
3. Heat Shock Proteins: These proteins are found in all cells in both normal and pathological conditions. They are responsible for intracellular transport. High levels of these proteins can be found whenever there is a stressful condition such as heat, virus, toxicity, or higher levels of noise such as NIHL. Higher levels can be ototoxic to the cochlea. For moderately high levels of noise, the heat shock proteins are actually protective but become toxic at higher levels. In a study of 70 Chinese automotive workers, the *HSP70* gene was analyzed and found to play a role for increased susceptibility to NIHL. This was confirmed in subsequent studies of Swedish and Polish workers.

The authors conclude with a discussion of the possible therapies for prevention that are based on these three areas that appears to be implicated in differing susceptibilities for NIHL. Among these proposed therapies that would use current and future technologies are the use of growth hormones, and stem-cell based therapies. Again the authors caution about making and final conclusions based on genetic studies as most of the research is both preliminary and the subjects involved may be affected by uncontrolled environmental toxins such as smoking.

Better Hearing Institute to Announce Results of MarkeTrak Survey

The Better Hearing Institue is pleased to announce that the much anticipated eighth survey of the hearing loss population and hearing health industry (MarkeTrak VIII - 2008) has been completed.

The goal of the MarkeTrak survey is to report on relevant trends and to explore new topics that are likely to contribute to our knowledge of the hearing aid owner population as well as the sizeable population of people with admitted hearing loss, who have chosen not to adopt amplification for their hearing loss. The first in a series of publications covering 25 year trends in the hearing loss population and hearing health market will be published in the Hearing Review in October.

Cathy Jones, president of the Better Hearing Institute stated "MarkeTrak VIII continues to be the most comprehensive and unique hearing healthcare database since its inception. Drawing on a screening survey of 80,000 households using the National Family Opinion Panel and detailed surveys on more than 3,000 hearing aid owners and more than 4,000 people with hearing loss, who have not chosen amplification, it promises to contribute a wealth of information to all stake holders in the hearing health industry. We hope you find it as fruitful as we intend it to be! "

Noise-Induced Hearing Loss, Cell Death, and More:

Interview with Donald Henderson, PhD

Donald Henderson

Douglas L. Beck, AuD, Web content editor, interviews Dr. Henderson on a variety of topics relating to pharmacological solutions and interventions regarding noise exposure and noise-induced hearing loss.

Academy: Good Morning, Don. Thanks for your time today.

Henderson: Hi, Doug. My pleasure. It's always nice to chat with a UB alum.

Academy: Don, you've done some extraordinary work regarding pharmacologic mechanisms as they relate to hearing protection and noise-induced hearing loss. How did you get involved?

Henderson: This area is relatively new, and I became interested in protecting the ear from noise-induced hearing loss because of a number of basic science findings. For example, we have recently learned that high-level noise exposure creates a level of oxidative stress within the cells of the cochlea.

Academy: And in this context, oxidative stress refers to the situation in which the cochlea is generating large numbers of free radicals?

Henderson: Exactly, and these are greater numbers of free radicals than can be neutralized via the natural protective action of cochlear antioxidants. I should mention that antioxidants are found in all tissues of the human body. Free radicals are oxygen or nitrogen molecules with un-paired, or free electrons. And simply, these molecules attack the nucleus or the mitochondria or the cell membranes of surrounding, and the cochlear damage leads to the resultant noise-induced hearing loss. In fact, the primary site from which the free radicals emerge are the mitochondria of the outer hair cells. We think this is true because the outer hair cells consume a lot of energy.

Academy: I believe you mean the outer hair cells consume a lot of energy in their role as the cochlear amplifier?

Henderson: Yes, that's correct. The outer hair cells use a lot of energy and a lot of oxygen.

Academy: And so even though noise-induced hearing loss looks like a "mechanical event," it may actually be a chemical event or perhaps a chemical event that results from an initial mechanical insult?

Henderson: Exactly. And if this is true, then we think there is an excellent likelihood that we can intervene in the process through chemical measures.

Academy: And just to be clear…some pharmacological solutions have been shown to work in animals, and some of the proposed solutions are available in pharmacies and health food stores, but there have not yet been large-scale randomized tests of humans to prove that pharmacological intervention and preventative measures work in humans.

And therefore, I want to be sure to say that in no way are you suggesting that chemical and pharmaceutical solutions and alternatives are to be used instead of normal hearing protection protocols, but indeed, the probable outcome of the research is that pharmacological agents may be advisable in addition to standard and historic hearing protection protocols.

Henderson: Yes, that's the direction we're going.

Academy: Okay, and so as the outer hair cells are damaged by a mechanical process, such as loud noise exposure, and the mitochondria give off free radicals that is a chemical process, the cells start to die off.

Henderson: Yes, and there are two cell death processes: necrosis and apoptosis. This is very important because apoptosis is a highly regulated event within a cell. The cell gets a trigger that indicates time is up, time to die, the proteins begin to break down, and the cell implodes. The components are carried off via the waste disposal system of the cochlea. However, maybe we can alter the outcome and prevent the cell death by blocking the trigger for apoptosis.

Academy: And then, what's the best relative description of necrosis?

Henderson: I think of necrosis more as passive cell death. The cell membrane is damaged and as calcium moves in and water moves in, the cellular contents slip out. The cell gets larger and finally ruptures and the cell contents can actually pollute the local area, and that local pollution can further damage neighboring cells with the reaction of trace amount of iron and oxygen radicals creating hydroxyl radicals, which are very toxic.

Academy: Okay. And there are two broad classifications of drugs being developed to be used in these endeavors, right?

Henderson: Yes. There are drugs that act as boosters to the normal antioxidant defense system of the cochlea, and there are drugs that prevent apoptosis. The larger category at this time is the antioxidant drugs, such as N-acetyl-L-cysteine ("L-NAC"), D-methionine and both promote glutathione (also called GSH). GSH is a naturally occurring antioxidant, and it protects cells from free radical damage, and so these drugs promote glutathione synthesis. However, it's difficult to give GSH orally because much of their activity is absorbed in the stomach and intestines, and so very little makes it to the target organ. So, one goal is to make the building blocks of glutathione more easily accessible and available for the cells to prevent free radicals from damaging cells and to prevent the apoptosis trigger.

Academy: And if I recall, the U.S. Navy was looking at L-NAC years ago?

Henderson: Yes. That's right. But the study was not as well controlled as would have liked.

Academy: Yes, well, of course one cannot take a group of humans, expose some to this, some to that, and then compare and see where less damage was done!

Henderson: Exactly. And the experiments made some assumptions about all subjects receiving equivalent noise exposures, but in the end, it was very hard to sort out. Some of the Navy personnel wore hearing protection (which was a reasonable idea!) and some didn't, and so it's very difficult to make a control and experimental group and to really document the outcomes.

Academy: And so maybe the only way is a shotgun style study, looking at very large groups and long-term trends over decades?

Henderson: Right, or maybe study musicians who experience TTS in their day-to-day music routines. Or maybe we would study people in noisy industrial situations. One might assume if we prevent some musicians or workers from experiencing TTS, we can safely assume they won't be developing PTS. And so there are a number of studies that can be done that may allow us to draw some fairly solid conclusions, but variability is difficult to overcome, and safety is of paramount concern.

Academy: But regarding animal studies, we can make some very strong statements.

Henderson: Exactly. There is no question that in animal studies, these drugs prevent noise-induced hearing loss. But again, in animal lab situations, we control everything; we test their hearing and we know the results, we know exactly the sounds they're exposed to in loudness and duration, we know the strength of the drugs administered, and we can measure the outcome.

Academy: So it appears the science is very solid, but the human applicability is as of yet to be defined.

Henderson: Yes. But to me, there really is no doubt. These approaches work for animals, and the animals used have auditory system and biochemistry similar to humans. I'm confident with more experiments in humans, that it'll be clear that the pharmacological contribution is worthwhile, beneficial, and protective.

Academy: Don, have you had personal human experience with these drugs?

Henderson: Well, I have a friend who is a music professor and conductor. She was having difficulty with TTS, tinnitus, and hyperacusis after practicing with an orchestra in a very reverberant room. I suggested she might try a combination of L-NAC and acetyl-L-carnitine (ALCAR), nutraceuticals we have studies with chinchillas. She purchased them from a health food store and after two weeks, she was relieved of her symptoms. Of course that's not to say that would happen for anyone else, but it worked for her, and so to me, that's very encouraging.

Academy: Amazing. And so far we've actually only addressed free radicals and antioxidants, but there's also a lot being done with regard to Src inhibitors and blocking apoptosis when cells physically lose their connections with neighboring cells.

Henderson: Exactly, and drugs that block apoptosis are very promising with regard to preventing noise-induced hearing loss. But we can chat about that another time.

Academy: Don, this is fascinating. Thanks so much for your time and knowledge.

Henderson: My pleasure, Doug.

Donald Henderson, PhD, is a professor with the Department of Communication Disorders and Sciences at State University of New York (SUNY) at Buffalo.

Douglas L. Beck, AuD, Board Certified in Audiology, is the Web content editor for the American Academy of Audiology.

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Considering the Real-Ear-to-Coupler Difference during the Verification of Hearing Aid Fittings for Older Children and Adults

André M. Marcoux, PhD

About the Author

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The most valid and informative means of objectively measuring hearing aid performance is in a coupler with properties which attempt to mimic the coupler, or cavity, in which the hearing aid is designed to function; the human ear canal.

These industrially designed couplers, including the Zwislocki, IEC-711 and 2-cc versions, vary in their overall ability to reproduce the response of the ear canal to various acoustic inputs. While the 2-cc coupler may not mimic the ear canal response as well as some analogous versions, it is nonetheless the most commonly used in North America. While measuring performance in a 2-cc coupler shows manufacturers and clinicians whether the hearing aid and many of its integrated features are functioning within specifications, they may not provide an accurate picture of performance for a given patient. Even if a standard coupler could be manufactured to exactly reproduce the influences that the ear canal has on acoustic input, this coupler would, at best, only mimic the ear canal of the population average. There are many reports in the literature which depict the variability in ear canal properties across the adult population and the variability they allow when transforming acoustic inputs from hearing aids or other transducers.[1–3] The Real-Ear-to-Coupler Difference (RECD) accurately provides a measure to depict the difference of how acoustic input is transformed between a 2-cc coupler and the human ear canal in relation to an insert earphone or hearing aid. Saunders and Morgan[4] compared the average RECD on 1,814 adult ears and observed a significant inter-subject variability as large as 35 dB at some frequencies, demonstrating that the use of a standard coupler or average ear canal estimate could provide misleading information regarding the level of hearing aid output being provided to a specific patient. Most variability in the RECD is encountered across different age groups such as when comparing children younger than two years of age with older individuals.[5] Previous research has shown that, for the same input level, the smaller ear canal of a child will cause a greater eardrum Sound Pressure Level (SPL) value due to its larger acoustical impedance and that the difference between children's RECD and those of adults will diminish as the child becomes older. The maturation of the ear canal is significant during the first two years of life and then occurs more gradually until approximately five years of age, at which point the RECD will have likely reached maturity.[5,6] In general, while there is important age-related variability in the RECD, there have also been reports of large amounts of variability within age categories for both children[6] and adults.[4] It has been suggested by both these groups of authors that a greater level of accuracy can be brought to the hearing aid fitting when the clinician can verify the performance beyond the 2-cc coupler, or an age-specific estimate, and consider the ear canal characteristics of the particular patient to which the hearing aid is being provided by measuring that patient's RECD.

The measurement of the RECD for pediatric and adult recipients of hearing aids also becomes important when conductive or mixed hearing loss is diagnosed. Certain middle ear pathologies have been shown to modify the ear canal and eardrum impedance thereby influencing acoustic input into the ear canal. Differences as much as 35 dB SPL (but most often around 10 to 15 dB) can be measured in the ear canal of a patient with abnormal middle ear function in comparison to one with an asymptomatic middle ear.[7] More specifically, if a pathological condition reduces the ear's impedance, such as a tympanic membrane perforation or the presence of a tympanostomy tube (both of which create the effect of an increased ear canal volume), the sound pressure level measured will be smaller than that of a normal ear. The opposite effect is also possible, where pathologies such as otosclerosis will increase the middle ear's impedance, resulting in a greater SPL measurement at the eardrum.

During the past decades, prescriptive rationales such as the Desired Sensation Level (DSL) method and National Acoustics Laboratories (NAL) have been developed to ensure that an optimal amount of hearing aid output and gain can be prescribed for specific levels of hearing loss and subsequently verified with in situ measurements. Formulae were developed to generate prescriptive amplification targets which reflect the amount of amplification required to account for a specific level of hearing loss in order to provide audibility for a defined spectrum of sound levels and/or intelligibility of the speech spectrum at various input levels. These formulae consider that while hearing aid output is measured in decibels of Sound Pressure Level (dB SPL), hearing loss is measured using a normalized decibel scale of hearing level (dB HL) where the zero value depicts normal hearing levels in a group of young adults with average outer ear characteristics and where elevated values can be neatly categorized in degrees of hearing loss. Obviously, the comparison between hearing aid performance and prescriptive gain targets only becomes possible once a common measurement scale is adopted.

Because dB HL values are always referenced to the hearing ability of the young adult population with a set of defined average outer ear characteristics, it does not appear sensible to use this scale and measure hearing aid performance of children or most adults (with outer ear characteristics which most often will differ from the norm). On the other hand, for the purposes of computing amplification targets, hearing level, expressed in dB HL, can effectively be transposed onto a dB SPL scale by adding the Reference Equivalent Threshold Sound Pressure Level (RETSPL) which was originally subtracted to normalize threshold data for the general population using a specific transducer. The caveat of expressing measurements in dB SPL is that a reference point must be inferred. The selection of the eardrum as a reference point to document hearing loss in dB SPL is an important point. Apart from obvious anatomical anomalies of the outer ear, milder variations in shape and size of the ear canal have never been considered to represent a deficit, although these variations may cause some minor decreases (or increases) in the amount of sound which is made available to the cochlea. Certainly this is the case for infants, who naturally have smaller outer ears than adults and although these immature structures may funnel less sound in the area of 2,700 Hz from the free-field (the resonance frequency of mature outer ears), we would never consider these individuals to have a hearing loss in this frequency region. Therefore, the fact that SPL is referenced at the eardrum is important, such that the influence of the outer ear is effectively controlled when determining the actual auditory deficit in hearing sensitivity caused by more central structures for the purposes of providing accurate levels of amplification to compensate. Measuring eardrum dB SPL directly at the eardrum would be the most accurate method for determining thresholds in dB SPL, but the difficulties in ensuring a constant position of the probe during this measurement,[8] as well as issues related to noise of the probe microphone and the test environment may limit the measurement of sound corresponding to very low hearing thresholds. As a solution, the measurement of an RECD and its subsequent summation with the patient's coupler-referenced threshold (dB HL + RETSPL) has been validated as an accurate and effective means of obtaining eardrum-level dB SLP thresholds.[9] Therefore, not only are in situ measurements, such as those required for the RECD, important in eliminating inaccuracies of hearing aid performance measures caused by using a 2-cc coupler or an age-specific estimate, but they are an important step in determining the patient's hearing loss in dB SPL at the eardrum: a reference point which can more accurately depict genuine levels of underlying deficit for which an accurate and appropriate prescription of gain can be provided. It is also important to note that the RECD will only be used to transform HL values into SPL when insert earphones were used to measure hearing thresholds. Because other transducers permit different portions of the outer ear to influence sound during psychoacoustic measurements with REDD, as with RECD, transformations aren't required. Different acoustic transforms will be required to obtain SPL values,[10] all of which are impractical to measure individually for a patient in the clinical setting. Furthermore, because the RECD is later used in the computation of prescriptive targets to determine the influence of the ear canal on hearing aid output, it makes sense to also use insert earphones, thereby limiting error of the entire target computation by using a single acoustic transform. To summarize, the RECD is considered at two important points during the hearing aid fitting procedure; in determining how the ear canal will influence the threshold measurement using insert earphones, thereby permitting the transformation of thresholds and loudness discomfort values from dB HL to eardrum-level dB SPL, and secondly in determining an appropriate hearing aid amplification target by considering how the ear canal will influence output. Whether the RECD is actually measured in the ear of the older child or adult is a decision which currently remains at the discretion of the clinician.

Infants and very young children may be those who currently benefit from the most accurate fitting and verification strategy as a result of intervening with such young individuals insofar as they are prone to moving and vocalizing during direct real-ear measurements. These two behaviours are often difficult to control and are counterproductive to obtaining a valid Real-Ear Aided Response. It is for this reason that clinicians often opt for using average acoustic transforms to estimate the REAR. However, accepting the arguments detailed above that individual real-ear measurements are necessary for accurate pediatric hearing aid fittings, the clinician must adopt a real-ear technique for these patients despite the inherent difficulties in application. Moodie et al., devised a technique which could effectively predict, or simulate the Real Ear Aided Response from a coupler-assisted verification technique in conjunction with the child's individual RECD.[11] This technique was subsequently validated as an efficient means to predict the REAR[9–12] in individuals who are not able to passively participate in the direct measurement of the REAR, and is commonly used in pediatric clinics.

Older children and adults, however, will easily remain still and silent during real-ear measurements following such instructions. As such, there is no behaviour-related reason to choose a time-efficient estimation of the REAR since direct measurements can be easily obtained. Consequently, the RECD is not measured for the patient and RECD estimates are used to compute SPL thresholds at the eardrum and an accurate REAR target. This technique sits well with most clinicians as there is an erroneous notion that the ear canal of the older child and adult has a volume, length and shape that is fairly standard in the general population.[4] Not surprisingly, documents such as Guidelines for the Audiologic Management of Adult Hearing Impairment[13] state that a variety of verification procedures, including the real-ear or coupler-assisted REAR and the REIG can be utilized with an adult population. Clinically, the REAR may be, and often is, measured as soon as the patient is able to provide a sustained level of passive participation during the verification process. This may occur in children as young as 2 years of age, and will certainly be available in older children and adults. As is normally the case, the REAR will be compared to its predicted targets, and the hearing aid may be adjusted until a good match can be observed between the response and target. The end result is that it is common practice for the REAR or the REIG to be the only real-ear measurements performed with the adult population.

However, one may question what would happen when a clinician assumes normal ear canal dimensions for his patient and decides, by default, to permit the computation of real-ear targets to be generated with an age-specific RECD estimate, and subsequently measure the REAR to match the prescriptive targets. First, what level of error can be reflected within targets if the patient's own RECD was not measured? Secondly, what would be the outcome of attempting to match these erroneous targets with an REAR? The hypothesis of this study is that a verification approach which relies solely on the direct measurement of the REAR may negatively influence the computation of prescriptive targets in the event where the RECD is not measured for older children and adults with ear canal dimensions that differ from the norm. Furthermore, attempting to match these targets will result in adjustments that may be counterproductive to providing appropriate amplification to these individuals.

The objective of the present paper is twofold; (1) to confirm that measurement of the RECD is an appropriate means of obtaining accurate amplification targets for individuals of all ages as concluded by Saunders and Morgan[4] and (2) to further provide evidence that the usefulness of the RECD extends beyond providing coupler-assisted means of obtaining the REAR as a substitute of direct conventional sound field verification for children, and that a direct sound field REAR should not be directly obtained in adults unless an individual RECD has been measured to more accurately define the real-ear targets. Case studies will be presented in order to show that some adults could benefit from a more precise hearing aid fitting when a REAR is obtained following the prior measurement of the patient's RECD.

Two case studies are offered to substantiate these points, one from a 25-

year-old female and the other from a 5-year-old boy.

Case 1: 25-Year-Old Female

Otoscopy did not reveal any indication that this patient had an ear canal that differed from clinical norms and thus required special consideration for the purposes of amplification. There were also no concerns regarding a conductive or mixed component to her loss of hearing. Tympanometry values were all within normal limits for adults: a physical volume of 1.2 cc with static acoustic admittance of 0.4 mmho and normal middle-ear pressure. She was fitted with Widex Inteo-9 hearing aids with standard custom ear moulds. The average RECD values were selected in the programming software. As a matter of routine, the RECD would not have been measured for this patient and rather, a direct sound-field REAR would have been obtained to closely match the hearing aid output to the DSL targets. Table 1 provides details of the hearing loss, real-ear targets and real-ear responses (REAR) for the patient's left ear following two scenarios: the first where the average adult RECD values were used to calculate targets and the second, where the patient's individual RECD, using the foam tip of the insert earphone transducer, was measured. Real-ear targets as well as the average RECD values were generated using the Desired Sensation Level 5.1 (DSL) calculation for adults.

The first notable difference for this patient is the extent to which her RECD (line 3) differs from the average (line 2). The reason for this difference is not immediately clear and may be caused by a combination of factors which are known to influence the RECD, such as ear canal length and occluded volume, middle ear impedance and coupling of the RECD transducer to the patient's ear and probe-tube microphone. However, none of these factors were obviously abnormal during otoscopy or immittance tests. Furthermore, every precaution was taken during the RECD procedure to minimize low-frequency leakage due to an under expansion or an insufficient depth of the transducer foam tip or a high-frequency loss due to an insufficient microphone depth in the ear canal.[8,14] One could hypothesize that the overall larger RECD across frequencies may stem from the patient's smaller occluded ear canal while the predominance of the RECD difference in the mid-frequencies may stem from a slight rigidity of the middle ear possibly combined with a slight reduction in SPL in the low and high frequencies due to coupling of the transducer and probe-tube microphone to the patient's ear. The variability of this RECD measurement clearly confirms the need to individually measure this acoustic transform on each patient.

The result of the larger RECD is different thresholds when referenced at the eardrum. What this implies is that this patient has a hearing ability (line 5) that is markedly different from a person presenting the same audiogram but with an average RECD (line 4). This can be explained by the fact that audiometers are calibrated to ensure that the audiometric zero (0 dB HL) is representative of normal hearing in a large group of young listeners, and who consequently would have dimensions of the ear canal that are on average representative of the average RECD value for adults. When the ear canal dimensions, and hence the RECD, are different from the average value, the audiometric zero is offset and is no longer accurate or helpful in defining the hearing ability of the patient. This 25-year old patient possesses a hearing loss which is worse than that depicted by her audiogram, and as such, her audiometric results will underestimate the deficits caused by auditory structures which lie beyond the ear canal. (For a comprehensive review of these notions, the reader is encouraged to refer to Marcoux and Hansen,[15] and Marcoux and Durieux-Smith.[16] This patient would therefore require REAR targets (lines 7, 10) which are greater than the average patient with a similar audiogram (lines 6, 9) to meet her need for audibility. What becomes clear is that unless the individual RECD of this patient was measured, the REAR targets provided by DSL or any other fitting software would have been too low.

Table 1. Thresholds, RECD and DSL hearing aid targets for a 25-year-old female

		250	500	1000	2000	3000	4000	6000
1	Thresholds (dB HL)	25	40	40	45	50	65	55
2	RECD (1)	3	4	8	7	8	13	13
3	RECD (2)	7	7	14	14	15	15	14
4	Thresholds (SPL eardrum) (1)	43	50	49	58	63	80	71
5	Thresholds (SPL eardrum) (2)	47	53	55	65	71	83	72
6	Target REAR, 55 dB input (1)	50	59	60	65	70	70	70
7	Target REAR, 55 dB input (2)	53	62	62	71	75	72	72
8	Measured REAR 55 dB input	51	63	65	72	78	72	72
9	Target REAR, 70 dB input (1)	64	72	71	77	80	81	80
10	Target REAR, 70 dB input (2)	65	75	73	80	85	83	83
11	Measured REAR 70 dB input	66	76	76	85	87	85	83
12	2 cc gain target, 70 dB input (1)	10	16	17	26	30	26	26
13	2 cc gain target 70 dB input (2)	10	15	15	22	27	26	26

The smaller ear canal of this patient will influence the REAR measurement. Notice how very different the REAR values for a 55 dB (line 8) and 70 dB input (line 11) are from the targets that would be available to the clinician who had chosen to use the average RECD values (lines 6, 9). As a result the clinician would note that the REAR is much too high and would conclude that the hearing aid was not programmed correctly and would proceed to reducing the gain of the instrument, leading to an under-amplification of this patient's hearing loss. In the mid-frequency, area, an under-amplification of close to 6 dB in gain would be produced by attempting to match the erroneous REAR targets which did not consider the patient's own RECD. Fortunately, most adults are able to provide subjective feedback when their hearing aids are not providing sufficient amplification and, in this case, the patient may have noted the under-amplification and requested a boost in gain.

Case 2: 5-Year-Old Boy

Let us now consider another example, that of a child, who may be able to refrain from talking or moving during the measurement of the REAR but who will likely not possess the vocabulary required to express his dissatisfaction with the performance of his hearing aid in the event it is not working optimally. This child was fitted with Phonak Perseo 211 dAZ FM hearing aids and standard ear molds. The hearing aids were programmed using the DSL-child fitting rationale and average RECD values were selected in the programming software. Again, let us assume that a clinician will carry out a comprehensive on-ear REAR procedure and where the RECD was not measured. Table 2 provides details of the hearing loss, real-ear targets and real-ear responses for the child's left ear using two scenarios: the first where the average RECD values for a 60-month-old patient would have been used to calculate targets and the second, where the patient's individual RECD was measured using the foam tip of the insert earphone transducer. Targets as well as the average RECD were generated using the DSL 5.1 version for children.

There were also no concerns regarding a conductive or mixed component to the hearing loss of this child. Otoscopy was normal and tympanometry values were all within normal limits for adults: a physical volume of 0.6 cc with static acoustic admittance of 0.5 mmho at -20 daPa pressure.

This patient's RECD (line 3) does differ slightly from the population estimate used for 5-year old children (line 2). The result of this difference will lead to different thresholds when referenced at the eardrum. This implies that this patient has a hearing ability (line 5) that is markedly different from a person presenting the same audiogram but with an average RECD (line 2). This can be explained by the fact that audiometers are calibrated to ensure that the audiometric zero (0 dB HL) is representative of normal hearing in a large group of young adult listeners, and who consequently would have dimensions of the ear canal that are on average representative of the average RECD value for adults. Routinely for children, the use of insert earphones and the measurement of an RECD are encouraged as the audiometric zero is offset but is seldom used in defining the hearing ability of the child. As such, this young boy not only possesses a hearing loss that is worse that an adult with the same audiogram but is worse than other 5-year olds with this same audiogram. This is likely due to a slightly smaller occluded ear canal which, when coupled to the insert earphone, provided an increase in SPL and allows for slightly better audiometric results. As such, our patient would require REAR targets (lines 7, 10) which are greater than the average 5-year-old child with a similar audiogram (lines 6, 9) to meet his need for audibility. What becomes clear is that unless the individual RECD of this patient was measured, the REAR targets provided by DSL or any other fitting software would have been too low.

The smaller occluded ear canal of this patient will influence the REAR measurement. Notice how very different the REAR values for a 55 dB (line 8) and 70 dB input (line 11) are from the targets that would be available to the clinician who had chosen to use the average RECD values (lines 6, 9).

Table 2. Thresholds, RECD and DSL hearing aid targets for a 5-year-old male

		250	500	1000	2000	3000	4000	6000
1	Thresholds (dB HL)	30	25	35	50	50	55	45
2	RECD (1)	3	5	9	8	8	13	13
3	RECD (2)	6	8	12	13	14	17	16
4	Thresholds (SPL eardrum) (1)	48	36	45	64	63	70	61
5	Thresholds (SPL eardrum) (2)	51	39	48	69	69	74	64
6	Target REAR, 55 dB input (1)	65	68	66	76	79	76	72
7	Target REAR, 55 dB input (2)	67	68	69	79	82	79	75
8	Measured REAR 55 dB input	67	70	69	80	84	80	73
9	Target REAR, 70 dB input (1)	75	79	76	85	88	85	80
10	Target REAR, 70 dB input (2)	76	79	78	88	91	87	83
11	Measured REAR 70 dB input	77	80	79	90	93	89	80

As a result the clinician would note that the REAR is much too high, would conclude that the hearing aid was not programmed correctly and would proceed to reducing the gain of the instrument, leading to an under-amplification for this patient's hearing loss. The output targets are lower than necessary and an attempt to match the inadvertently higher REAR with these targets will result in a significant under-amplification, which at certain frequencies will be as great as 5 dB in the mid-frequencies for 55 dB inputs. In the case of this hearing-impaired child, this may be a serious cause for concern as language development may be impacted. While this child possesses expressive skills that are considered age-appropriate, there continues to be difficulty in describing satisfaction or dissatisfaction with the hearing aid fitting. As has often been reported in the literature, children are quite dependant on the audiologist's fitting skills for their continued language development as children are unlikely/unable to subjectively report inaccuracies in the fitting.

Discussion

When we consider that the hearing threshold is the sole basis of a hearing aid output calculation and that so many complex signal processing features hinge on this initial calculation, it seems counter-productive to fail to obtain the most accurate starting point, the real-ear targets, and then later to rely on patient feedback to achieve the optimal performance of the hearing aid. Furthermore, many adults may have little patience for hearing aids that are not working to their satisfaction and may subsequently reject or return them. Most would argue that successful fittings are often dependant on achieving the most accurate fitting from the outset.

The two case studies presented in this article highlight a few pitfalls of current practices with older children and adults. Notice how for both case studies, the measured REAR values for a 55 dB (line 8) and 70 dB input (line 11) resemble the REAR targets for these patients when the acoustic transform (i.e., RECD) had been measured (lines 7, 10). In essence, a problem only arises when the RECD used to generate SPL thresholds and the corresponding real-ear response depicts average-estimated ear canal properties rather than those of the patients, which could otherwise have been measured. The error introduced to the calculation of real-ear targets will increase as differences between average-estimated and actual values increase. This error becomes most problematic and counter-productive when matching the real-ear aided response (i.e., using the patient's own ear canal properties or RECD) with real-ear aided targets which have been influenced by the inclusion of an RECD depicting average/estimated ear canal properties. As such, matching the real-ear response of a hearing aid to targets that do not consider the same real-ear properties as those used during audiometry should not be considered as good clinical practice. Using the case studies of this article, one could easily determine that the REAR obtained from these patients would be much closer to the ideal response (lines 7 and 10) without matching the REAR to target obtained using an average RECD. However, by no means should verification be foregone. Unfortunately a lack of verification has been shown to provide hearing aid output that is markedly different from the intended values shown on the computer software, even when software may ascribe to reaching targets recommended by prescriptive approaches such as DSL and NAL.[17] While verification of hearing aid output is a necessity, guidelines are necessary to strengthen the validity of the static verification process.

Real-ear measurement guidelines should be revised to (1) eliminate the preconceived notion that any real-ear measurement will suffice for optimally fitting a hearing aid to a specific configuration of hearing loss, (2) encourage the measurement of the RECD in older children and adults in order to compute more accurate amplification targets, and (3) discourage the use of the REAR in older children and adults unless the measurement of an RECD was previously performed. Specific suggestions should include the following: (1) the measurement of a coupler-assisted (i.e., simulated) REAR following the measurement of the patient's RECD, or (2) the measurement of a direct sound-field REAR in the event the patient's RECD has been measured prior to the computation of real-ear amplification targets. These guidelines should apply for patients of all ages. As such the measurement of the RECD would no longer be recommended solely for the pediatric population.

INSERTION GAIN

Although Real-Ear Insertion Gain (REIG) measurements are becoming less frequently utilized, one may question whether insertion gain measurements may be useful to optimally fit hearing aids. Most prescriptive gain software will provide REIG targets. Practically, insertion gain measurements are not suggested for infants and young children as a patient must hold completely still during both the unaided (i.e., REUR) and aided (i.e., REAR) portions of the measurement. Furthermore, even in cases where an age-appropriate REUR estimate can be used, the REIG target calculation requires two acoustic transforms: the REUR and the RECD to calculate the aided component of the insertion gain calculation. The use of multiple acoustic transforms, whether estimated or measured, can potentially increase the amount of error contained within target and measured values. As most adults are able to sit still during real-ear measurements, insertion gain measurements can be easily obtained. However, as with all real-ear output or gain measures, the clinician must ensure that the acoustic transforms of the patient's external ear (i.e., the REUR and the RECD in the case of insertion gain) are the same as those used to compute real-ear targets. Seldom has the present author witnessed clinicians measuring the REUR and the RECD to generate insertion gain targets as there is a general misconception that all adult ear canals are identical. In general terms, real-ear insertion gain techniques will be erroneous in a manner proportional to the difference between the patient's REUR and RECD and the estimated values used for the computation of real-ear targets.

Conclusion

As a closing argument, one may question whether systematically measuring the older child's or adult's RECD will have a significant influence on benefit and satisfaction of fittings. Obviously, evidence would be helpful in determining whether this is the case. One could argue that measurement of the RECD is only important for infants and young children who require the utmost precision from verification techniques due to the fact that they are unable to provide feedback leading to modifications of hearing aid output, compounded by their dependence on optimal amplification to develop language. Furthermore, it is obvious that corrections in output, based on the RECD, often occur in 1 dB steps in comparison to the 5 dB audiometric step. When considering that a patient may provide a threshold that is inadvertently 5 dB higher that its true value, it is difficult to fathom how the RECD can be as helpful to the patient when providing audiometric responses conducted with 5 dB step sizes.

However, verification measures are here to stay in order to ensure that a hearing aid's programmed output can actually be provided by the instrument. Although some may initially think that the RECD measurement appears unnecessary in older children and adults because of the ability of these patients to provide feedback which can result in drastic changes of hearing aid output from those prescribed by real-ear targets, they would think again if static verification measures are performed. An intuitive and effective verification approach which is based on prescriptive output targets should involve the individual measurement of the RECD for all age groups. While prescriptive targets do not depict how the hearing aid will perform in real-world environments, they do provide a starting point which has been validated in the literature as providing benefit to hearing-impaired patients.[18] Although modifications are often brought to the output characteristics of hearing aids to address the real-life performance of hearing aids, the static target remains an anchor-point which can provide context for these modifications.

The purpose of this paper is not so much to justify the use of real-ear measures as it is to direct the clinician as to their proper use. Clinicians should therefore accept that if real-ear static verification techniques are being used to enhance clinical practices, then they should be performed optimally. As such, clinicians should consider measuring the older patient's RECD prior to performing a coupler-assisted or direct REAR.

It should also be noted that, instead of finding cases with remarkably abnormal RECDs, such as those with obvious differences in outer ear dimensions or mixed hearing losses, a more ubiquitous, nondescript selection was considered for this article in order to highlight the fact that average RECDs are not as constant in older children and adults as some may imagine. As such, manufacturers should be encouraged to develop equipment which could increase the ease with which acoustic transforms, such as the RECD, are measured during hearing aid fittings, or even during audiometry. Innovation in this area could help convince professionals of their added value to clinical practice without the burden of additional training, manipulation and clinical testing time.

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Advanced User Control and Trainability to Improve Performance and Increase Wearer Satisfaction: Achievable Benefit in Quiet

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About the Author

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There are several fitting formulas with which to adjust a hearing instrument for optimal performance in quiet. The best known, and most widely accepted, are DSL v5[1,2] and NAL-NL1.[3] Combining the benefits of accepted fitting formulas with the flexibility and sound quality of current multichannel digital instruments, ensures that almost all fittings can yield excellent performance in quiet without much difficulty.[4]

The Dilemma of Listening in Noise

Determining desired audibility for listening is noise is much more challenging. There are many unknown factors at the time of the fitting. For example, there are no defined methods for adjusting adaptive parameters such as speech enhancement, noise reduction, and microphone strategy; features that significantly impact noisy or reverberant environments. As such, clinicians are forced to make theoretical assumptions regarding the impact of several parameters in multiple listening situations. Furthermore, what counts as desirable listening for one person may represent unacceptable noise for another.

In a quiet listening situation, it is reasonable to assume that an individual's primary amplification goal is to improve the perception of speech. However, the hearing instrument wearer's goals in more challenging environments will vary across a continuum, from speech perception to comfort or sound quality, depending on the nature of the situation and the person's reason for being there. Figure 1 shows the listening goals for two individuals across five common listening situations. In a general sense the importance of speech understanding increases from the left panel (public transit) to the right panel (doctor's office). Within each panel the two people demonstrate a range of preferences on the comfort/clarity continuum, also called speech audibility that varies by listening situation and individual. For example, both people prefer very high clarity when speaking to their family doctor, for obvious reasons. They also prefer a similar balance of comfort and clarity while at the shopping mall. However, though they may have very similar audiograms and sit in the same bus or jazz club on a regular basis, their preferences on the comfort/clarity scale are completely different in those environments.

For example, while riding the bus the wearers' goals will surely include awareness of alerting signals for safety. Yet one individual may not require speech clarity, especially if clarity reduces comfort or sound quality. Meanwhile the other person rides the bus with a spouse or colleague on exactly the same busy street. This person may readily accept diminished comfort in exchange for improved speech clarity. Furthermore, while one person goes to a jazz club exclusively to enjoy the music, another prefers the music only as a backdrop to conversing with friends. Once again their goals diverge considerable in the same environment based on their intent. Despite these differences, at the initial fitting, when asked in which situations they would like to hear better, both might respond, "At the jazz club." This will doubtlessly lead the clinician to set both of their hearing instruments in the exact same way.

Figure 1 shows how preferences for comfort and clarity can vary across individuals in any given situation. The second individual (dark blue dot) has a much higher need for clarity in the jazz club than the first individual (light blue dot) because he is more interested in social interaction than in primarily listening to the music. Even though the two individuals represented in this diagram frequent the same listening situations, and may have similar hearing losses, their goals in many cases are quite different.

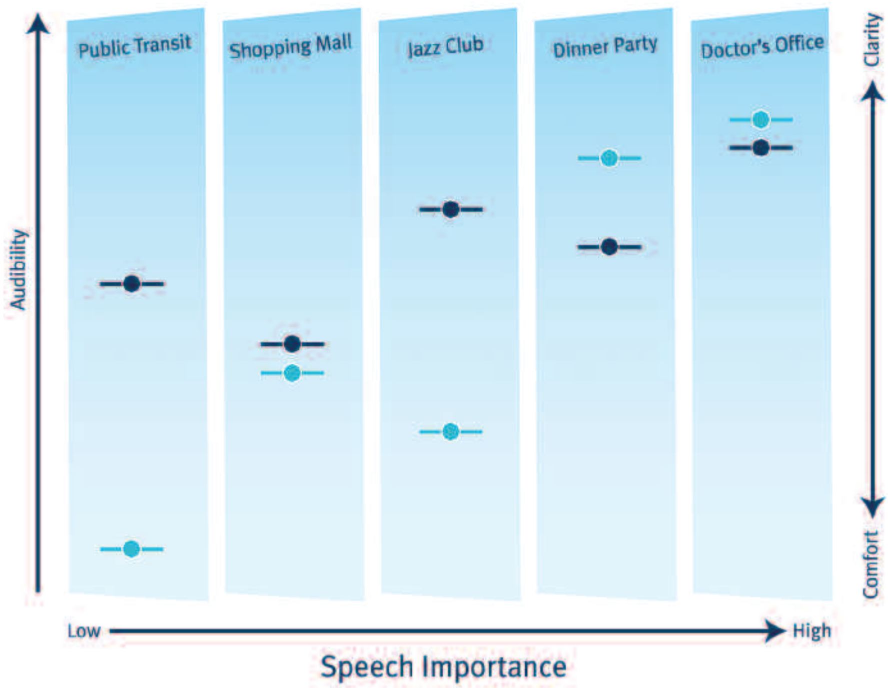

Figure 1

A User Control Solution

An alternative to the standard clinical approach described above is based on an adjustable user control for multiple adaptive features. The approach begins with an initial fitting where the clinician presets the instruments in the office for the wearer's desired listening environments. While some minor fine-tuning is often desirable, a high level of precision is not required at this stage. Instead a user adjustment is provided that allows the wearer to control the strength of the features that will yield the most demonstrable impact in difficult listening situations.

User control has always been limited to volume control or the ability to make broad program changes according to settings the fitter thinks might be best for a particular listening environment. Automatic programs are also available but the parameters within these programs require certain assumptions on the part of the fitter; assumptions which may not always meet the needs of the wearer. In contrast, it is highly effective to empower users to manipulate those features which impact hearing instrument output, but have no clearly associated prescription. For example, when the wearer experiences a difficult listening situation, they can control a group of parameters including: microphones, speech enhancement, noise reduction, and overall gain. Using one simple control, the wearer can simultaneously optimize all four parameters to meet their desired goal in any listening environment. Thus the wearer has the opportunity to rapidly converge on an optimized fitting in any listening environment as efficaciously as possible, increasing satisfaction and performance, while minimizing problems and complaints, even before the follow-up visit.

Here is an example of how such a user control can work. The example is based on the smartFocus™ control and it provides a range of adjustment from comfort to clarity. When adjusting towards comfort, the goal is not to maximize speech intelligibility or improve understanding, but rather to increase the overall listening comfort without losing environmental awareness. The parameter settings at the comfort end of the continuum are optimized specifically to meet these goals.

Conversely, when adjusting toward clarity, all of the parameters have been optimized to enhance the perception of speech, particularly in noisy environments.

Both comfort and clarity can be adjusted as follows (Figure 2–4 and Table 1).

Although the noise canceller is engaged whether the control is adjusted toward comfort or clarity, its impact is different in each direction. When adjusted towards the direction of comfort, the noise canceller is more aggressive, reducing noise by up to 10 dB/band at its maximum. The relatively greater aggressiveness along this end of the control is designed to meet the listening goal of comfort in noise. However, when adjusted towards the direction of clarity, the impact of the noise canceller is limited to 6 dB/band. The noise canceller is less aggressive at the clarity end of the continuum than at the comfort end

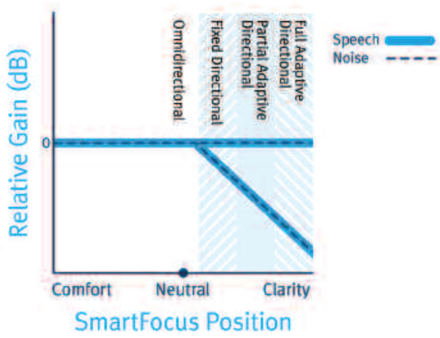

Figure 2. Microphones

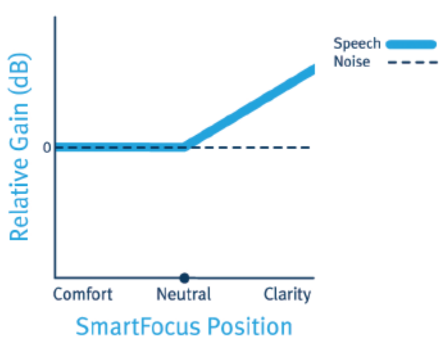

Figure 3. Speech Enhancement

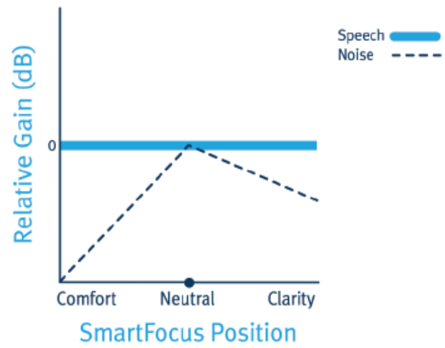

Figure 4. Noise Canceller

Table 1.	**SmartFocus™ Position Microphones**	**Speech Enhancement**
Comfort through neutral	Omni-directional	No need for speech enhancement
Neutral through clarity	Gradual shift from omni-directional to fixed directional to fully adaptive, provides increasingly aggressive reduction for off-target sounds as control approaches clarity	Strength of speech enhancement increases progressively to a max. 8 db/band Progressive reduction in off-target sounds; desired target speech selectively enhanced

because its purpose is to improve the clarity of speech signals in this area. If the noise canceller works too aggressively in combination with speech enhancement it can actually deteriorate clarity. This is one benefit of pre-configuring the relative combination of these multiple parameters along the control. It helps ensure that parameters will be set to achieve desired goals without causing artifacts

Another effect that most hearing instrument wearers associate with comfort is a slight gain reduction. Thus a variable broadband gain reduction of up to 5 dB is also applied as the control is adjusted from neutral to comfort.

The combined effect on the gain model of all parameters under adjustment is shown below in Figure 6.

More Control Without Increased Hassle

There is the risk that constant adjustment of a user control in different listening situations will rapidly become intrusive. Therefore, other components of the hearing system can be utilized to help the wearer converge on their desired smartFocus setting with minimal adjustment. It should then automatically return to the new settings whenever the wearer is in the same listening environment. There are two components of the hearing system which make this possible.

AUTOPRO4

This is an automatic program, which includes the following destinations: speech only, speech in noise, noise only, and music. The smartFocus control can be adjusted to a different position for each of these destinations. As the instrument cycles from

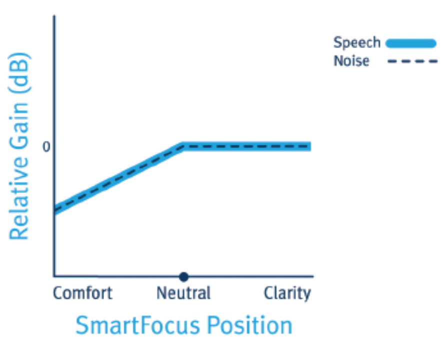

Figure 5. Gain Reduction

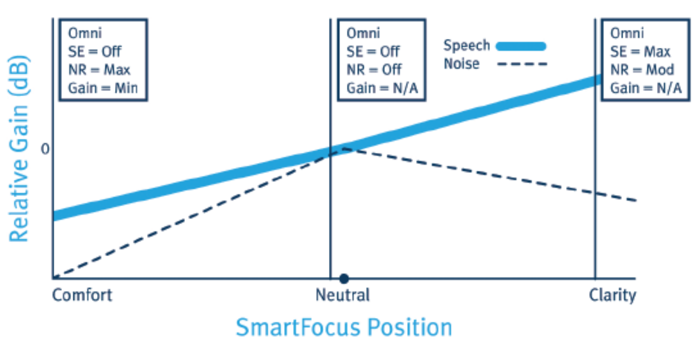

Figure 6.

one destination to the next, reflecting changes in the listening environment, it updates the position of the control to the wearer's desired setting for each destination.

Optimizing the control for up to four destinations significantly reduces the need for constant user adjustment, provided the correct settings have been chosen for each destination. It is extremely helpful if the hearing instruments can learn the client's preferred settings, reducing the need for repeated wearer interventions each day.[5,6] Plus, fewer return visits are needed to update the device.[5,6] Furthermore, wearers are generally more satisfied with an aid that they have optimized in their own listening environments.[7]

SELF LEARNING

SmartFocus and the volume control are preset for all four destinations at the fitting. The wearer takes the hearing instruments home and makes adjustments to both controls while moving through common listening situations. The hearing instruments learn the wearer's preferences in each destination and gradually updates both controls, thus optimizing smartFocus and the volume control for each of the four destinations. By the time of the follow-up visit, two to three weeks after the fitting, the instruments have applied the wearer's preference for both controls in each of four listening destinations. The wearer now only needs to make adjustments in novel listening environments.

Results from Internal Validation of the Feature

To validate the performance of the smartFocus control, 35 individuals experiencing a wide range of hearing loss were fitted with Unitron hearing instruments featuring a variety of shell types and venting. Each participant wore their assigned hearing instruments for three weeks. At the end of the three weeks they were asked to rate their overall satisfaction with the instruments on a 1 – 10 scale, where 1 is "very dissatisfied" and 10 is "very satisfied." The participants were overwhelmingly either very satisfied or satisfied with the hearing instruments after three weeks of use. Their ratings are shown in Figure 7.

Aside from satisfaction levels, the participants also reported significant benefit from the hearing instruments on the Abbreviated Profile of Hearing Aid Benefit (APHAB) questionnaire[8] The results for the new hearing instrument wearers and experienced hearing instrument wearers are shown in Table 2 and Table 3 below. New and experienced users are separated because benefit from wearing these hearing instruments is calculated as a decrease in problems relative to no amplification for new users, and as a decrease in problem relative to their previous hearing instruments for the experienced users.

In both cases there were significant improvements in Global aided benefit from Passport as well as in Reverberant and Noisy listening environments. The new users also showed significant improvements for quiet listening over the unaided condition. The experienced users reported about the same performance as with their existing hearing instruments in quiet listening environments.

The clarity provided by the smartFocus control was tested on another group of 33 participants. They were assessed using the HINT9 under very challenging conditions. HINT sentences were presented from 0° azimuth. Speech weighted noise was presented from four separate speakers at: 0°, 90°, 180°, and 270° azimuth. The noise was presented at a fixed level of 65 dBA and the HINT sentences were varied adaptively to obtain Sentence Speech Reception Thresholds (SSRT's). Analyses of the results are graphed below.

For the 25 participants who had conventionally fitted hearing instruments there was a significant improvement in HINT SNR's for the neutral setting of the smartFocus compared to no aid and there was a further significant improvement from the neutral setting of smartFocus to the clarity

Figure 7. Overall Satisfaction after 3 Weeks Use

Table 2.

Category	Difference between Means (Benefit Score %)	*p* Value	Significant Benefit (New Users)
Global	21.95	< .0001	Yes
EC	19.9	.0017	Yes
RV	18.91	.0003	Yes
BN	28.23	< .0001	Yes
AV	-22.08	.0039	No

Table 3.

Category	Difference between Means (Benefit Score %)	*p* Value	Significant Benefit (New Users)
Global	22.043	.0054	Yes
EC	16.529	.025	No
RV	31.364	.0016	Yes
BN	18.38571	.0023	Yes
AV	-8.321	.2465	No

setting. For the eight participants with open fitted instruments there was a significant improvement in HINT SNR's for the clarity position compared to the neutral position. In both cases there was a substantial and significant improvement in HINT SNR's for the clarity position over the unaided condition.

Summary

It is fairly straightforward to provide hearing instrument wearers with good performance in quiet listening situations. However, the problem becomes much more complicated when the listening situation is a noisy or reverberant environment. Clinicians must fine-tune fittings without the ability to replicate each listening environment in their offices.

To overcome this problem, clinicians can provide the wearer with a simple but powerful user control. This control allows the wearer to simultaneously adjust multiple adaptive parameters to improve comfort or clarity in any listening situation. Trials of Unitron hearing instruments employing the smartFocus control have demonstrated that this approach substantially improves user satisfaction and benefit across a range of listening situations. These tests also suggest that this feature can improve speech perception in noise as demonstrated by HINT SNR results.

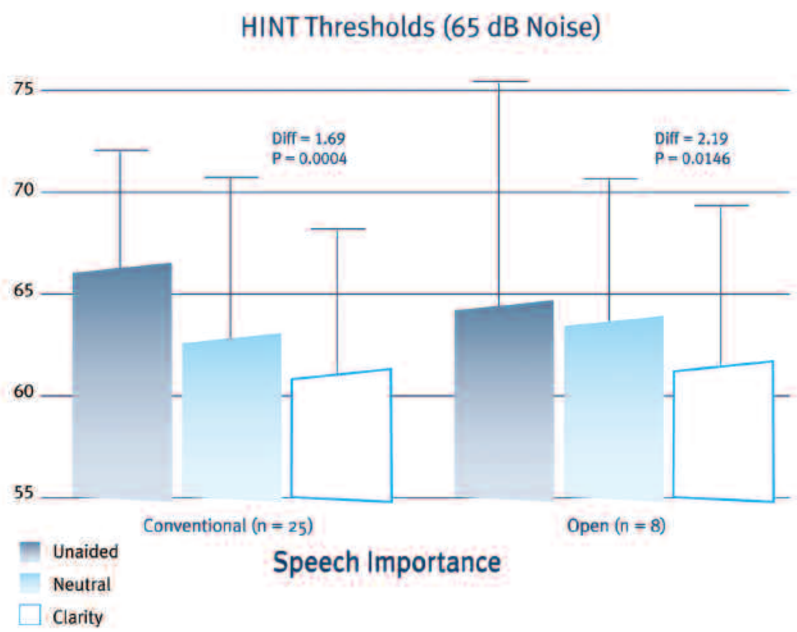

Figure 8.

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Did you know...

that kids between the ages of 6 & 19 are suffering from noise-induced hearing loss?

The **good news** is **noise-induced hearing** loss is 100% preventable.

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By Deborah Ranson, AuD, Reg. ACSLPA
Doctor of Audiology

About the Author

Deborah Ranson is an audiologist and provides technical support for Widex Canada, Ltd. She also works with the sales staff to provide peer training in western Canada. Her primary areas of interest are pediatric audiology and noise-induced hearing loss prevention.

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HiP, or *Hearing is Precious*, is a noise-induced hearing loss prevention program for kids and teens developed by Widex Canada, Ltd.

The first question people ask when we tell them about this program is "How is it that a hearing aid manufacturer is promoting hearing loss prevention?" I tell them that we see it as an opportunity to not only practice good corporate citizenship, but to lead by example, which we have done with our hearing aids for over 50 years. Aside from developing some of the most advanced technology in the market today, we have the flexibility to take our efforts in a direction that has increased our profile in the area of pediatric audiology. In this article, we will share our experiences of the work completed so far and introduce you to possibility of bringing this program to your community. This is an opportunity to practice what researchers have taught us as a profession about pediatric noise-induced hearing loss (NIHL), related tinnitus, and its prevention. We hope you will be inspired to make hearing loss prevention an active part of your practice.

HiP was developed under the umbrella of our pediatric program, Widex Connect. The basis of Widex Connect is as a website designed for kids and teens with hearing loss. It is a place where they can connect with each other so they know they are not alone. In addition to articles and information designed to help kids and teens grow with their hearing loss, there is also information for parents. The decision to add a hearing loss prevention aspect under Widex Connect was an easy one to make. As a hearing aid manufacturer, we understand the importance of good hearing health and the detrimental effects hearing loss has on communication. When we learned that in an American population study, approximately 12.5% of 6–19 year olds had elevated thresholds due to noise exposure[1] it was agreed that this was an important issue. It was from this desire to help prevent noise-induced hearing loss that HiP was born. As a result of bringing the HiP program into the schools, we discovered that it is an important community service message that, with a little creative thinking, can be actively promoted by audiologists.

The development of HiP began over two years ago and continues to evolve. It is important to know that we have not worked in isolation. Those of us at Widex who have been working on this project have grown as a team. We have also been fortunate to work closely with some of the world's leading researchers and contributors in the field of pediatric NIHL and tinnitus prevention. William H. Martin, PhD, from the Oregon Health and Science University, and Deanna Meinke, PhD, from my alma mater, the University of Northern Colorado, collaborators of Dangerous Decibels, and Linda C. Howarth, the program manager, have given us valuable feedback and cheered us on from the sidelines as we have worked with various schools and communities in Canada. Karen Turner, of Protec Hearing, Inc. in Winnipeg, helped us bring our "Under Pressure: Noise F/X" seminar to selected schools in Manitoba. In addition, we have drawn on the vast body of literature available from a variety of sources.

Our original program objectives were to raise awareness of noise-induced hearing loss and prevention in the pediatric population and to strengthen our relationships with local school boards in the communities we serve. This program was no small undertaking and we soon found that our biggest limitation was our human resources. To make this project manageable, we had to decide what we could "borrow" from the many programs that were already up and running and what we could create ourselves. We decided to use the Dangerous Decibels classroom program for elementary school age children. For the teens and young adults we determined we could create an education program to meet their needs, by expanding on one aspect of Dangerous Decibels and adding our own material. As a result, we came up with two components for tweens and teens: the "Shocque Attack," a fun event that allows students a unique opportunity to measure the loudness of their personal stereos. To support the Shocque Attacks we also developed "Under Pressure: NoiseF/X," an educational program focusing on hearing appreciation and the how-to's of NIHL and tinnitus prevention. For teachers, we created a presentation that is suitable for professional development. It includes the background, research, and resources relating to NIHL prevention for kids and teens and encourages them to consider implementing a NIHL and tinnitus prevention program at their school. Details of these program elements, including information about the HiP website, are described later in the article.

This is a long-term commitment and we are far from finished, but as you will see, we have come a long way. The response we have received for the HiP program has been tremendous. We will continue taking this program forward, expanding it from the schools into communities with the help of audiologists across Canada. Pediatric noise-induced hearing loss prevention is a topic that generates strong interest and garners great acceptance and support. I hope what you read here will inspire you to consider adding prevention of NIHL and tinnitus, for patients of all ages, to your audiology practice.

Why Include Prevention in Clinical Practice?

As audiologists, we are aware of the dangers of occupational and industrial noise exposure. Workers are protected by established Occupational Safety and Health Administration (OSHA) guidelines which must be adhered to in the workplace. This includes, among other things, the maximum noise exposure allowed and the requirement to use personal hearing protection to help prevent noise-induced hearing loss. This legislation extends to all provinces and territories. Unfortunately, this is not the case when it comes to recreational and social noise. Similarly, there are no guidelines or limits when it comes to children and the noise levels they are exposed to when playing with their toys, listening to their music, or when engaging in recreational activities where they are exposed to hazardous sound levels.

No longer relegated to occupational or industrial audiology, the area of pediatric NIHL prevention is one that has gained recent attention and continues to increase in momentum in countries such as the United States, New Zealand, and Australia; and now, Canada. The first ever conference on this topic, "Noise-Induced Hearing Loss in Children at Work and Play" was held in 2006 in Covington, Kentucky. The National Hearing Conservation Association has held a variety of annual conference proceedings during which the topic of NIHL in children was highlighted, particularly at the 2008 and 2009 meetings.

Widex believes NIHL and tinnitus prevention can become an important part of your clinical practice and must include even the youngest patients. Greater numbers of children are exposed to louder sounds at younger ages which may increase their risk for developing earlier and more severe noise-induced hearing losses.[2] Researchers are very interested in noise-induced hearing loss in children as there are currently many unanswered questions. Early onset noise-induced hearing loss may have different and possibly greater consequences on auditory processing than later onset noise-induced hearing loss. Animal model research shows that young animals exposed to loud noise had accelerated hearing loss later in life, even without further noise exposure.[3] The consequences of NIHL in children include a greater incidence of learning difficulties and behavioural problems.[4] There are also public health issues related to NIHL such as communication difficulties, frustration, isolation, and depression.[5] Taking noise exposure a step further, living near noise can affect language learning, influence brain development (plasticity), create stress, and cause sleeplessness.[6] Early-onset NIHL may be associated with longer term consequences that might even influence one's vocational or occupational choice.

Our world is a much noisier place than it used to be and the habits of kids and teens are different than those of their parents. Some kids and teens are spending hours each day listening to personal stereos at volume levels that are as loud, and in some cases louder, than those levels found in the workplace. One study found that 16% of 14–18 year-olds use their personal stereo systems daily at levels and durations that exceed NIOSH (National Institute of Occupational Safety and Health) recommended levels.[7] Children are at high-risk for NIHL and tinnitus based on recreational and social listening habits. Many of them engage in activities such as attending concerts, snowmobiling, gaming, shooting, and woodworking. The World Health Organization notes that in developing countries the risk of noise-induced hearing loss from social noise is increasing among young people.[8]

There is a known disconnect among teens and young adults when it comes to knowledge about the dangers of loud noise. Many do not know that loud noise can cause permanent hearing damage and that the use of hearing protection can help avoid hearing loss.[9] The popular MTV (Music Television) teamed up with researchers at Harvard University to ask teens and young adults about their listening habits and attitudes towards hearing protection. Over 9,600 teens responded to the web-based survey. Here are some numbers that might surprise you:

- 61% said they experienced tinnitus in their ears after attending a concert
- 43% said the experienced tinnitus after going to a dance club
- 14% said they used protective ear plugs

What surprised the researchers was the fact that so many teens had not made the connection that loud music can cause permanent hearing loss. While this news is disheartening, they also discovered that many teens, once they understood that their listening habits could result in permanent hearing loss and tinnitus, would consider wearing hearing protection if they were encouraged to do so by a medical professional.[10] This bodes well for us professionally as it indicates that we may be able to make a difference if we step up to the plate and promote prevention as part of our clinical practice.

Researchers continue to learn and publish findings we can put to use. They continue to encourage us to educate our patients, young and old, about the importance of NIHL and tinnitus prevention. Prevention needs to become part of our daily practice so we can educate and inform our patients, of all ages, about the fact that NIHL can occur outside of occupational and industrial settings. We need to alert them that NIHL and tinnitus can occur through recreational and social activities. Your role is vital in helping your patients understand how dangerous sound levels, regardless of the source, can damage the inner ear structures. You can help them appreciate the importance of personal hearing protection and fit them with the most suitable protection for the activities they enjoy. Counselling and instruction of proper use and insertion is the key to compliance. This can range from demonstrating proper insertion of foam earplugs, to helping the patient source earmuffs from a safety supply company, to fitting them with custom noise-attenuating ear moulds or musicians' earplugs.

HiP: A Corporate Affair

Since we are encouraging you to consider making prevention a part of your clinical practice, we thought we had better "walk the talk" ourselves. We had to come up with something that we as a corporate entity could offer. For our contribution to NIHL and tinnitus prevention, we created the HiP program which was briefly described at the beginning of this article. One of the goals of HiP is to reach out to local communities to promote awareness of the dangers of loud sounds and to teach children and teens ways to protect their hearing to avoid permanent hearing loss and tinnitus. We have created an on-line presence with our website and have been active in the schools at the elementary, secondary, and trade school levels. Each aspect of HiP offers something for the various age groups that have been targeted.

HiP Website

As mentioned earlier, the HiP website was created as part of our Widex Connect program. There are lots of terrific sites that focus on NIHL prevention and each is unique. Many of them were aimed at a younger age group in terms of the look and feel of the graphics so we decided to focus on a format that would speak to the tweens and teens. Our design team created an urban, edgy look for the site which has gone over well with this age group. Currently available in English, the website will eventually be translated into French.

It was important that the site offer comprehensive information with plenty of depth and breadth for those teens who are interested. The HiP website is an ongoing project and is updated several times a year to add fresh articles and highlight new research as it becomes available. There is also a professional section on the website where you can find information, such as "12 Ways to Bring NIHL Prevention to Your Practice." You can find us at www.widexconnect.ca.

HiP in the Schools

In the winter of 2008 and spring season of 2009, we worked closely with some dedicated hearing conservationists, audiologists, and local hearing resource teachers. They helped us bring HiP to schools in Winnipeg, Calgary, and throughout southern Ontario. So far we have visited 35 classrooms in 9 different school districts, and met nearly 1,500 students, ranging in age from 8–24 years old. We interacted directly with the students and teachers to bring the message about the dangers of loud sounds, tinnitus, how NIHL can occur, and how it can be prevented. While this was very time consuming and physically demanding, it was easily one of the most rewarding aspects of the entire initiative. We brought three programs into the schools. The first program is Dangerous Decibels, designed for the elementary age students. The second and third are the "Shocque Attack" and the "Under Pressure: Noise F/X" presentation, both of which are designed for teens and young adults.

DANGEROUS DECIBELS

The goals of this classroom program are to reduce the incidence and prevalence of noise-induced hearing loss and tinnitus by increasing knowledge and changing attitudes and behaviours of students.[11] The program is can be adapted for K–12 classes. It is interactive and hands-on, giving the students an opportunity to discover just how important it can be to protect their ears. With the help of some fun activities and some scientific tools, the students learn about decibels, study sound levels, find out how loud is too loud, and learn how sound can damage the delicate inner ear structures. They also discover three easy ways to protect their hearing. The program has three educational messages that teach students the answers to the following questions:

- What are the sources of dangerous sounds?
- What are the effects of listening to dangerous sounds?
- How do I protect myself from dangerous sounds?

The program was created through a collaboration of various disciplines which is best described as found on the Dangerous Decibels website at www.dangerousdecibels.org. We wanted to be able to deliver this program to students in Canada in a way that would ensure the expected outcomes as maintained in the literature. We brought the faculty of the Dangerous Decibels program to Burlington, Ontario to teach us how to deliver this program so that the correct educational criteria would be met. Now as Certified Dangerous Decibel Educators, a few members of our staff are able bring this program to the schools. There is also a Virtual Museum at the Dangerous Decibels website which has many of the classroom activities and can be accessed by anyone. It makes an excellent supplementary booster to reinforce the messages of the classroom program using a different modality. We worked to make this valuable teaching tool available to a wider audience in Canada by funding the French translation collaboration between the creators of Dangerous Decibels and the University of Ottawa.

SHOCQUE ATTACK

For high school students, we decided that something more extreme was necessary. As part of the Dangerous Decibels education and research projects, a special teaching tool (a mannequin with a sound level meter in place of an ear) was created by an undergraduate student during her summer fellowship in the Center for Research and Environmental and Occupational Toxicology at the Oregon Health and Science University.[12]

Inspired by Ms. Martin's creation, we devised our own mannequin and named her "Shocque." The modifications of the mannequin and her sound level meter were pretty simple. We cut out the ear (Figure 1) and mounted a silicon ear through which a hole had been drilled where the eardrum would be. A sound level meter was modified by removing the microphone, attaching it to a length of speaker wire, and then placing the microphone in the hole of the silicone ear, as if it were an eardrum. This enables us to obtain a sound level measurement by placing an earbud to the outer ear part of the silicon ear, as would be normally worn. The final product (Figure 2) is an interactive teaching tool that is unforgettable.

The Shocque Attack itself involves going into the high schools during the lunch hour and setting up an area where students can measure the sound levels of their earbuds (or headphones) of their personal stereo systems through Shocque's "ear." We talk candidly with them about the consequences of listening to loud music for extended periods of time and the possibility of permanent tinnitus and noise-induced hearing loss. We discuss ways they can protect their hearing and show them what volume setting on their personal stereos would be considered safe, and for how long, according to NIOSH guidelines. We remind them of the many cool things their ears are capable of doing and how some things they take for granted would change if they had a hearing loss.

Research indicates education alone is not very effective at getting teens and young adults to change their attitudes and behaviours when it comes to protecting their hearing. Peer educators are effective at delivering health messages. If this age group can be taught to mentor others, in a peer training format, then they can and will change their attitudes and behaviors.[13] We saw this happen at a very basic level when we were hosting the Shocque Attacks. The teens who participated accepted the message and quickly recruited their friends to come take part in the exercise. They eagerly explained to their friends how Shocque worked, and told them the message we were teaching. Several students voluntarily set their maximum volume level not to exceed 85 dBA as measured on Shocque. It has been documented in the Health Behaviour Model, that teaching individuals about predictive consequences can make them consider changing their habits.[14]

Figure 1. Shocque under construction.

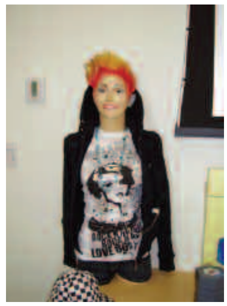

Figure 2. Shocque!

It is possible to build your own loudness level measurement mannequin. You can download your free "Jolene Cookbook" for the easy to follow instructions. People from 47 American states and 14 countries have already done this and you can see photos of the various mannequins that have been made at www.dangerousdecibels.org/jolene.cfm. It makes for a great group science project and teens can be taught to host a Shocque Attack to encourage peer-to-peer interaction which is an effective way to get them to change their attitudes and behaviours and helps indirectly address the important issue of peer pressure.

UNDER PRESSURE: NOISE F/X

This seminar was presented to high school students and young adults in a trade school setting. Designed for students in at-risk classes for noise exposure and possible NIHL, such as shop and music classes, this seminar covered the physics of sound, normal and abnormal auditory function, and the idea of hazardous noise as it relates to occupational and recreational noise exposure. It includes information on hearing appreciation, how different cultures relate to loud noise, and how teens around the world have different attitudes and behaviours in response to loud noise or music. For example, did you know that teens attending a concert in Sweden are more likely to wear personal hearing protection than teens attending a concert in North America?[15]

Shocque was also recruited for this session to demonstrate for the participants how their listening levels of their personal stereos can easily become unsafe; often exceeding what is permissible in occupational settings according to OSHA and NIOSH. We taught them proper insertion of foam insert earplugs with hands-on practice and the benefits of wearing properly fitted hearing protection. To address the very important issue of peer pressure, we have also created a role-playing group activity to help them practice how to handle themselves in a situation when they are faced with a choice to use hearing protection (or not) when exposed to hazardous sound levels in occupational and recreational situations.

Professional Development for Educators and Audiologists

Educators and audiologists from various backgrounds have expressed an interest in learning about the educational aspects of NIHL among children and how they can help prevent it. To provide education and support for them we have developed a seminar that is suitable for professional development. It has been delivered to teachers in several school boards in Ontario. The seminar includes the following elements:

- Overview of current research about children and the educational impact of NIHL
- Importance of NIHL prevention
- Overview of school-based NIHL prevention programs
- Resources for child-friendly hearing protection devices
- Brainstorm sessions for establishment of NIHL prevention program in their classroom

The teachers reported to us that they often see the students subjecting their ears to unsafe loudness levels. While health education includes learning about the sense of hearing, there is little offered to teach children how this most precious sense can be permanently damaged and how to protect it.[16] The seminar shows them why and how to incorporate these important aspects into the health unit about hearing.

In support of the various professional organizations, which we are proud to help sponsor, we hosted a pre-conference workshop at the Canadian Academy of Audiology at Niagara Falls, Ontario; and a general session presentation for the British Columbia Association of Speech Language Pathologists and Audiologists at Whistler, BC, both in 2007. That same year at the "Excellence in Hearing Conservation" convention in Winnipeg, MB we sponsored two members of Dangerous Decibels to present an overview of their program.

As a result of the various activities in the schools, the importance of NIHL and tinnitus prevention was highlighted in the local press. It is hoped that these news articles resulted in the students and their families having informal conversations in the home setting to remind the kids and teens of the importance of healthy listening habits. One school board highlighted the Shocque Attack events on their website and encouraged parents whose children listen to their personal stereos regularly to contact their local audiologist for a hearing test. This is great support for the local audiologists and shows how the corporate initiative we have put forward into the schools has come back around to benefit the audiologists in that community.

Looking back on all of the work we have done gives us encouragement to continue promoting the HiP program. As you can see, there are lots of ways to bring NIHL and tinnitus prevention to the schools in your community. Various professional groups, such as the National Hearing Conservation Association, and not-for-profit groups, like the Hearing Foundation of Canada's Sound Sense program, also promote hearing loss and tinnitus prevention. There are campaigns that are supported by other hearing aid manufacturers which focus on "Hear the Music," a campaign that heightens awareness of the importance of the sense of hearing. Even professional organizations such as the Canadian Academy of Audiology and the National Coalition of Noisy Toys are promoting NIHL and tinnitus prevention to consumers. All of these efforts show just how important it is to make prevention a part of our daily practice as audiologists. Websites and campaigns are wonderful places to start, but the magic truly happens at the individual level, one presentation and one conversation at a time. This is why we have made a commitment to provide a hands-on approach. We have seen the impact it has had on the individuals we have reached. You can experience this too when you make the time to get involved and reach out to touch the children and families in your community.

A Professional Challenge

The time and effort we have invested into the HiP initiative has resulted in a tremendous response. Our experience has taught us not only what is possible and what works, but it has also taught us that we need to look to the audiology community to help us sustain this initiative. To this end, we are currently preparing a workshop that will expand the initial scope of this initiative to include activities that will help you bring HiP to your community.

There is no one better qualified than you to be the voice for this important topic. You have the professional knowledge and experience to bring this positive, proactive message about the importance of NIHL and tinnitus prevention to your community. You can do this regardless of the age group you serve or the environment in which you practice.

By speaking out, you will increase the profile of audiology and of your practice. You may even find it to be a refreshing change of pace if you have spent most of your career primarily in diagnostics and rehabilitation. So much of what an audiologist does centres around helping patients live with the consequences of hearing loss. Promoting the prevention of NIHL and tinnitus gives you an opportunity to make a difference and save someone from unnecessary injury. This will bring you tremendous professional and personal satisfaction. Prevention is an entire aspect of audiology that is often under promoted and with a little bit of your professional expertise, time, and energy, you can have profound and lasting effects on those individuals you reach. Imagine if we were able to accomplish such a feat collectively as a profession. That would be truly amazing.

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Noise: The Hazardous Pollutant We All Must Curb

Arline L. Bronzaft, PhD

About the Author

Dr. Arline L. Bronzaft is a professor emerita of the City University of New York and serves on the Mayor's Council on the Environment of New York (named to the Council on the Environment by three previous mayors as well) where she chairs the noise committee. Dr. Bronzaft, conducts research on the impacts of noise on mental and physical health, writes on the effects of noise in academic journals and books, serves as an expert witness on noise issues and advises anti-noise groups in the United States and abroad.

Moms, dads, girls and boys
Join together to stop the noise
So that we can one and all
Forever hear the raindrops fall

The above are the last four lines in my children's book Listen to the Raindrops, illustrated by Steve Parton, that teaches children about the beauty of sound and the dangers of noise. If we fail to lessen the noise, it won't be only raindrops we will no longer hear but we will be unable to tune in to all the other beautiful sounds that surround us – birds singing, leaves gently falling to the ground, waves brushing against the shore. Noise has become so intrusive that it frequently interferes with our daily activities at home as well as at our workplace. Murray Schafer claimed that: "The modern city has become a sonic battle-ground."[1] Unfortunately, so have the suburbs and the small towns. Mr. Schafer believes that we are losing our battle against the encroaching noises and notes that the prophets "... vision of an end making a mighty noise"[1] may prove correct.

This article is being written to motivate readers to join anti-noise activists who are waging a battle to lower the din, to protect our soundscape, and, possibly, to "save our civilization."

Noise Is More Than an Annoyance: It Is Hazardous to Our Mental and Physical Health

The evidence that loud sounds and noise can lead to hearing loss is generally acknowledged, but too many people are still exposed to sounds that can damage their hearing. That noise is annoying is also accepted but, unfortunately, too frequently tolerated as a "necessary evil." However, that noise is hazardous to our mental and physical health has not yet received wide attention or acceptance. Noise, sound that is unwanted, disruptive, bothersome, but not necessarily loud, brings about stress in individuals whose activities are being disrupted by noise. The neighbour's loud boom car, the overhead jet's roar or the constant backup beeps at the nearby construction site act as stressors to the body and trigger off a set of complex physiological reactions – a rise in blood pressure, a change in the rhythm of the heart, the production of an excessive secretion of certain hormones. If the noise continues over time, then the stress to the body can result in cardiovascular, circulatory or digestive ailments.

The growing body of studies, conducted largely on residents living adjacent to highways, railroads, and airports, have shown that noises can indeed result in illnesses, with the strongest evidence for increased hypertension and cardiovascular disorders.[2–4] Passchier-Vermeer and Vermeer found that traffic and aircraft noise affected children's cardiovascular systems as well.[5] A review study by the Health Council of the Netherlands found that aircraft noise disrupts normal sleep patterns.[6] Sleep serves a restorative function but a loss of sleep also makes it difficult for people to perform their tasks the next day and may make them less attentive to cues of dangers as they walk or drive.

Yet, short of actual physiological symptoms, noise, according to the World Health Organization, diminishes one's "quality of life." Good health is not merely the absence a group of physiological symptoms. When individuals living near airports reported their sleep, as well as their household conversation, television viewing and reading, were disrupted by airport-related noises, they were essentially speaking to a diminished "quality of life."[7,8]

We can always call for additional studies to strengthen the health/noise link but there is certainly enough evidence to warn people about the potential danger of noise to their health, and we can generalize from the existing research to individuals disturbed by noises other than transportation.

Laboratory and field studies have demonstrated that noises made people angry and more aggressive.[9,10] News stories throughout the world have reported fights erupting between neighbours because of noise. In New York City, a former director of the Victim Services Medication Program had commented frequently on how often noise disputes escalate to aggressive behaviour. Bronzaft and colleagues distributed a questionnaire querying respondents about their reactions to noise and found that fifty per cent responded that noise makes them angry.[11]

Anger can be viewed as a strain on mental health. The anguish and distress in the voices of the callers who complain to me as chair of the Mayor's Council of the Environment in New York City similarly speaks to the adverse impact of noise on mental health. Kozo Hiramatsu and his colleagues found that aircraft noise resulted in an increase in perceived psychological disorders such as "depressiveness and nervousness."[12] When individuals find that their noise complaints are not attended to, as often happens to tenants who complain to their landlords or citizens who complain to airport authorities, then people develop what psychologists call "learned helplessness." Learned helplessness is a feeling that nothing can be done to alleviate the pain brought about by the noise and these feelings tend to exacerbate the stress and the mental discomfort.

Of special concern are the findings that demonstrate that children's language, both cognitive and learning, are impeded by noise. Even President Obama, in a recent speech before Congress, noted that a school he visited in Dillon South Carolina was a place where they had "...to stop six times a day because the train barrels by their classroom." Noisy homes can slow down language and cognitive development[13] and studies on children who live and go to schools near noisy highways, elevated trains and airports have found that these children are slower in psychomotor skills, reading, problem solving and learning.[14]

When we examine the research on the effects of noise on physical and mental health, as well as the impacts on learning in children, we would certainly concur with a statement made by the U.S. Environmental Protection Agency (1978): "It is finally clear that noise is a significant hazard to public health. Truly noise is more than an annoyance."[15]

However, the United States federal government did not act upon this statement to lessen the noise, but rather regressed with respect to its role in advocating for a quieter, healthier environment, and left it up to cities and local municipalities to pass legislation to abate noise.

Citizens and Researchers Uniting Against Noise

In the United States, many local authorities (New York City being the exception with a noise code dating back to 1972) were slow to legislate noise but with the growth of anti-noise groups these past few years, there has been an increase in the number of cities and towns that have passed ordinances limiting noise. Similarly, around the world, anti-noise organizations (www.nonoise.org; www.noiseoff.org; www.quiet.org; www.ukna.org/uk) are advocating for less noise. When these advocates approach public officials on noise issues, they come armed with research linking noise to adverse health effects, now readily available on the Internet, and in some cases have enlisted the assistance of some of the scholars who have undertaken the research. In the United States, this year, a coalition of citizens in five Atlantic states, outraged by a Federal Aviation Airspace Redesign Project, that would increase noise to residents in these five states, joined forced with public officials in these five states to bring a lawsuit against the Federal Aviation Administration, citing noise and air pollution concerns. In the United Kingdom, citizen and public officials similarly protested against an expansion at Heathrow Airport.

Citizens can indeed advocate for a quieter environment and very often they are more knowledgeable about what is happening in their community than their public officials. What they lack is the confidence that they can challenge "city hall." Too often, the frustration of not having a call returned or a letter responded to causes people to give up. That is why individuals must form groups to combat the noise. People should not be intimidated by the noisemakers – irresponsible store owners who don't keep their ventilating systems in good working order, producers of loud movies, highway departments that are reluctant to provide sound barriers, and airlines that give little attention to the noises inflicted on community residents.

Lessening the noises from overhead jets and highway traffic will take much time and a great deal of effort because driving and flying are viewed as inalienable rights. Yet, residents living near highways and airports must continue to fight for their rights which include the "quiet enjoyment of their homes." Similarly, academicians and other professionals must make a commitment as well to continue to conduct the research that is necessary to solidify the links between noise and health, despite funding difficulties, and to work together with citizens and public officials to translate their findings into appropriate public policy. Unless we all take an active role in lessening the noises around us, we will be overwhelmed by the horrific sounds that will eventually rob us of the ability to appreciate the wondrous sounds in our environment, as well as our mental and physical well-being.

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