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Revue canadienne d'audition

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ACA Académie canadienne d'audiologie Entendus. Compris.
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Vol. 5 No 4

The Application of Cortical Evoked Potential Measures in Hearing Aid Research

The Comprehensive Professional Behaviours Development Log–Audiology

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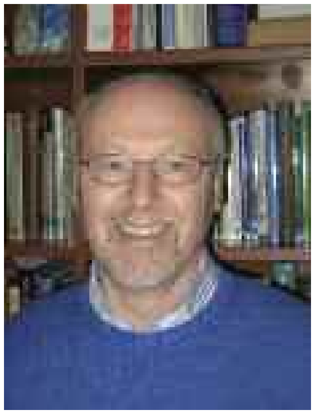

Now that the FIFA World Cup has finished and there are no more vuvuzela horns blaring away and no more Long Range Acoustic Devices (LRADs) for crowd control during the G20, we can turn back our attention to some non-noise aspects of our field. After 30 years as an audiologist I thought that I had figured it all out. Audiologists are half counsellor, half acoustician, half teacher, and half technical wiz. During the 1980s I thought that the best audiologist was a decibel counter and our role was to squeeze out every last decibel through hearing aids that had limited technology. The 1990s were a lost decade in the sense that we had the technology, but we didn't know what to do with it. The 2000s were slightly better, but more time was spent on keeping up with new technology that was really just a repackaging of the old stuff. Throughout the 2000s about 500 new hearing aids were introduced to the market every year. And now I am beginning to suspect that we are electron counters that have to be concerned with the number of electrons on the rear plate of a hearing aid microphone. This "E for Engineering" column in this issue is by Steve Armstrong, who is perhaps one of the most creative and most thoughtful hearing aid design engineers. Among other things, Steve discusses some of the detailed thought processes that go into designing and using hearing aid microphones. Initially Steve had responded to a question I had asked about some other aspect of hearing aids and he had told me that I was confused about hearing aid microphones. Steve's "E for Engineering" column topic has "unconfused" me … a bit.

But audiologists are still counsellors and teachers as well. Dr. Moe Bergman has reminded us of that. Dr. Bergman, who now resides in Israel, was one of the early pioneers in audiology and has been instrumental in the assessment and treatment of American servicemen who had just returned from the Second World War. I always find it surprising and gratifying that many of the founders of our profession who are known for their technical contributions were also great counsellors and could convey technical data to the everyday person.

The "E in ENT" column in this issue is by David Clinkard and Vincent Lin from the Sunnybrook Health Sciences Centre in Toronto. What can you do when someone wakes up with a sudden sensorineural hearing loss? We call this an "idiopathic sudden sensorineural hearing loss" but other than sounding really sexy, it doesn't tell us much about the etiology. Some of the state of the art treatment options are discussed.

And, while we are talking about Beethoven, Doctor Lendra Friesen, also of the Sunnybrook Health Sciences Centre in Toronto (a coincidence?), discusses the genetic basis of otosclerosis in her "Spotlight on Science." I haven't seen Beethoven clinically in the last several years, but rumour has it that much of his hearing loss was probably due to otosclerosis (with a bit of lead poisoning thrown in as well). Is there a genetic basis for otosclerosis and what is it? Why is otosclerosis more prevalent in women than men.

The "From the Classrooms" column is made up of contributions from a number of graduating audiology students in the various Canadian universities. In this issue we have contributions from two students at the University of British Columbia – Anika Cai who looks at the maturation of the middle ear system in the first 6-months of life using multi-frequency, multi-component tympanometry, and Erin Hansen who examines the effective masking level for bone conduction ASSR in infants. These are well researched overviews of the evidence of different areas of audiology. I must admit that this is my favourite part of the *Canadian Hearing Report*, and I thank these students for submitting their work.

And to round out an informative issue, we have two articles for our "R & D Focus." Stella Ng introduces the comprehensive professional behaviours development log for audiology. And Danielle Glista and her colleagues look at cortical evoked potential measures in hearing aid research. If the goal is to re-establish normal neural function with amplification, as it is with some hearing aid manufacturers currently in the marketplace, then this, and Stella's research is mandatory reading.

I hope you all had a pleasant and relaxing summer. See you all in Montreal at the CAA annual convention.

Marshall Chasin, AuD,
Editor-in-Chief

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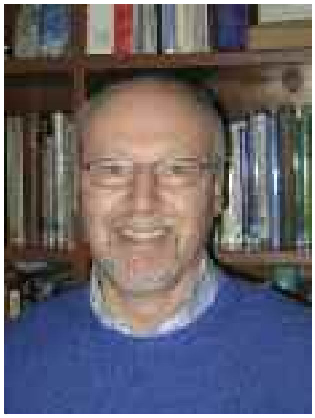

Maintenant que la coupe du monde de la FIFA est finie et plus de sons assourdissants de vuvuzela dans les airs et plus de dispositifs acoustiques de longue portée pour le contrôle des foules pendant le G20, nous pouvons reporter notre attention sur des aspects sans bruit de notre secteur . Après 30 ans d'expérience comme audiologiste, je m'étais dit que j'avais tout compris. Les audiologistes sont mi conseiller(e), mi acousticien(ne), mi enseignant(e), et mi technicien(ne) prodige. Pendants les années quatre-vingts, je pensais que le meilleur audiologiste était un compteur de décibel et que notre rôle était de presser le tout dernier décibel de tout appareil auditif à technologie limitée. Les années quatre-vingt-dix ont été la décennie perdue du fait que nous avions la technologie sans savoir quoi en faire. Les années deux milles étaient meilleures, mais plus de temps était dédié à se tenir au courant des nouvelles technologies qui étaient plutôt juste un remballement de l'ancien. Pendant les années deux milles, presque 500 nouveaux appareils auditifs sont introduits dans le marché chaque année. Et je pense que nous sommes maintenant des compteurs d'électrons plutôt préoccupés par le nombre d'électrons dans la plaque arrière du microphone d'un appareil auditif. La colonne “E for Engineering”de ce numéro est de Steve Armstrong, qui est probablement le plus créatif des ingénieurs de la conception des appareils auditifs. Parmi autres choses, Steve discute de certains processus de réflexion dans la conception et l'utilisation des microphones des appareils auditifs. Au départ, Steve répondait à une question que je lui avais posée et il m'a répondu que j'étais confus au sujet des microphones des appareils auditifs. Le sujet de la colonne “E for Engineerng”de Steve disons a dissipé ma confusion ..... un peu.

Mais les audiologistes restent aussi des conseillers et des enseignants. Dr Moe Bergman nous l'a rappelé. Dr Bergman, qui vit actuellement en Israël, a été l'un des premiers pionniers en audiologie et a contribué à l'évaluation et au traitement des soldats américains de la seconde guerre mondiale qui venaient de rentrer. C'est toujours surprenant et gratifiant pour moi de constater que plusieurs fondateurs de notre profession connus pour leur contribution technique étaient aussi des conseillers exceptionnels qui pouvaient acheminer des données techniques aux personnes ordinaires.

La colonne “E in ENT”de ce numéro est des Docteurs Clinkard et Lin du the Sunnybrook Health Sciences Centre à Toronto. Que faire quand quelqu'un se réveille avec une surdité neurosensorielle soudaine? Nous l'appelons “une surdité neurosensorielle soudaine idiopathique” mais autre le ton sexy du mot, nous n'apprenons rien sur l'étiologie. Certaines options de traitements de pointe sont discutées.

Et puisque nous parlons de Beethoven, Dr Lendra Friesen, aussi du the Sunnybrook Health Sciences Centre à Toronto (une coïncidence?), discute de la base génétique de l'otosclérose dans son “Spotlight on Science.”. Je n'ai pas traité Beethoven dans les dernières années, mais la rumeur se veut que sa surdité était probablement due à l'otosclérose (avec un peu d'empoisonnement par le plomb dedans). Y'a t-il une base génétique pour l'otosclérose et qu'en est-il? Pourquoi l'otosclérose est plus courante chez les femmes que les hommes?

La colonne “From the Classrooms” est une contribution d'étudiants sortants d'audiologie dans divers universités canadiennes. Dans ce numéro, nous avons la contribution de deux étudiants de the University of British Columbia – Anika Cai qui traite de la maturation du système de l'oreille moyenne dans les premiers six mois de la vie en utilisant la tympanométrie multifréquence à composants multiples, et une d'Erin Hansen qui examine le niveau efficace de masque pour la conduction osseuse chez les bébés. Ce sont des aperçus bien recherchés des preuves des différents domaines de l'audiologie. Je dois admettre que c'est ma partie préférée de La revue canadienne d'audiologie, et je tiens à remercier ces étudiants pour leur présentations.

Et pour terminer en beauté un numéro informatif, nous avons deux articles de notre colonne “R & D Focus”. Stella Ng présente la grille approfondie du développement des comportements professionnels pour l'audiologie. Danielle Glista et ses collègues regardent de près les mesures corticales potentielles évoquées dans la recherche des appareils auditifs. Si l'objectif est de rétablir une fonction neuronale normale avec l'amplification, comme c'est le cas avec certains fabricants d'appareils auditifs sur le marché, alors ceci, et la recherche de Stella est une lecture obligatoire.

J'espère que vous passez un bel et agréable été. Rendez vous à Montréal à la convention annuelle de l'ACA.

Marshall Chasin, AuD,
Éditeur en chef

Vol. 5 No 4, 2010

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What You Can't Hear Can Hurt You

A wind turbine is a rotary device with a gigantic propeller whose span can be as big as a football field. That propeller turns in the wind to generate electricity. Wind farms are rapidly becoming more popular in North America as a green energy source; however, the rotors of wind turbines also generate noise, particularly in the infrasound range that some people claim makes them feel sick.

Infrasound is a subset of sound broadly defined as any sound lower than 20 Hertz (Hz), which is the lowest pitch that most people can hear. Things like the wind in the trees, the pounding of surf, and the deep rumble of thunder are natural sources of infrasound. There is also a wide range of man-made infrasounds such as industrial machinery, traffic, and heating and cooling systems.

Alec Salt, PhD, a researcher at Washington University in St Louis School of Medicine who is supported by the National Institute on Deafness and Other Communication Disorders (NIDCD) studies the inner ear. For years, he and his group have been using infrasound as a way to slowly displace the structures of the inner ear so that their movement can be observed. In their experiments, infrasound levels as low as 5 Hz had an impact on the inner ears of guinea pigs.

“We were doing lots of work with low-frequency tones,” says Salt, “and we were getting big responses.” What they were observing in the lab, however, didn’t jibe with the scientific literature about hearing sensitivity, which was in general agreement that the human ear doesn’t respond to anything as low as 5Hz. Since human ears are even more sensitive to low frequencies than guinea pig ears, that didn’t make sense.

Salt and a colleague conducted a literature search, focusing not on papers about hearing sensitivity, but on the basic physiology of the inner ear and how it responds to low-frequency sounds. During the search, Salt found anecdotal reports of a group of symptoms commonly called “wind turbine syndrome” that affect people who live close to wind turbines.

“The biggest problem people complain about is lack of sleep,” says Salt, but they can also develop headaches, difficulty concentrating, irritability and fatigue, dizziness, and pain and pressure in the ear.

Salt and his colleagues still aren’t sure why some people are sensitive to infrasound and others aren’t. It could be the result of anatomical differences among individual ears, or it could be the result of underlying medical conditions in the ear that cause the OHCs to be ultrasensitive to infrasound.

Regardless, it might not be enough to place wind turbines further away from human populations to keep them from being bothersome, since infrasound has the ability to cover long distances with little dissipation. Instead, Salt suggests wind turbine manufacturers may be able to re-engineer the machines to minimize infrasound production. According to Salt, this wouldn’t be difficult. “Infrasound is a product of how close the rotor is to the pole,” he says, “which could be addressed by spacing the rotor further away.”

http://www.nidcd.nih.gov/news/releases/10/07_28_10.htm

Imaging Reveals How Brain Fails to Tune Out Phantom Sounds of Tinnitus

About 40 million people in the U.S. today suffer from tinnitus, an irritating and sometimes debilitating auditory disorder in which a person "hears" sounds, such as ringing, that don't actually exist. There isn't a cure for what has long been a mysterious ailment, but new research suggests there may, someday, be a way to alleviate the sensation of this sound, says a neuroscientist from Georgetown University Medical Center (GUMC).

In a Perspective piece in the June 24 issue of Neuron, Josef P. Rauschecker, PhD, says that tinnitus should be thought of as a disorder akin to the "phantom pain" felt in an amputated limb.

"Neurons, trying to compensate for loss of an external signal, fire to produce sound that doesn't exist in tinnitus patients, just like neurons send pain signals to someone who has lost a limb," Rauschecker says. "What both people have in common is that they have lost the feedback loops that stop these signals from reaching consciousness."

Rauschecker says this conclusion, from his research and from other leaders in the field, provides the first testable model of human tinnitus that could provide some new avenues for therapy. "If we can find a way to turn that feedback system back on to eliminate phantom sound, it might be possible one day to take a pill and make tinnitus go away," he says.

Georgetown University Medical Center. ScienceDaily
<http://www.sciencedaily.com - /releases/2010/06/100623123338.htm>.

Canadian Civil Liberties Association Wins Limits on Use of "Sonic Cannons"

In June, 2010, both the G8 and the G20 meetings were held in Ontario.

Concern arose over the use of Long Range Acoustic Devices (LRADs), also known colloquially as "sonic canons." These are loudspeaker systems that can be mounted on trucks or can be stationary. They use very intense sound levels to increase the range of audibility. Both speech stimuli and warble/high frequency tones can be used to control, or disperse crowds. Robert Harrison, PhD and Marshall Chasin, AuD, served as expert witnesses for the Canadian Civil Liberties Association suit against the Toronto Police Services to limit the use of these devices. The suit resulted in a judgment of a very limited use of these devices for only verbal crowd control instruction and no other permissible stimuli. Even with the speech stimulus, levels in excess of 120 dBA are emitted with the police officer who is operating the LRAD also being subject to these same levels. Concern was expressed not only for those in the crowd, but also for the operators of these devices. A future issue of the *Canadian Hearing Report* will have the exact submission, written by Marshall Chasin that was used as the source document for the court deposition.

CASLPA Applauds Government for Reintroduction of Consumer Product Safety Legislation

Government also working to protect children from dangers of noisy toys

The Canadian Association of Speech-Language Pathologists and Audiologists (CASLPA) commended the Government of Canada on the recent introduction of Bill C-36, the Canada Consumer Product Safety Act (CCPSA). C-36 builds on the efforts of similar legislation from the last session of parliament in updating Canada's consumer and product safety legislation. "We are pleased that the government is continuing its efforts to modernize Canada's product safety regime," said CASLPA Executive Director Ondina Love. "This legislation will give the government the tools it needs to be proactive in ensuring that the goods Canadians use are as safe as possible."

This legislation will have a particular effect on ensuring the safety of children's toys, especially through a general prohibition on the sale of unsafe products and requirements for manufacturers and importers to submit test results. However, it is important to remember that proper toy safety extends beyond dangers that can cause immediate harm. CASLPA is very supportive of the continued commitment and progress that the government has made to reduce the risks associated with excessively noisy toys.

www.caslpa.ca.

"QUICK NOTES"

FROM THE EXECUTIVE DIRECTOR

Well, hard to believe it is August already! Where has the summer gone? Having said that, CAA has seen a flurry of activity as it gears up for a very busy fall season.

The response from members about the new **CAA website**, which was launched in June, has been extremely positive. In particular, our Facebook page is growing daily with more than 50 "friends" who currently network and communicate with each other.

Registration has been brisk for our upcoming **CAA Conference in Montreal October 5–8 at Le Centre Sheraton.** An outstanding line-up of international speakers has been put together by the Planning Committee co-chaired by Erica Wong and Patty Van Hoof. Social highlights include a **"CAA's Got Talent Show"** during the Opening Reception on the Tuesday, and a **Soiree Evening** with live entertainment on the Wednesday. Close to **70 exhibit booths** will surely provide a wealth of information about latest trends in audiology services and hearing equipment and supplies. For the talent show sign-up, registration, and program information, go to www.canadianaudiology.ca We hope to see you there!

As a partner in the Inter-organizational Steering Group for Audiology and Speech-Language Pathology, CAA is taking the lead role in a project to develop **Guidelines for the Assessment, Diagnosis and Intervention/Mediation of Auditory Processing Disorders (APD)**. Your participation in an online APD Survey will be requested soon.

I also attended a meeting in May in Whitehorse with the **Federal Healthcare Partners (FHP) / Third Party Payers Group** to discuss items of concern to audiologists. The FHP/Third Party Payers Group includes Veterans Affairs Canada (VAC), Non-Insured Health Benefits (NIHB), Department of National Defense (DND), RCMP, and Blue Cross. A full report on decisions and recommendations coming out of our meeting is now posted on the Third Party Payer page of our website.

The next meeting of the group is scheduled for October in Montreal during the CAA Conference. In advance of this meeting, CAA members will have had a chance to provide input on which issues need to be addressed that currently impact their ability to provide services to their clients.

A further meeting has been set up with the NIHB group in September that hopefully will provide additional answers to the many questions from CAA members specific to NIHB.

CAA's **strategic marketing and branding exercise** continues to advance CAA and the profession to government agencies, universities and colleges, the Canadian auditory manufacturers industry and the general public. A number of new audiology tools and products – posters, stickers, "connect the dots" colouring sheets, and hearing test pads – have been produced for members and are available on the CAA website.

Now that our bid to co-host with CASLPA the **International Society of Audiology Congress** in Vancouver, British Columbia in October 2016 has been accepted, we will be searching for a hotel venue, recruiting conference co-chairs and members to participate on the planning committee, and seeking a professional congress organizer (PCO) to manage the event. If you are interested or know someone in CAA who may be, please contact me at director@canadianaudiology.ca

I hope you all enjoy the balance of the summer with family and friends!

Tom McFadden
Executive Director
Canadian Academy of Audiology

"DÉPÊCHES RAPIDES"

DU DIRECTEUR EXCECUTIF

Eh bien, difficile à croire mais nous sommes déjà au mois d'août! Où est passé l'été ? Ayant dit ça, l'ACA a vécu une série d'activités en se rapprochant d'une saison d'automne bien remplie.

La réponse des membres au nouveau site web de l'ACA lancé au mois de Juin a été extrêmement positive. En particulier notre page Facebook qui s'allonge quotidiennement avec plus de 50 "amis(es)" qui communiquent et font du réseautage les uns avec les autres.

L'inscription à notre prochaine **Conférence de l'ACA à Montréal du 5 au 8 Octobre au centre Sheraton** a été bien animée. Une liste de conférenciers internationaux exceptionnels a été établie par le comité de planification coprésidé par Erica Wong et Patty Van Hoof. Parmi les points sociaux culminants **"Le spectacle l'ACA a du talent"** durant la réception d'ouverture le mardi, et une soirée avec un spectacle sur scène le mercredi. Près de **70 cabines d'exhibition** vont sans aucun doute fournir une mine de renseignements sur les dernières tendances dans les services d'audiologie, en équipements auditifs et en audiologie. Pour s'inscrire au spectacle du talent, inscription et information sur le programme, veuillez consulter le www.canadianaudiology.ca. Nous espérons vous voir là!

En tant que partenaire du groupe directeur interorganisations pour l'audiologie et l'orthophonie, L'ACA est totalement impliquée dans un projet pour développer **des lignes directrices pour l'évaluation, le diagnostic et l'intervention/ médiation des troubles des traitements des informations auditives.** Votre participation à un sondage en ligne sur la question vous sera bientôt demandée.

J'ai aussi assiste à une réunion en mai à Whitehorse avec le groupe **Partenaires au niveau fédéral en matière de soins de santé/Tiers payants** pour discuter des préoccupations des audiologistes. Parmi les partenaires au niveau fédéral en matière de soins de santé , l'ACC (Anciens Combattants Canada), Service de santé non assurés (SSNA), ministère de la Défense nationale (MDN), la GRC, et la Croix Bleue. Un rapport complet sur les décisions et recommandations découlant de notre réunion est maintenant affiche à la page Tiers payants de notre site web.

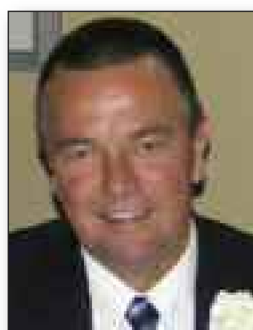
La prochaine réunion du groupe est programmée pour Octobre à Montréal durant la conférence de l'ACA. En préparation pour cette réunion, les membres de l'ACA auront une chance de fournir leurs commentaires sur les enjeux qui ont un impact sur leur capacité à fournir des services à leurs clients et auxquels il faut trouver des solutions.

Une réunion ultérieure est programmée en septembre avec le groupe SSNA qui espérant fournira plus de réponses aux questions spécifiques des membres de l'ACA aux SSNA.

L'exercice de la stratégie marketing et image de marque de l'ACA continue de propulser l'ACA et la profession devant les agences gouvernementales, les universités et collèges, l'industrie auditive canadienne, et le grand public. De nouveaux outils et produits d'audiologie – affiches, autocollants, feuilles de coloriage "connecter les points" et bloc- notes de tests auditifs – ont été crées à l'intention des membres et sont disponibles sur le site web de l'ACA.

Maintenant que notre soumission pour être le co-hôte avec l'ACOA, de la conférence de la **Société internationale d'audiologie** à Vancouver, en Colombie Britannique en Octobre 2016 a été acceptée, nous allons chercher l'hôtel, recruter le co ou la co-présidente, des membres pour participer au comité de planification, et un organisateur professionnel de conférence pour gérer l'événement. Si vous êtes ou connaissez quelqu'un de L'ACA qui serait intéressé(e), veuillez me contacter au director@canadianaudiology.ca.

J'espère que vous allez tous et toutes passez un excellent restant de l'été entre famille et ami(es)!



Tom McFadden
Directeur Exécutif
L'académie Canadienne d'Audiologie

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Canadian Hearing Report: Call for Reviewers

Canadian Hearing Report is published six times per year and is the official publication of the Canadian Academy of Audiology (CAA).

CHR is pleased to offer peer reviewing to all interested authors who submit manuscripts to the journal.

To carry out this process, the editorial board of Canadian Hearing Report is currently assembling a group of volunteer peer reviewers. We are looking for dynamic experts in various fields of audiology to serve on our peer-review panel. The list of the peer reviewers will be published annually in the journal. The manuscripts would be sent and received via email.

If you are interested in becoming a peer reviewer for CHR, please contact Marshall Chasin (marshall.chasin@rogers.com), editor-in-chief to discuss your particular area of expertise.

World War II, Aural Rehabilitation, and Tinnitus: Interview with Moe Bergman, EdD

Douglas L. Beck, AuD, speaks with Dr. Bergman about noise-induced hearing loss, Grant Fairbanks, Raymond Carhart, Ira Hirsh, and more.

Dr. Moe Bergman

Academy: Good day, Moe. It's an honor to speak with you.

Bergman: Hi, Doug. The honor is mine.

Academy: Moe, I know you've been officially retired for a couple of decades now (actually since 1985) and you make your home in Israel. Nonetheless, your history and insights are still very important to audiologists in the United States. In fact, I noticed in Jack Katz's latest edition of the *Handbook of Clinical Audiology* he dedicated the book to you, Fred Martin, Laura Ann Wilber, and one of my favorite people, Mark Ross.

Bergman: Thanks, Doug. Yes, Jack is a wonderful person. I was honored to learn about that dedication

Academy: Moe, where and when did you get your education?

Bergman: I earned an Ed.D. in 1949 at Columbia University. I only took one course in lip reading—that was as close as anything got to audiology in the 1940s! I also earned my master's from Teacher's College at Columbia University, in New York.

Academy: And then you were an itinerant teacher of "speech correction" until World War II? Is that correct?

Bergman: Yes. That's right. And I might note it wasn't until years later that we got the first "portable audiometer" (a Western Electric 2A), which weighed some 68 pounds. I immediately dubbed it "trans-portable." Portable audiometry was not for the weak!

Academy: I can just imagine people lugging those units across town! When did you join the army?

Bergman: I was in the army from 1943 to 1946. I had studied radio and radio repair in an army pre-induction course—before being called up for active duty. In fact, the army decided to have me learn about stringing telephone lines so I actually had to climb telephone poles! Of course, we all thought that it was a great challenge because we were young and naïve—but the reality was we didn't have the safety equipment they have today. Once you got to the top and looked down, it seemed pretty high.

I learned quite a bit about electricity and electronics and that served me well as I got more involved with audiology. Nonetheless, the army was getting more concerned with soldiers who had suffered noise-induced hearing loss and tinnitus secondary to weapons and noise exposure. I sought out a position working with soldiers with hearing impairment to allow me to use my skills and knowledge related to aural rehab. Back in those days, it wasn't a good idea to be too aggressive while you were in the army! But I did send a letter to the Surgeon General's office in Washington and stated I was prepared to work with soldiers with hearing impairment. The timing of my letter was fortuitous. The army had decided to set up the west coast Aural Rehabilitation Clinic at the Hoff General Hospital in Santa Barbara and a clinic at Borden General Hospital in Chickasha, Oklahoma, and one at Walter Reed Hospital, in DC. Ray Carhart joined the Deshon program in Butler, Pennsylvania 7 months later.

At the Hoff clinic I remember we selected new equipment and rack-mounted it to perform tests of hearing, hearing aid "fittings," etc. This was my job, since the remainder of the large rehabilitation staff at first were teachers of lip reading, auditory training, and speech therapy. Then Ira Hirsch arrived and he, too, joined the technical activities as acoustics officer. The program just got better and better with the addition of other professionals, such as a psychologist, a social worker and more ENT doctors. My program was called the Aural Rehabilitation Unit of the Department of Ear, Nose, and Throat at Hoff General. I arrived as they were starting the program and I stayed there until 1946, when they closed the unit after Hiroshima.

Academy: And when you left Hoff, where did you go?

Bergman: The army sent me to Borden General Hospital, which was another aural rehab unit in Oklahoma. Dr. Grant Fairbanks headed that unit. He was quite the genius and very well respected.

Academy: Yes, I recall the "Fairbanks Model" in the aural rehab book by one of my first professors, Dr. Derek Sanders. And I hate to bring it up, but oddly enough, I remember Dr. Sanders telling us that Dr. Fairbanks actually died a tragic death while flying somewhere?

Bergman: Yes, that's' true. Dr. Fairbanks was actually an expert in the larynx and voice. Ironically, as it happened, we had hosted him at a restaurant in White Plains, NY, the night before he left to attend a meeting in Florida. Apparently, as he was flying and a fish bone from the onboard dinner lodged in his throat and he died. That was June of 1964.

Academy: That is amazing. What a tragedy. And then you were at Borden for just a short time?

Bergman: Yes, well, Borden had their own professional staff, and they actually were well positioned and didn't really need more clinicians. I was reassigned to the Pentagon to write up the history of the Aural Rehabilitation Clinic and to describe our experience with sodium pentathol interviews to uncover feigned deafness. We wrote that up in 1946, but I don't think the published version came out till 1957!

Academy: Wow, an 11-year publication process—unbelievable! And after that you worked with the Veteran's Administration (VA) in New York?

Bergman: Yes, I think it was near the end of 1946 that I got to the New York VA. I designed that clinic with my wife. We had to cut and paste pieces of paper representing test rooms, therapy rooms, etc., and that became the first of the VA centers in audiology. I hired a staff and then I served as chief audiololgist there until 1953.

Academy: And that's about the time you started to publish on tinnitus?

Bergman: Yes, it was about the mid-1950s. I took 100 people with normal hearing and placed them in the sound booth for some 15 minutes or so. As you can imagine, more than 90 percent of them heard whistling, buzzing, and other sounds. Then I did the same thing with 100 people with hearing loss. The obvious conclusion was simply even people with normal hearing hear tinnitus, but because their hearing is so good, the everyday acoustic environment masks their ability to perceive their tinnitus.

Academy: And before that you were involved with an audiology course offered in Sweden with Raymond Carhart and Ira Hirsh?

Bergman: Yes, you're talking about the First International Course in Audiology in Stockholm, 1950. We participated as instructors. That was a pivotal point in my life and career. While I was there, some of the doctors from the brand new state of Israel (founded in 1948) asked me to consider teaching in Israel. It took a little while, but they raised some funds and in 1953, I was able to go to Israel for the first time. I lectured around the country and saw they had virtually no audiology services at that time. I went back and forth a few times as a visiting professor and I worked with people to design audiology clinics for different regions of the country. I worked with sound booth companies to get appropriate facilities installed, and then I finally moved to Tel Aviv, Israel, in January of 1975 to accept a position as professor in the Sackler School of Medicine, Tel-Aviv University

Academy: Moe, your story and your life is fascinating. And I happen to know your son, Jay Bergman, is a well-respected author and he has recently published a well-received and highly acclaimed book titled Meeting the Demands of Reason—The Life and Thought of Andrei Sakharov.

Bergman:: Thanks for mentioning that! Yes, it was an exciting project for Jay, and of course for my wife (Hannah) and me, it's so exciting to see the book doing so well!

Academy: I'll bet! You should be very proud, and I'll look forward to reading the book myself very soon. Moe, you've been very generous with your time, thank you for speaking with me.

Bergman: It's been fun for me, too, Doug!

Academy: Okay, well, next time we'll have to cover the 70s, 80s and 90s, but in the meantime, thanks again, and very best personal regards.

Bergman: Thanks, Doug.

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

Microphones

By Steve Armstrong, B.Eng

About the Author

Steve has specialized in the ultra low power audio niche called Hearing Aids for some 25 years. Having developed skills in chip design, electroacoustics, algorithms and fitting software he now heads up SoundsGood Labs, which provides engineering services within the field.

In 2006, James E. West, research professor, Department of Electrical and Computer Engineering, Johns Hopkins University, received the National Medal of Technology for "co-inventing the electret microphone" at Bell Labs in 1962.

A modern hearing aid (HA) microphone is an electret condenser microphone, condenser being the old term for capacitor. The way these devices work is that there are two parallel plates (like a capacitor). The front plate is actually the microphone diaphragm and moves closer and further from the fixed rear plate depending on the vibrations in the air. The rear plate is charged which is why all condenser microphones require a power source. In contrast, dynamic microphones do not use this approach and no power source is required.

A hearing aid microphone consists of two basic elements: First is a capacitive sensor made by placing a flexible (but conductive) diaphragm in front of a fixed "back plate." The close spacing between the two plates forms an effective capacitor that uses air as its dielectric (insulator). As the spacing between the plates is changed, due to varying sound pressure from the environment, the value of the capacitance changes.

A thin layer of Teflon is added to the backplate for in important function. Teflon is an electret material, meaning it's very good at holding on to extra electrons. The easiest way to sense the change in capacitance is to have a fixed charge (or fixed number of electrons) in the gap between the plates. Mathematically the voltage on a capacitor is proportional to the charge on the plates and inversely to the capacitance value. Hence we have a voltage output from this sensor, that produces very little distortion for the small changes in capacitance sound will produce. The amount of charge directly controls the voltage sensitivity of the microphone.

The impedance of this tiny capacitor is very high – so high in fact that we cannot just simply wire it up to the preamp section of our digital signal processing (DSP) circuit. The resulting signal would be so small that it would be lost in the circuit noise.

Internal to every HA microphone is a buffer circuit. The purpose of this device is to provide extremely high impedance to this little capacitive sensor, allowing for large voltage swings to occur (good sensitivity). The buffer typically provides a voltage gain of 0 dB, meaning its output faithfully follows its input voltage. The benefit of the buffer is it can provide the higher currents needed by the DSP input circuitry hence avoiding signal loss.

Since this buffer is powered by the HA battery it has limited voltage swing capabilities, which leads to clipping of the microphone output with sufficient acoustical input. It is this clipping phenomenon that imposes the upper end of dynamic range for the microphone. The noise floor is limited by the combination of noise in the buffer circuit, and the random motion of air molecules in the capacitive sensor.

There are three ways to prevent clipping of an intense input signal, such as those found in many forms of music: (1) increase the spacing between the backplate and the diaphragm, which may be quite difficult; (2) shunt some of the capacitor output signal away into another capacitor, but this would require a circuitry change; or (3) lower the amount of charge put into the Teflon layer, which is the easiest of the three options.

Desensitizing the microphone has the benefit of allowing a higher headroom for intense sounds, and may be useful for HA patients who want an undistorted experience. Lower sensitivity microphones are readily available to the HA manufacturing community.

Treatment Options for Idiopathic Sudden Sensorineural Hearing Loss

By David J. Clinkard, MSc, and Vincent YW Lin, MD, FRCSC

About the Authors

David Clinkard (far left) and Vincent Lin are with the Department of Otolaryngology/Head & Neck Surgery, Sunnybrook Health Sciences Centre, Toronto

ABSTRACT

Sudden sensorineural hearing loss is a challenging condition for the audiologist and otolaryngologist to treat. In the vast majority of cases no cause can be found, and infections or vascular disturbances are thought to be responsible. Currently, the standard method of treatment is with oral and/or intratympanic corticosteroids, though evidence for this remains equivocal, partially due to the variable rates of spontaneous hearing recovery. With or without treatment, prognosis is still good, with 40–65% of patients regaining some hearing within two weeks.

One of the more challenging problems an audiologist may be presented with is a patient complaining of suddenly losing hearing in one ear. Despite many possible causes for this hearing loss, often the reason cannot be determined and a diagnosis of idiopathic sudden sensorineural hearing loss will be given.

Sudden sensorineural hearing loss (SSNHL), defined as the loss of 30 decibels of hearing in three continuous frequencies within three days,[1] has a variably reported prevalence, with rates of 5–160 cases per 100,000 people per year.[2,3] SSNHL usually manifests as a unilateral hearing loss, though bilateral loss occurs in a small minority (2–4%) of cases.[4] Accompanying symptoms often include tinnitus (80%), and less commonly, vertigo/balance symptoms (30–60%) and a feeling of aural fullness in the ear. Patients are usually middle aged or older (range 50–60 years old) and can be of either gender.[2]

CAUSES

The causes of SSNHL are still debated and no specific cause can be determined for the majority of cases (85–90%). Two distinct pathophysiological mechanisms are currently hypothesized to be responsible for the majority of SSNHL cases; vascular disturbances or bacterial/viral infections. Vascular disturbances can include thromoembolic events, vasoconstriction, hypertension, and hypotension.[5,6] Viral infections such as mumps, Epstein-Barr, herpes zoster, and enterovirus infections have all been implicated in SSNHL.[7] Case reports of sudden hearing loss with ototoxic drugs such as chemo-theraputic, aminoglycosides, PDI-5 inhibitors, and antibacterials have also been noted, though it is extremely uncommon.[8–10] A small percentage (10–

15%) of SSNHL can be attributed to identifiable causes such as vestibular trauma, Meniere's disease, autoimmune disease, syphilis, mumps, Lyme disease, or perilymphatic fistula.[2,3]

ASSESSMENT AND TREATMENT

Recommendations for clinical assessment of SSNHL include a full otologic history and physical assessment, blood work (antibodies for lupus, C-reactive protein, antinuclear antibodies, anti-cardiolipin antibodies, antineutrophil cytoplasmic antibodies, and VDRL (venereal disease research laboratory test), as well as a full cardiovascular and neurological workup. Gadolinium-enhanced magnetic resonance imaging is also recommended to rule out retrocochlear pathologies (neoplasm, stroke, demyelination).[2,8]

Due to the multifaceted nature of SSNHL, multiple pharmacological treatments modalities have been proposed. Currently corticosteroids (oral, intravenous and intratympanic) are the standard of care, though antioxidants such as *N*-acetylcysteine, vitamins A, C, and E and Ebselen, hyperbaric oxygen, and antiviral therapy all have been currently or previously used as treatments around the world.

Corticosteroids are naturally produced by the adrenal cortex gland. There are two classes, glucocorticoids and mineralocorticoids. Mineralocorticoids are responsible for electrolyte control, while glucocorticoids are responsible for regulation of the stress and immune response, as well as carbohydrate and protein metabolism. Specific glucocorticoid effects in the ear include alterations to the microcirculation, decreasing endolymph pressure, and reducing inflammation.[2,11] The glucocorticoids, dexamethasone, prednisone, prednisolone, and methylprednisone all are currently indicated for SSNHL due to their presumed anti-inflammatory effects on the inner ear.[2,4] Choice of a specific glucocorticoid is variable and dependent on physician preference and any specific patient contra-indications.

While oral steroids are the standard of care, supporting evidence is weak.[12] Recent literature reviews concluded that there is limited efficacy of corticosteroid treatment,[12,13] despite previous studies shown positive treatment effects.[13–15] However, in absence of definitive evidence to the contrary, best clinical practice guidelines are still to treat with a short (2–3 week) tapering dose of oral corticosteroids.[2,3,8]

Limited evidence is available comparing treatment regimes, and currently 1 mg/kg/day prednisone or prednisolone to a maximum of 60 mg/day for 4–10 days followed by a taper of dose is recommended.[15] The senior author has noted good results on a protocol that includes 1 mg/kg/day for the first six days and then tapering for eight days, for a 14-day total course.

Investigations into high doses of anti-inflammatory drugs are equivocal when compared to standard prednisone dose (60 mg/day maximum). Two studies have investigated high dose intravenous injection of corticosteroids. A 2006 study compared intravenous injections of 600 mg to a 1,200 mg hydrocortisone followed by a conventional tapered oral corticosteroid treatment,[16] and noted significant improvements compared to the lower hydrocortisone dose. However, a more recent study (2009) utilizing a similar protocol, 1,200 mg hydrocortisone for the first two days, tapering to 200 mg by day 10 and then switching prednisolone (30 mg tapering to 5 mg) over the next seven days did not show any appreciable benefit on hearing rate improvement compared to a 600 mg hydrocortisone loading dose with the same prednisolone taper.[17] No difference in hearing outcomes or rate of recovery was noted when a pulse therapy protocol of 300 mg dexamethasone for three days was compared to 70 mg prednisolone for seven days, though this could have been due to the fact that steroid treatment in the high dose group was discontinued after three days.[18]

Targeted topical treatment, specifically intratympanic application via injection, catheters, or round window pledgets has been suggested as a means of delivering a higher dose of steroid to the inner ear.[20,21] Reviews examining this method have shown weak treatment effects with results comparable to oral therapy and suggest use when oral therapy is contraindicated or fails.[22] Interestingly, combination therapy, (intratympanic dexamethasone plus oral prednisone) showed significant improvement in speech discrimination compared to oral prednisone, but no improvement in discrimination of pure tone averages.[23] However, criticisms of this paper include small sample sizes and possibility of statistical error.[24]

Hyperbaric oxygen treatment is premised on the fact that with altered vascular flow to the cochlea, hypoxia results, causing altered Na-K pump activity in the cortical cells and thus altered hearing. With increased oxygen delivery to the cochlea, it is thought that hearing can be restored.[25–27] The effects of hyperbaric oxygen treatment on SSNHL is mixed, though the protocol is popular in Europe. Multiple studies have shown hyperbaric oxygen treatment to have a beneficial effect on hearing improvement.[25–27] A recent Cochrane review concluded that while hearing loss treated quickly was improved with hyperbaric oxygen, due to lack of study power, poor reporting, and methodological shortcomings there was no evidence to support a beneficial effect on long standing SSNHL.[28]

The effects of antiviral therapy in addition to corticosteroids has not been shown to improve outcomes.[10] Several small scale retrospective studies have shown antiviral therapy plus corticosteroids compared to corticosteroids alone to have significantly better hearing recovery,[29] though blinded crossover studies and a meta-analysis has failed to show this effect.[30]

Evidence exists to show increased oxidative stress in noise-induced hearing loss,[31] and that administration of anti-oxidants provides a protective effect against noise-induced hearing loss.[32] While suggestive of a role for oxidative species in SSNHL, limited work has examined oxidative stress in SSNHL. Alterations of serum coenzyme Q10, a marker of oxidative stress in patients with SSNHL have however been noted,[34] and a retrospective study of 87 patients showed that administration of vitamins A and E in addition to corticosteroids had a significant improvement compared to corticosteroid treatment alone.[35] While preliminary, these studies suggest a possible involvement of the redox pathways in SSNHL, and future studies are needed to determine the role and extent of this involvement.

The treatment protocol followed at Sunnybrook Health Sciences Centre is outlined in Figure 1.

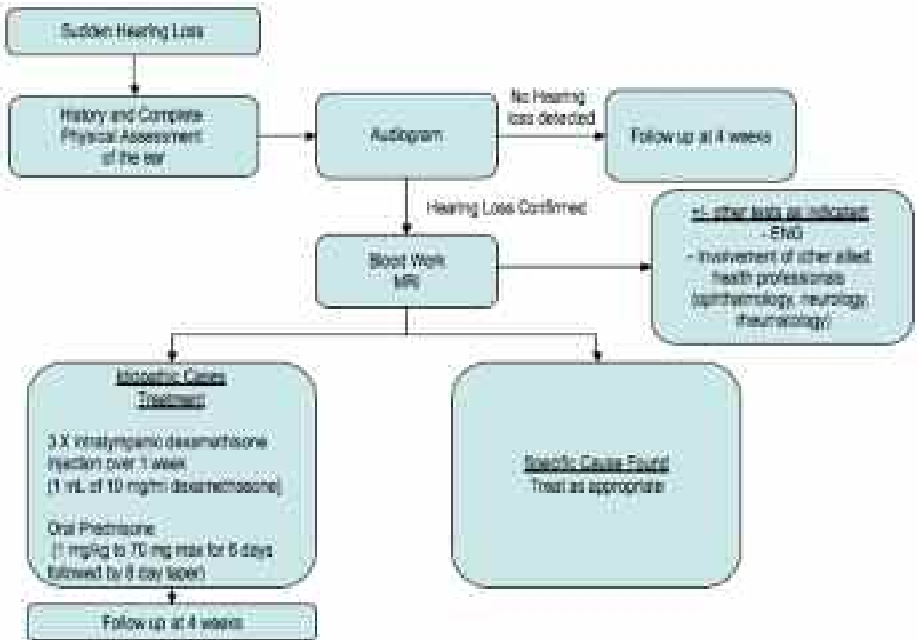

Figure 1. The Sunnybrook Health Sciences Centre treatment protocol for sudden sensorineural hearing loss.

PROGNOSIS

SSNHL is an otological hearing emergency and should be treated as such. Care should be taken to minimize time between hearing loss onset and time to treatment, and patients should be seen by an otolaryngologist as soon as possible. There has been limited evidence presented showing severity of loss can be linked to the time between onset and treatment[19]; however, this has not been definitively established. Regardless of treatment, there appears to be a two-week window from initial hearing loss after which limited recovery will occur.[2]

Reported rates of recovery in patients with SSNHL are between 40 and 65%, suggesting that many patients will have a favourable outcome.[11] However, with the lack of understanding to the precise etiology of SSNHL, treatment of this condition is challenging and outcomes extremely variable.

FUTURE DIRECTIONS

While the exact mechanisms remain unclear, there are several potential therapies under investigation, including gene therapy to regenerate auditory hair cells, application of hydrogels and nanoparticles to improve delivery of pharmaceuticals to the inner ear and the use RNA interference to alter cellular messaging pathways.[36,37] While these is still a significant amount of work that needs to be done before these therapies can move from the bench to the bedside, with time undoubtedly more knowledge will emerge resulting in improved treatments and outcomes for patients with SSNHL.

CONFLICT OF INTEREST

There are no conflicts of interest to report.

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The Genetics of Otosclerosis

By Lendra Friesen, PhD, Sunnybrook Health Sciences Centre

One article you might want to read this year related to the genetics of otosclerosis, is a review by Ealy and Smith.[1] The authors describe the characteristics of otosclerosis, its prevalence, the genetic contributions to the disease which are poorly understood, and suggest some studies that could be completed to help further progress in this area.

Although most of you are familiar with otosclerosis, I'll briefly summarize some of the characteristics of the disease as described by the authors. Otosclerosis is a disease of the bony labyrinth of the inner ear and is caused by changes in the otic capsule, most commonly anterior to the stapedio-vestibular joint. It is considered an autosomal dominant disease, with only about 40% penetrance, or actual occurrence, and about half of the cases are sporadic. The form of otosclerosis, which results in hearing loss, affects 0.3–0.4% of the Caucasian population, with females more frequently affected than males. The average age of onset is 30 years and it occurs bilaterally in 70–80% of individuals. Surgical treatment is often effective in improving hearing.

The active form of the disease is characterized by highly vascularized regions of the otic capsule that contain activated macrophages and osteoclasts and is termed otospongiosis. Later stages of otosclerosis include new bone deposition, which can be replaced by fibrous tissue and the formation of dense sclerotic bone (Schuknecht, 1993).[2]

Several techniques are involved in identifying the genetic contributions to the disease. These include: (1) linkage analysis and (2) population-based studies.

(1) Linkage analysis involves studying large families with the disease to determine the causative gene. The aim of linkage analysis is to find out the rough location of the disease gene on the chromosome relative to another DNA sequence on the chromosome called a *genetic marker* (segment of DNA in an identifiable location on the chromosome whose inheritance can be followed). To date, eight otosclerosis loci (specific locations on a chromosome) named OTSC1-8 have been mapped in different families. However, no otosclerosis-causing mutations have been identified. The use of deep re-sequencing, where the DNA sequences suspected of containing a mutation are examined for rare variants, is a technique that might help identify disease-causing mutations at these loci.

(2) Population-based studies are also completed where the associations between genes and a disease are examined in a well-defined population such as individuals living within a certain geographic location. Several association studies have been completed examining (a) type 1 collagens, (b) the TGFβ superfamily, (c) CD46 alleles, (d) the renin-angiotensin-aldosterone system, and (e) genome-wide association studies.

Type 1 collagens are proteins and the main component of connective tissue, but are also found in cartilage and bone. An association between otosclerosis and the gene *COL1A1* has been demonstrated. *COL1A1* encodes collagen type 1a and is involved in osteogenesis imperfecta, a disease in which there is often a conductive hearing loss similar to that found in otosclerosis.[3] An allele (alternative form of the gene) of *COL1A1* has also been associated with osteoporosis.[4]

The TGFβ superfamily is a group of proteins that control proliferation, differentiation, and other functions in many cell types. Based on the data of Thys et al,[5] it is hypothesized that the actions of the 1263 allele of TGFβ1 might include the prevention of otosclerosis by inhibiting osteoclasts and preventing the early bone resorption stage of otosclerosis. Also, an association between otosclerosis and *BMP2* and *BMP4*; two other members of the TGFβ family, has been found.6 More functional studies are needed to better understand the role of BMP2 and *BMP4*.

CD46 alleles are genes that act as a receptor for the measles virus. Measles viral infections have been implicated as an environmental trigger of otosclerosis and the measles receptor *CD46* has been reported to be increased in otosclerotic lesions.[7] However, additional studies in multiple populations are needed to determine whether there is an association between *CD46* and otosclerosis.

The renin-angiotensin-aldosterone system regulates blood pressure and fluid balance. Various associations with the genes *ACE* and *AGT* of the renin-angiotensin-aldosterone system and otosclerosis have been observed.

Genome-wide association studies can be performed where the entire human genome is studied to identify genetic associations with observable traits or presence or absence of the disease, finding potential associations that might otherwise be missed. Significant associations to otosclerosis have been observed with the gene RELN and a specific region on chromosome 11.[8] Re-sequencing, or determining the sequence of nucleotides along a strand of DNA, is needed to determine the causal variant in this specific region on chromosome 11. RELN encodes an extracellular matrix protein that is involved in neuronal positioning during brain development,[9] but its role in otosclerosis is unknown.

The authors summarize by stating that significant strides have been made in the identification of genetic contributions to otosclerosis. An interesting finding is that the loci identified in family studies and the genes implicated through association studies do not overlap. It is suggested that identifying families linked to regions that include associated genes will be helpful in identifying disease-causing alleles.

Also, sporadic otosclerosis may be due to multiple genetic variants with small effects that act synergistically to cause disease. To date, no variants causing a large effect on the disease have been identified. Once potential disease-causing variants are identified, functional studies will be required to better define the pathogenesis of this disease.

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UBC School of Audiology and Speech Sciences MSc Thesis Defense: 2009–2010

Longitudinal Investigation of Middle-Ear Function Using Multi-Frequency, Multi-Component Tympanometry from Birth to Six Months of Age

Student: Anika Cai

ABSTRACT

Objectives: The overall goal of the current study was to define the time course and rate in which functional maturation of the middle-ear occurs in human infants through conventional and multi-frequency tympanometry. The specific goals of this study were: (1) To understand the mechano-acoustical properties of the normal ear canal and the middle ear and its maturation as a function of age using conventional and high frequency tympanometry; (2) to establish tympanometric guidelines and normative data to characterize acoustical properties of the normal ear canal and middle-ear in infants birth to six-months of age.

Design: Thirty-one newborns were recruited and tested longitudinally in one-month intervals up to six-months of age for a total of six visits. All babies passed transient otoacoustic emission (TEOAE) screening on each visit. Tympanograms were recorded and the distributions of patterns were analyzed using the Vanhuyse model at 226 Hz, 678 Hz, and 1000 Hz. Additionally, tympanometric recordings of admittance (Ya), susceptance (Ba), and conductance (Ga) were analyzed at 226 Hz and 1000 Hz probe-tone frequencies. Lastly, the variation of compensated susceptance and conductance (Delta B and Delta G) were recorded using sweep frequency method at extended frequencies between 250–2000 Hz in 50 Hz intervals during each visit for 16 infants.

Results: Results showed that 1000-Hz tympanograms were the simplest to quantify as most recordings were single-peaked with few complex patterns. 226 Hz and 678 Hz recordings were often complex with multiple peaks. Both positive and negative admittance and susceptance tail values increased with age for 226 Hz and 1000 Hz. However, tail values at 1000 Hz increased faster than for 226 Hz. Negative tail values were smaller compared to positive tail values which resulted in smaller compensated admittance values for the positive tails compared to negative tails across all six visits. Overall admittance magnitude decreased with age at 226-Hz as susceptance increases and conductance decreases. However, at 1000 Hz, admittance magnitude increases as susceptance remains relatively constant and conductance increase.

Conclusion: Results suggest that the infant middle-ear and ear canal develops towards compliance as age increases. An increase in volume in the middle-ear cavity, reduction of middle-ear debris, and overall decrease in resistive elements may be attributing to these changes. However, the infant middle-ear is not a pure acoustic compliance by six-months of age, particularly at high frequencies. Significant differences were observed between each visit and warrant the use of age-specific norms when applying tympanometric data to infants below six-months of age.

Effective Masking Levels for Bone Conduction Auditory Steady State Response Thresholds in Infants

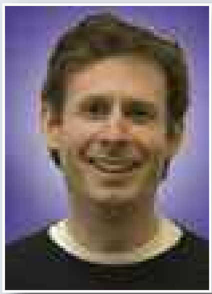
Student: Erin H. Hansen

ABSTRACT

To obtain ear-specific bone-conduction thresholds, masking of the non-test ear is often required. Masking is not currently utilized in the pediatric diagnostic test battery, partly because effective masking levels (EMLs) for bone-conducted stimuli in young infants have not been specified. The purpose of this study is to determine EMLs for auditory steady-state responses (ASSRs) elicited by bone-conducted stimuli in a group of young normal-hearing infants (under six-months of age) and adults, through the presentation of binaural air-conducted masking noise. Unmasked bone-conduction threshold studies have shown that in comparison to adults, infants have better and similar sensitivity to bone-conducted stimuli at 1000 and 4000 Hz, respectively. Masked threshold studies for air-conducted stimuli have revealed thresholds in six-month old infants to be elevated by approximately 5–15 dB, with infant-adult differences being greatest in the low frequencies and least in the high frequencies. Additionally in comparison to adults, infants have similar signal-to-noise ratios (SNRs) across different masker levels at 4000 Hz but larger SNRs for lower compared to higher masker levels at 500 Hz. It is hypothesized that EMLs obtained in this study will reflect these frequency-dependent trends. Therefore, it is expected that EMLs for infants will be higher or similar to the EMLs of adults for 1000 Hz and lower to the EMLs of adults for adults at 4000 Hz. Results of this study indicate that in comparison to adults, infants have higher and lower EMLs at 1000 and 4000 Hz, respectively. When differences in bone-conduction sensitivity are accounted for, infants have lower EMLs at both 1000 and 4000 Hz. When differences in ear canal volume are taken into consideration, infants have lower EMLs at 1000 Hz and the same EMLs at 4000 Hz. SNRs at 1000 and 4000 Hz for EMLs were consistent for infants and adults. However, SNRs for infant and adult ASSR amplitudes were always consistent for adults, but were only consistent for infants at 4000 Hz.

The Application of Cortical Evoked Potential Measures in Hearing Aid Research

By Danielle Glista, David Purcell, and Susan Scollie


About the Authors

Danielle Glista (far left), David Purcell (middle), and Susan Scollie are all with the National Centre for Audiology, at the University of Western Ontario

A growing body of literature exists on the use of the cortical evoked potential measure known as the P1-N1-P2 complex as a diagnostic tool in aided and unaided conditions. This complex is traditionally comprised of slow components ranging from 50 to 300 ms.[1] The peaks of the complex are thought to reflect synchronous neural activation of the central auditory system in response to spectral and temporal cues.[2,3] Research suggests that spectrally different speech sounds are encoded differently at the cortical level[2,4]; the P1-N1-P2 response therefore has the potential to provide information related to both detection and discrimination of aided speech sounds.[5,6]

Research completed with normal hearing and hearing impaired (HI) participants concludes that P1-N1-P2 responses elicited by various sounds can be recorded reliably to produce distinct neural patterns in aided and unaided conditions.[7,8] Research in this area includes the use tonal stimuli as well as various speech tokens. Responses elicited by a change in an ongoing stimulus, such as a consonant-vowel (CV) stimuli (e.g., /si/ and /ʃi/), have been termed the "acoustic change complex" (ACC).[9] Current research on aided cortical responses applies to conventional amplification; results have not yet been demonstrated using frequency lowering hearing aids such (e.g., aids with nonlinear frequency compression [NFC]). NFC technology can improve audibility of high-frequency sounds for hearing impaired listeners.[10] Therefore, these measures have the potential to provide information related to the effects of hearing impairment on the auditory system as well as the potential benefit of hearings aids, for listeners of all ages.

This article will present pilot results for aided P1-N1-P2 responses recorded for two pediatric case studies. Specifically, equipment modifications have allowed tones and naturally produced speech stimuli to be presented directly from the Biologic Navigator Pro System to the direct-audio-input (DAI) on hearing aid + audio-shoe connector. Measurements using this unconventional approach were completed to determine feasibility of P1-N1-P2 recordings on HI participants wearing behind-the-ear (BTE) hearing aids (coupled to personal earmolds) using a two-channel recording system.

METHOD

Participants

Participants presented with bilateral sensorineural hearing loss, sloping from normal to a mild loss in the low frequencies to a severe to profound loss in the high frequencies (Figure 1). The ages of the two participants were 13 and 15 years. Participants were fitted with Phonak V SP BTE hearing aids with NFC active. Test stimuli were presented monaurally to each participant's better ear, according to pure-tone-average.

EXPERIMENTAL SET-UP

During testing, participants were awake and watching a silent DVD with closed-

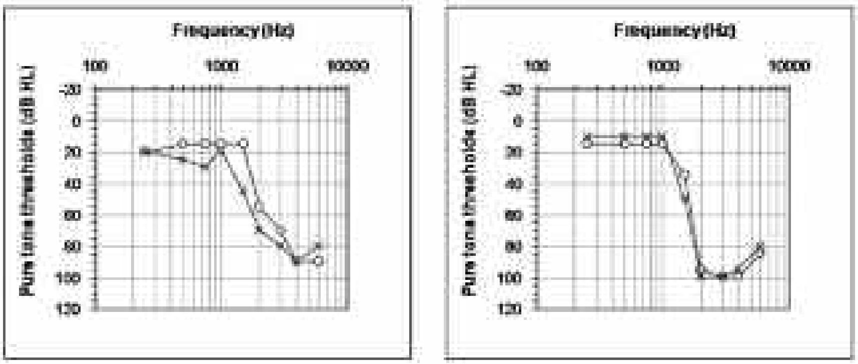


Figure 1. Air-conduction thresholds measured for pure-tones presented at octave and inter-octave frequencies ranging from 250 to 6000 Hz (o = right; x = left) for case 1 (left panel) and case 2 (right panel).

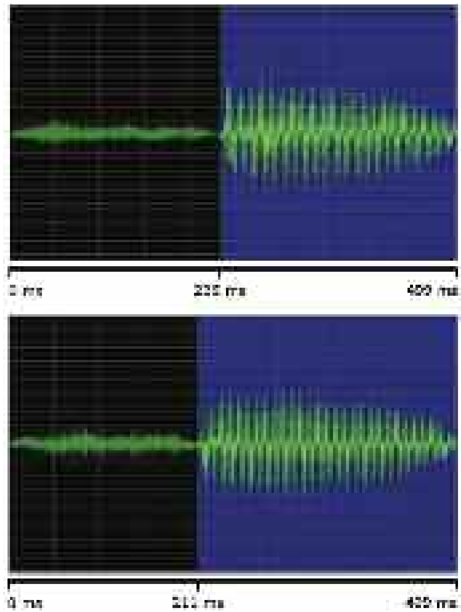


Figure 2. Illustrations of the acoustic waveform for /si/ (top) and /ʃi/ (bottom) for stimulus duration of 499 ms. The onset of the vowel begins at 235 for /si/ and at 211 ms for /ʃi/.

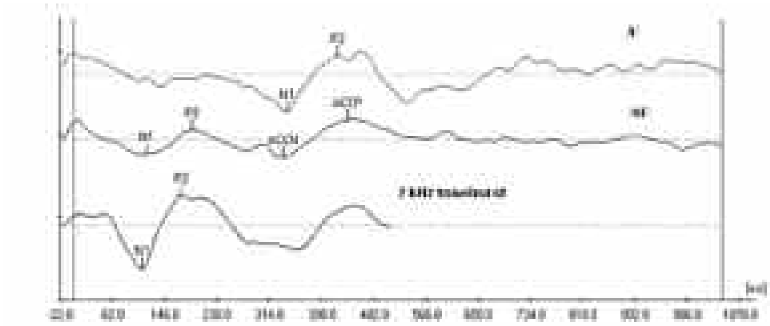


Figure 3. Resulting waveforms for case 1 displayed as follows (order of top to bottom): /i/, /si/ and a 2 kHz toneburst. The waveform displayed for /i/ reflected only one repetition, while all others are mean waveforms computed using two repetitions.

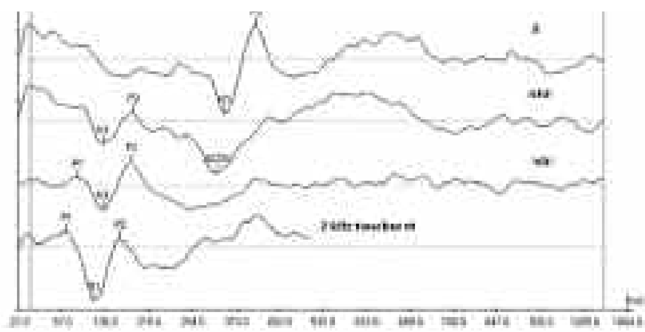


Figure 4. Resulting mean waveforms for case 2 displayed as follows (order of top to bottom): /i/, /ʃi/, /ʃ/, and a 2 kHz toneburst.

captioning enabled. A total of four electrodes were used to record P1-N1-P2 responses: Non-inverting Cz, inverting A1, A2 (mastoid), and a ground/common placement (forehead). Time windows of 533 ms (tonebursts) and 1066 ms (speech) were used, with a static pre-stimulus time of 21 ms. Waveform averaging included 64 (tonebursts) and 200 (speech) sweeps in each of two repetitions. Stimuli were presented at a rate of 0.5/sec. The amplifier gain was 50,000 with an artifact rejection threshold of 100 uV. Recordings included online band pass filtering (0.1 to 100 Hz).

Stimuli

Evoked responses for tonebursts and naturally produced speech stimuli were recorded for each case. Stimuli were presented at a comfortable, suprathreshold level. Parameters for the 2 kHz toneburst stimulus included Blackman ramping (20 cycles rise/fall, 80 cycles plateau). Custom sound files included: /s/, /ʃ/, /i/, /si/ and /ʃi/. Selections of these sounds were presented to each participant, time permitting. The /i/ sound was created using Goldwave software by replacing the /s/ portion of /si/ with silence. All sound file recordings were comprised of naturally produced female speech presented at a sampling rate of 48 kHz. Acoustic waveforms for the stimuli /si/ and /ʃi/ are given in (Figure 2), showing vowel onset times and total duration values. Stimuli were presented at an audible and comfortable level according to participant feedback.

WAVEFORM ANALYSIS AND RESULTS

Off-line analysis of the data involved digital band pass filtering (1 to 30 Hz). Averaged waveforms were generated across repetitions of stimuli; mean waveforms were generated using weighted-averaging. The resulting mean waveforms are displayed across stimuli and for each case (Figures 3 and 4). Visual analysis was used to mark the centre of all positive and negative waveform peaks. Evoked responses to these CV stimuli are labelled according to the onset of the fricative portion and the onset of the vowel portion. The response to the frication portion is labelled using P1-N1-P2 markers; custom labels such as "ACCN" and "ACCP" are used to designate the N1 and P2 response for the vowel portion.

SUMMARY AND RESEARCH IMPLICATIONS

A clinically available evoked potential system, incorporating a modified set-up, was used in this research. Specifically, the use of the DAI + audio-shoe connectors allowed for the tonal and custom speech stimuli to be presented directly to the hearing aid from the recording system. Pilot results suggest the presence of aided cortical responses recorded for HI participants wearing NFC hearing aids and that variability in waveform morphology exists across cases. For the tonal stimuli, a robust N1-P2 response is displayed for both cases. A positive going peak is noted at the end of the response recorded for case 1 (Figure 3); this was not consistent across pilot subjects. To aid in the analysis of cortical responses elicited by tonal stimuli, longer time windows have been incorporated into the testing parameters. Responses occur at the expected latencies, according to stimulus properties, for the vowel-only stimulus as well as for the onset of the fricative and the onset of the vowel for CV stimuli (Figures 3 and 4). An earlier onset response for the vowel portion of /ʃi/ can be observed when compared to the onset for the vowel only stimuli from /si/ (according to latency values, not reported for the purpose of this article); this agrees with the acoustic analysis of the CV stimuli (Figure 2). These observations are consistent with those reported in previous studies.[8,9]

In summary, use of aided cortical recordings may provide evaluation of frequency compression hearing aid technology, although more research is needed to determine both validity and reliability. Further modification to the testing parameters (e.g., pre-stimulus timing and window duration for tonebursts) may improve waveform analysis. Further research with HI participants is needed to help quantify the relationship between latency and amplitude values with regards to audibility provided for a given hearing aid fitting.

DECLARATION OF INTEREST/ACKNOWLEDGEMENTS

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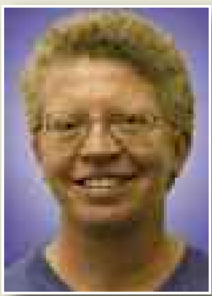
Introducing the Comprehensive Professional Behaviours Development Log–Audiology (CPBDL-A): Rationale, Development and Applications

Stella L. Ng, Doreen Bartlett, and S. Deborah Lucy


About the Authors

Stella Ng (far left) is a practicing educational audiologist and a PhD candidate in health professional education, Health and Rehabilitation sciences Graduate Program, Faculty of Health Sciences, The University of Western Ontario. Doreen Bartlett (middle) and Deb Lucy (right) are associate professors with the School of Physical Therapy, Faculty of Health Sciences at The University of Western Ontario as well as field members in Health Professional Education.

The purpose of this article is to introduce and provide the rationale for and outline the process of development of the Comprehensive Professional Behaviours Development Log-Audiology (CPBDL-A) as a tool for use by audiology students, their clinical supervisors, and audiologists in general to heighten awareness, support development, and monitor performance of professional behaviours over time.

WHY DO WE NEED TO FOCUS ON PROFESSIONAL BEHAVIOURS?

Many North American audiology educational programs are in transition, highlighted by the move to a doctor of audiology as the entry-to-practice degree requirement in the United States, with repercussions of this change in Canada. To help navigate this time of change, programs may choose to examine their curricula including underlying educational philosophies, course content, and clinical education approaches. Associations and regulatory bodies may choose to develop content-knowledge and/or skill-based competency expectations as part of an ongoing goal to improve hearing health care delivery and outcomes.

Equally important as the afore-mentioned, but less tangible and quantifiable, are the intrinsic elements of professional practice, *reflective practice* and *professional behaviours*. This paper focuses on professional behaviours, with reflective practice necessarily discussed as a precursor. If we consider audiology practice as both an art and a science, then reflective practice[1–6] and professional behaviours[7–11] can be viewed as the more artistic components contributing to effective practice.

Reflective practice is based on the process of reflective thought – defined as “active, persistent and careful consideration of any belief or supposed form of knowledge in light of the grounds that support it, and the further conclusions to which it tends”[12] – and reflection has long been considered crucial to learning and professional development.[13] Reflective practice may be described as processes of *critical consideration*, based on *multiple sources of knowledge* before, during, and after professional action takes place with resultant improvement *of clinical/professional* actions. The “critical” in critical consideration may be understood dually as: (1) applying critical thinking to a situation or (2) critical questioning in the context of challenging our assumptions and systemic or social structures with the ultimate goal of effecting change.[14,15] The notion of multiple sources of knowledge is a key element of reflective practice; reflective practice acknowledges that much of what we know as practitioners is learned through experience. Further, if we make the most of experiential learning by engaging our reflective capacities,[16] the resultant knowledge is as important to good practice as is that gained from (for example) conducting a systematic review on the effectiveness of a new technology. For further examples of reflective practice in audiology please see Ng and colleagues.[5]

Professional behaviours are the ways in which practitioners enact the values held by their profession and as such are considered defining aspects of being a practitioner of that profession. For example, a commonly discussed professional behaviour in audiology (and across professions) is *evidence-based practice*.[17,18] Another common example is *lifelong learning*, as demonstrated by regulatory bodies' requirements for continuing education.[24] As opposed to a specific behaviour, reflective practice can be considered a *way of being*, as an effective, artful, reflective practitioner.[20] It is less something that we *do* and more something that we are, as demonstrated through our intelligent, rather than impulsive, actions.[12]

Reflective practice is important to mention in this article because as practitioners we would be hard-pressed to effectively identify, develop and monitor our professional behaviours if we did not possess some reflective capacity. Self-assessment has been shown to be flawed in terms of our self-assessing accuracy.[21] Reflective practice moves beyond a basic inwardly-directed assessment of self. Reflection can take place with a *critical companion*[22] or can occur through "lenses" borrowed from literature, theory, fellow practitioners, and clients, in addition to ourselves.[14] A critical companion is someone who helps us see ourselves through the more objective, critical yet supportive lens of another through dialogue. Awareness of an expected behaviour is necessary, but not sufficient, in guiding improvement in the performance of the behaviour. Reducing professional behaviours to a mere checklist can thus be seen only as a first step.

Chial[23] published a very concise list of professional behaviours expected of an audiologist, such as: "I show up," and "I show up on time." Chial's list albeit brief is a starting point; one that the CPBDL-A can potentially advance, by providing a more comprehensive tool to stimulate thought and discussion among students, between students and supervisors or faculty members, between clinicians and mentors, among fellow clinicians, and among educators and regulators.

The College of Audiologists and Speech-Language Pathologists of Ontario has a Self Assessment Tool and Guide, Code of Ethics, and Continuous Learning Activity Credits (CLAC) Program.[24] Nationally, the Canadian Association of Speech-Language Pathologists and Audiologists (CASLPA), and the Canadian Academy of Audiology (CAA) each have a Code of Ethics and position statements to help guide practice. One might ask why we would need yet another document to outline the behaviours expected of audiologists.

The CPBDL-A serves a complementary purpose as a tool primarily targeted at (but not limited to) the individual *student* to foster professional growth through in-depth reflection upon a breadth of professional behaviours deemed important to the profession by stakeholders involved in the development process. The CPBDL-A is a very comprehensive document, composed of nine professional behaviours, with a description and indicators of performance for each behaviour. The CPBDL-A is an interprofessional tool, evolved from the CPDBL, which was initiated in physical therapy (PT). A core set of professional behaviours across the health professions is in line with recommendations from a summit of experts in health professions education who called for movement beyond isolated pockets of professions working toward similar goals independently.[25] Rather, an integrated, interprofessional approach to developing the health care practitioner skills that are common across professions is an efficient and effective way to reach the common goal of improved health outcomes.

It is important to note that many other (and older) professions, including medicine,[11,26] have explored the notion of professional behaviours in greater depth than our own. In the School of Physical Therapy at The University of Western Ontario, the CPBDL was developed through a rigorous and systematic process. Rather than "re-invent the wheel," audiology may now borrow from the solid foundation established in PT. In the future, other professions may continue this trend of adapting rather than starting over independently.

The purpose of the current project was to adapt the PT-developed CPBDL for use in audiology (CPBDL-A). The project took place in two major phases: phase 1, adaptation; and phase 2, pilot testing. The results of analyses of phase 2 data will be published separately, with some preliminary results discussed in this article.

DEVELOPMENT OF THE ORIGINAL TOOL

Development and Pilot Testing of the Original CPBDL

In the initial development of the CPBDL, a consensus process was first used to identify key professional behaviours.[9] Next, methods to foster their development were proposed.[8] The professional behaviours identified through the consensus were: *communication, adherence to legal and ethical codes of practice, respect, empathy and sensitive practice, lifelong learning, evidence-based practice, client-centered practice, critical thinking, accountability,* and *professional image*.[9] The methods for fostering such behaviours in students were identified as: lead by example, explicit teaching, mentoring, reflective imaging, and wider context education.[8]

The original CPBDL used nine professional behaviours (as listed above, with *respect* and *empathy*, and *sensitive practice* collapsed into a single behaviour). The consensus process used in the development of the CPBDL was replicated for the adaptation of the CPBDL to audiology and thus the methods for development of the original CPBDL[27] will not be described in detail here. Members of the focus group and consensus process included recent physical therapy graduates, faculty members, clinical instructors and professional practice leaders. Each of the nine behaviours includes up to 23 behavioural criteria for individuals to reflect on and assess their performance, indicating that they perform each of the behaviours "not at all," "sometimes," or "always."

An important piece of the CPBDL is the action plan that students are asked to develop, setting goals for the continued development of each of the key behaviours. The School of Physical Therapy at The University of Western Ontario borrows from the College of Physiotherapists of Ontario Professional Practice Portfolio's[19] use of "SMART" goals. Students are advised to develop SMART goals, or goals that are **S**pecific, **M**easureable, **A**ction-oriented, **R**ealistic and **T**ime and resource constrained. This type of goal-setting can be seen as an action of a reflective practitioner. This type of reflection is termed *anticipatory reflection*[28] in contrast to reflection-in-action, which takes place in the midst of a clinical activity (e.g., during visual reinforcement audiometry), and reflection-on-action, which occurs some time after the clinical activity (see Ng, 2009 for details about these distinctions[5]).

The CPBDL was pilot tested with 42 physical therapy students in their final year of entry-to-practice training. In order to score each of the key behaviours, authors assigned a rating of "not at all" a score of 0, "sometimes" a score of 5, and "yes, always" a score of 10. Students indicated that the criteria were clear and that the measure could be completed within 50 minutes while the action plan for each of the nine key professional behaviours could be completed within two hours. The CPBDL demonstrated modest convergent validity[29] with the California Critical Thinking Disposition Inventory[30] (comparing the total CCTDI Score with only the critical thinking key behaviour of the CPBDL) and the Physical Therapist Clinical Performance Inventory,[31] a clinical assessment tool completed by clinical instructors. The authors of the CPBDL noted that the distribution of scores indicated lack of overall ceiling or floor effects in students near completion of their entry-to-practice training program, and suggested that the tool may be useful not only for entry-to-practice but also for continuing competency.

The School of Physical Therapy where the CPBDL was developed continues to use the CPBDL (among other tools including the CCTDI and CPI) as part of an ongoing strategy to promote professional behaviours in their students and also as part of continuous evaluation of the PT educational program. Parts of the CPBDL are being used in the Canadian Physiotherapy Association's efforts toward clinical specialization. The authors of the CPBDL noted that other professions may wish to adapt the tool for use in their own professions, and that continued development and evaluation of the CPBDL may be warranted to further validate the tool. These two goals were adopted for the current study, with the first goal published in this article, and the second goal to be published at a later date.

PHASE 1: ADAPTATION FOR AUDIOLOGY

Participants

Participants (see Table 1) were recruited via an e-mail containing the original CPBDL, a letter of information about the project, and a consent form, to audiology stakeholders across the London, Ontario, Canada community.

An effort was made to recruit a variety and even distribution of representatives from clinical settings, the audiology student population, and clinical and academic faculty members. In addition to the participant breakdown listed in Table 1, additional clinical audiologists expressed interest in participating, but scheduling conflicts prevented their participation. The first and second author of this paper also participated in the focus group as facilitator and recorder. Participants were purposively sampled based on the criteria described in Nominal Group Technique.[32] That is, participants were deemed to meet the following inclusion criteria: able to recognize equality among group members, willing to listen to ideas of others, able to effectively communicate his/her ideas, open minded and flexible, and aware of current audiology professional issues.

Table 1. Participant breakdown

Clinicians	Students	Faculty
(*n* = 2)	(*n* = 2)	(*n* = 3)
In-house	1st year	Academic
Community	2nd year	Clinical
Facilitator	**Recorder**	
Stella Ng	**Doreen Bartlett**	
(Audiologist Clinical and PhD Student)	(Faculty Member in Physical Therapy)	

Procedures

The Nominal Group Technique[32] was used to run a focus group involving the nine individuals listed in the table above. The focus group was 1.5 hours in duration. Participants received the nominal question and a copy of the original CPBDL by email prior to the session. The nominal question was: What would you like to (a) delete, (b) modify and (c) add in order to make the CPBDL more appropriate for audiology? The timeline for the focus group was as follows:

- 10 minute introduction and signing of consent forms
- 10 minute nominal question silent generation of ideas in writing
- 30 minute round robin recording of ideas
- 20 minute serial discussion for clarification
- 10 minute vote on items
- 10 minute meeting wrap-up

Follow-up Consensus Process

The follow-up process was completed using the Delphi Process[32] for reaching consensus. A benefit of the Delphi Process is that responses can be collected from participants electronically (or by mail) so that multiple in-person meetings are not required. Within two weeks of the focus group, all suggestions from the focus group participants were organized into table form. Suggestions that had received a majority of votes in favour were implemented and highlighted in the electronic first draft version of the CPBDL-Audiology (CPBDL-A). Participants were asked to review the CPBDL-A with the following request: "Please list the items that you feel require further revision, and provide a suggested revision for each." The Delphi Process states that iterations continue until there is a consensus. After two formal rounds of revisions, there were no further changes recommended by participants, and the Delphi Process concluded.

Results

Examples of two of the nine behaviours in the CPBDL-A can be seen in Figures 1a and 1b. The initial vote on the nominal question resulted in two proposed deletions of items (deemed specific to PT and irrelevant to audiology), 16 proposed modifications, and 19 proposed additions. Modifications were primarily wording-related, removing PT-specific language, while additions focused on unique characteristics of audiology that were

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Key Professional Behaviour: ***Adherence to Legal and Ethical Codes of Practice and Monitoring Relations with Hearing Instrument Manufacturers***

- Understand the rationale behind current professional and regulatory codes of ethics and be aware of the consequences of breaching them
- Understand the rationale behind professional boundaries and be aware of the consequence of not respecting them
- Facilitate informed client decision-making and obtain informed consent
- Ensure confidentiality in all interactions (verbal & written) with clients, families and other providers
- Ensure appropriate relationships are maintained with hearing instrument manufacturers

	Professional Behavioural Criteria	**Do I perform this behaviour consistently?**					
		No opportunity	Not at all	Some of the time	Most of the time	Almost always	Always
1	Aware of and follow the Code of Ethics of my regulatory body and/or professional association(s)						
2	Aware of and remain current with the practice guidelines/standards of my regulatory body						
3	Aware of legislative frameworks, e.g. the Health Care Consent Act						
4	Treat information from medical records, examinations, photographs, and/or videotapes associated with clients and cases confidential						
5	Demonstrate ways of ensuring confidentiality						
6	Introduce myself and ask for informed consent before conducting any clinical practice activity						
7	Obtain explicit consent from client before involving others (professionals, family members) in discussions about the client						
8	Develop and revise as necessary my personal ethical framework for use in making decisions						
9	Review options for action when faced with difficult decisions and consult colleagues as needed						
10	Abide by all professional codes of ethics						
11	Uphold all professional standards of practice						
12	Involve others in informed decision-making						
13	Recognize the power imbalance inherent in all audiologist-client relationships						
14	Keep the best interests of clients in mind when confronted with incentives or sources of bias (e.g. from manufacturers)						
15	Maintain ethical, client-centred practice in the face of conflicts of interest (i.e. bonus programs, company ownership, sponsorship) inherent in the system under which I practice						

Ng, S., Bartlett, D., Lucy, D., 2008, adapted with permission

MPT Program Evaluation Task Force (D. Bartlett, D. Lucy, L. Bisbee, C. Beggs), 2004

Figure 1a. Sample behaviour: Adherance to legal and ethical codes of practice and monitoring relations with hearing instrument manufacturers.

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Key Professional Behaviour: *Best Evidence and Evidence-Based Practice*

- Use standardized measures (when available) to evaluate the outcome of audiology interventions
- Continue to expand individual knowledge base and contribute to the knowledge base of the profession
- Incorporate valid research findings into practice and discontinue using interventions that are determined to be ineffective
- Participate in the critical appraisal of new and existing techniques and methodologies on an ongoing basis
- Take an active role in research whenever possible

	Professional Behavioural Criteria	Do I perform this behaviour consistently?					
		No opportunity	Not at all	Some of the time	Most of the time	Almost always	Always
1	Aware of the need to use standardized, reliable and valid outcome measures and attempt to do so at all times.						
2	Aware of acquiring knowledge, i.e., use of data bases such as CINAHL or Medline, or evidence-based websites (e.g. websites subscribing to Health on the Net Foundation -www.hon.ch) and do so when necessary						
3	Demonstrate skill in acquiring information through using databases and evidence-based web sites						
4	Demonstrate skill in synthesizing existing evidence to inform audiology practice						
5	Apply standardized, reliable and valid outcome measures as available and appropriate for the patient's level of impairment, activity, and/or participation						
6	Ensure that audiology-related activities reflect current scientific evidence (i.e., assessment, identification, intervention/recommendations and outcome measurement)						
7	Demonstrate routine integration of evidence into clinical decisions						
8	Demonstrate commitment to continuous quality improvement						
9	Support and participate in audiology research or related activities such as seminars, workshops, guest lectures, research projects, etc.						
10	Remain current on developments in hearing instrument and related technology, considering appropriate sources of information (i.e. not relying on marketing materials)						
11	Seek out evidence for all areas of practice						
12	Apply information from regulatory body's practice guidelines and/or standards, when appropriate/necessary						

Ng, S., Bartlett, D., Lucy, D., 2008, adapted with permission

MPT Program Evaluation Task Force (D. Bartlett, D. Lucy, L. Bisbee, C. Beggs), 2004

Figure 1b. Sample behaviour: Best evidence and evidence-based practice.

missing from the original CPBDL.

Following voting, all deletions and modifications were voted in by a majority and 17 of the 19 proposed additions were voted in by the majority of participants. The result of proposed additions and discussions around hearing instrument dispensing was a revised key behaviour, to include relationships with hearing instrument manufacturing (see Figure 1a). Managing relationships with hearing instrument manufacturers arose as a major concern among focus group participants, with the growing movement of private practice audiology toward a business model of practice. As a result of the consensus process, the group decided to add a sub-behaviour to the behaviour labelled *Adhering to legal and ethical codes*. This behaviour is now termed *Adhering to legal and ethical codes and monitoring relationships with hearing instrument manufacturers.*

The *nine behaviours of the CPBDL-A are: accountability, adherence to legal and ethical codes of practice and monitoring relations with hearing instrument manufacturers, best evidence and evidence-based practice, client-centred practice, communication, critical thinking, empathy/sensitive practice and respect, lifelong learning, professional image*.

The CPBDL-A uses the extended indicator scale, a modification recommended by the CPBDL authors, with six distinct selections: "No opportunity," "Not at all," "Some of the time," "Most of the time," "Almost always," and "Always." For the purposes of scoring for phase 2 of the project, these selections were assigned numeric values of 0, 2, 4, 6, 8, and 10, respectively. The average score across criteria per behaviour can then be calculated by dividing the total score by the number of criteria for the behaviour.

PHASE 2 PREVIEW: PILOT TESTING AND FURTHER EVALUATION

Seventeen students from a cohort of audiology students at the School of Communication Science and Disorders, The University of Western Ontario will have completed the CPBDL-A three times prior to graduation: at the start of program, after the first external placement, and at the end of the academic program just prior to the final clinical placement.

To date, students have completed the first and second administrations. Similar to the results from PT, there were no ceiling or floor effects for behaviours, students were able to complete the CPBDL-A including SMART goals within a two-week timeframe in the midst of their schooling, and there was variability in responses between students. SMART goals also revealed variability in terms of thoroughness and thoughtfulness of the developed goals.

Students also completed the CCTDI (prior to completion of the CPBDL-A at each of the three previously stated time-points), a well-standardized and widely used inventory of critical thinking dispositions[30,33] and total score results from the CCTDI were correlated with the CPBDL-A total score. The results of this comparison revealed a very strong and statistically significant Pearson correlation between CCTDI and CPBDL-A total scores ($r = 0.95$, df= 15, $p < .01$).

Further analysis will look at trends in the trajectory of development, whether or not trends correlate with those for the CCTDI, potential relationships with students' reflective capacity (qualitative data collected on student reflection is also part of the authors' ongoing program of research), and potential comparisons to PT students. Results of analyses of total and behaviour-specific scores at group and individual levels, including their change over time, and findings from qualitative analysis of the SMART goals, will be presented in a separate paper.

Provision of Feedback

Constructive feedback is important to the growth of students[34] and is recommended for effective use of the CPBDL-A. However, given that the use of the CPBDL-A as described in this study was part of a doctoral student's program of research, phase 2 participants were not provided with feedback specific to their professional or academic development or relating to perceptions of their behavioural ratings. This restriction was part of the authors' agreement with the School of Communication Sciences and Disorders to conduct the research with this cohort of students. Feedback was restricted to encouraging students to seek opportunities to relate items to their experiences if they were selecting "not applicable" frequently, to think about areas for improvement if they were selecting "always" frequently, and to refer them to the SMART goal approach to goal-setting if goals were lacking in content.

In future applications, we strongly suggest providing students with in-depth and timely feedback, following an established, effective feedback approach in order to best facilitate the development of professional behaviours. Clinical supervisors, faculty members, or mentors may be best suited to providing such feedback. Students should also have the opportunity to discuss the feedback for clarification as part of a guided reflection[22] upon specific examples relating to their demonstration of professional behaviours.

Discussion

The following section summarizes the authors' experience with the development of the CPBDL-A, highlights a current professional issue for audiology and demonstrates the value of a reflective practitioner's focus on his or her professional behaviours. Future directions for this work, applications to audiology education and professional development and potential challenges will also be discussed.

The Nominal Group Technique and Delphi process were efficient and effective methods for the goals of reaching consensus in the adaptation of the CPBDL to the CPBDL-A based on input from audiology stakeholders. These techniques have been recommended for use in rehabilitation sciences for precisely such purposes.[35] One important benefit of the chosen approach was the reduction of participant burden in the requirements for just one face-to-face meeting followed by e-mail communication. The structured approach also ensured that every participant was given equal respect and opportunity to provide input, and indeed each participant contributed to the adaptation of the CPBDL during the focus group meeting.

A notable discussion topic from the focus group was that of the tensions that exist in hearing instrument dispensing, given the inherent conflicts of interest that may arise. In the age of evidence-based practice, what are we to do as clinicians when faced with situations that: (A) lack research evidence or (B) involve complexities that make the application of evidence difficult if not problematic. In current practice as an educational audiologist, the lead author often faces dilemma A and dilemma B. In her former practice as a dispensing audiologist, she was often faced with dilemma B, and at times dilemma A. Conflict of interest in hearing instrument dispensing may arise for a variety of reasons: employer-pressures to make sales, financial incentives, or lack of impartial evidence to justify certain features in hearing instruments. The result of the discussion that arose in the focus group to develop the CPBDL-A was to add two behavioural criteria about monitoring relations with hearing instrument manufacturers. However, navigating a situation is much more challenging than simply being aware of tensions and intending to best serve our clients. If we cannot rely on evidence alone to guide us in these situations, as reflective practitioners we may demonstrate a number of our professional behaviours such as accountability, best practice and evidence-based practice, client-centered practice, communication, and critical thinking, all crucial to our role in the selection process of a hearing instrument. Two recent experiences, one as a healthcare client and the other as a health care provider, highlighted this issue to the lead author and these will be reflected upon below:

> First, I went for a temp-oromandibular joint (TMJ) consult as a result of symptoms I was experiencing. After a thorough assessment that revealed I indeed had some TMJ concerns, I was unsettled when I was guided into a room with a woman who walked me through the treatment options that would be most appropriate, and disclosed the hefty price tags (comparable to hearing aids!) associated with each treatment option. As the client in this case, I was surprised by the cost of

treatment, and by the assumption that was made that because I was at the clinic seeking assessment, so too was I ready to consider treatment. I had not yet made that decision, and was not prepared to even be put in a position to make such a decision at that time. The experience left me feeling disconcerted about the process, and left me thinking back upon dispensing experiences in which I had likely held the same assumption, that any client who I assessed as having a certain type of hearing loss was likely interested in learning about treatment options. Some clients may walk in the door simply to determine if perceived difficulties are indeed related to a particular health condition, and that knowledge alone may be all they wish to seek. Readiness at the moment of receiving information relating to treatment options may play a large role in the overall perception of a practice, a practitioner, even a profession. Our ability to recognize this readiness and put aside our own assumptions for the client demonstrates our professional behaviours of client-centered practice, respect, empathy and sensitive practice.

The second example follows a similar theme. This incident occurred at a meeting with an interprofessional team and a young child's family to discuss implications of an auditory processing report that contained directive educational and technological recommendations based on slight difficulties with one part (a competing sentences task) of the auditory processing assessment. The parents were confused and alarmed by the results and recommendations; their daughter had gone in for a hearing test and the auditory processing assessment was recommended and later performed, with the ensuing report. I played my role in the team as the educational audiologist, explaining the assessment results and considering the recommendations within the educational context through our interprofessional team discussion. Through this discussion, it became clear that the "straight-A's student" had no complaints or concerns in the educational setting, though preferential seating was given as a precaution and reassurance. Another professional in the room made the comment that all auditory processing reports looked the same and that every child was given the same generic recommendations. It was not the first time that I had heard this concern from another professional, or from a parent, but what made this particular incident an especially important opportunity for reflection, was this other professional's informal, post-meeting statement: "It's just like going for orthotics. Apparently, everyone needs them." Again, this comment helped me realize the disservice we can do not only to our clients, but also to our own reputation, professional image, and profession's image if we fail to engage in client-centered and evidence-based practice. This disservice occurs if we fail to attend to the specific complexities involved in the individual client's case. Also, highly important in this example, we need to work with other professionals when necessary, rather than making strong recommendations in isolation. In fact, an interprofessional approach to management of auditory processing disorder would be considered a current best practice recommendation.[35]

These examples demonstrate the potential outcomes of neglecting to recognize the importance of professional behaviours, or failure to reflect about such behaviours both in the moments of practice, after significant learning experiences, and before we act again. As reflective practitioners engaging in professional behaviours, we would demonstrate awareness of the values that we as audiologists should enact, navigate situations with the client's best interests in mind, recognize that our solutions are not the "be all and end all" of what a client needs, remain open-minded, listen closely to our clients, and respond with the same care and respect that we would want for ourselves.

Future Research Directions

In the future, CPBDL-A behaviours and items could be further refined and continually updated to reflect current practice. Relationships between the CPBDL-A, students' dispositions for critical thinking, capacity for reflection, and clinical outcomes may be worth investigating further to potentially aid in the selection of candidates for audiology training programs, or to help us better foster desirable behaviours in future audiologists. A key behaviour to consider adding to the CPBDL-A is interprofessional practice and collaboration. Currently interprofessional practice is subsumed under both communication and client-centred practice; however, to highlight the critical contribution of this professional behaviour to all practitioners and educators, it might be useful to create a tenth behaviour.

CLINICAL APPLICATIONS

For Clinicians

As clinicians, we can use the CPBDL-A as a supplement to existing self-assessments, codes of ethics, and continuing education documents that exist from associations and regulatory bodies. Because the CPBDL-A is broad in scope and detailed, its completion may lend itself to transfer to (for example) the CASLPO self-assessment, given the overlap in professional practice standards and professional behaviours. Likewise, borrowing from the learning goal examples of the CASLPO self-assessment guide for completion of the CPBDL-A, may assist in developing goals that will ultimately serve the CASLPO self-assessment guide. We may also wish to use the CPBDL-A as a starting point for in-depth reflection on our practice, and this type of activity, optimized by working with a critical companion, may be worth officially recognizing as a professional development activity (by employers or regulators).

For Clinical Supervisors

As clinical supervisors we may benefit from a tangible tool to assist us in the challenging task of conveying some of the intangible but important aspects of practice to students. The CPBDL-A could serve as a way to work with students to help them be aware of expected behaviours, to monitor their implementation of such behaviours, and to encourage growth in specific areas of professional behaviour. If both the student and supervisor use the tool at the beginning, middle, and end of a clinical placement, discussion around areas of discrepancy between student and supervisor ratings may also provide insight into the student's ability for self-assessment. For supervision, the CPBDL-A may best serve as a tool to generate discussion and reflection between student and supervisor, to support continuous development of professional behaviours.

For Students

It can be difficult for students to relate abstract concepts to their current stage in professional development. The benefits of the CPBDL-A are potentially best appreciated by students in the midst of clinical placement, with direct and indirect guidance from supervisors. Some students may benefit from and respond with more enthusiasm and detail to the CPBDL-A than others. Future research could investigate the effectiveness of the CPBDL-A in fostering professional behaviour in students depending on their overall profile of critical thinking dispositions, reflective capacity, academic background prior to entering audiology, and subsequent clinical and academic performance.

For Educators and Regulators

As educators and regulators, the CPBDL-A may serve as a model for competency-based approaches. Curriculum design may benefit from beginning with a global "outcome" to consider in the design of the individual parts of the educational program. A tool such as the CPBDL-A could be used to ensure that each part of the curriculum considers the key professional behaviours necessary for the entry-to-practice audiologist, integrating and instilling value for these behaviours in every facet of the educational program. Likewise, such a tool could be useful to regulators determining entry-to-practice and continuing competency requirements. SMART goals could also be analyzed qualitatively in relation to the CPBDL-A quantitative data (with scores generated as described above). A combination of qualitative and quantitative evaluation of current curriculum is a recommended first and crucial step for curriculum redesign.35

Challenges

Challenges associated with the application of the CPBDL-A include: time commitment, valuing of the tool by individuals and institutions, and the pitfalls of self-assessment. Continuing education is accepted as an important aspect of professional development, and yet some continuing education activities may provide less than meaningful learning experiences, and may not always contribute to increased knowledge or improved service delivery despite providing the necessary credits or hours.

It is our hope that instilling the values for the artful side of practice may become a priority for educators, employers and regulators, and as such, that time for such development may be provided. Values instilled early on in a curriculum, at times unintentionally or unknowingly passed on through the "hidden curriculum,"[38] may affect the professional socialization and thus permeate the professional identify of students, with far-reaching consequences for what future practitioners may consider worthwhile to their practice. If focusing on development of professional behaviours was valued and thus counted as professional development activity, time would become less of a barrier.

Current funding priorities, the evidence-based movement, and the youth of our profession may make non-technical foci in training and non-traditional research approaches seem of low value to the advancement of audiology. However, if we look to the movement in other health care professions away from a strictly technical and biomedical model to one that values and fosters personal and professional growth in areas such as those described in the CPBDL-A, we will find that we are at the forefront of health care instead of following on the tail-end.

Given the generally agreed upon importance of evidence-based practice to audiology,[17,18] one question that arises is whether or not a tool such as the CPBDL-A is itself evidence-based. Traditional hierarchies of evidence[17,18,39] would rate the development of the CPBDL-A as low, because it was developed predominantly from expert opinion. However, the traditional hierarchy of evidence may be an inappropriate metric for certain topics and may not be applicable to every type of research question.[27,40] We strongly believe that the CPBDL-A is informed by relevant sources of knowledge and appropriate types of evidence, and if continually updated to reflect current practice, it can be applied effectively by individual practitioners to support practice in noticeable yet difficult to quantify ways.

Finally, self-assessment has been questioned as an effective tool for professionals, because not all individuals are able to accurately assess their skills and knowledge.[21] Reflective practice has been emphasized in this paper for this very reason; especially in collaboration with colleagues or informed by external sources of knowledge, reflection can improve our ability to be critical of our own assumptions and actions and can help us attend to areas for improvement within our practice.[14] Reflection about professional behaviours can lead us to seek out evidence, to consider a client's unique values, or to develop a new skill. Even if individual differences and reflective capacity are determining factors in the performance of professional behaviours by an individual practitioner; so too is appropriate fostering of such attributes.[3] We acknowledge that individuals may possess different strengths and weaknesses, and perhaps different "floors" and "ceilings" of potential for various aspects of practice. Yet, we still need to strive to bring each practitioner to his/her ceiling potential; this effort is our responsibility, as a profession, to the public that we serve.

For a copy of the CPBDL-A, or if you have any questions, please e-mail Stella Ng at SLNG@uwo.ca.
The CPBDL-A is available for download at: http://publish.uwo.ca/~sng9/CPBDL-A.pdf

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Changing the way Patients Interact with Hearing Aids

Jason A. Galster, PhD and Aaron Schroeder, MA

About the Authors

Jason Galster, PhD (pictured), is director of audiology communications with Starkey Laboratories, Inc. He is responsible for ensuring that all product claims are accurate and backed by supporting evidence. He has held a clinical position as a pediatric audiologist and worked as a research audiologist on topics that include digital signal processing, physical room acoustics, and amplification in hearing-impaired pediatric populations.

Aaron Schroeder is a research audiologist in the Clinical Product Research group at Starkey Laboratories, Inc. He is routinely involved in the development of emerging technology and fitting processes with specific focus on Alpha and Beta studies. Prior to joining Starkey he worked as a dispensing and clinical audiologist for seven years in a variety of clinical settings. He has continued his education with current enrolment as a PhD student at the University of Kansas Medical Center. He has been a clinical teacher and lecturer on hearing aid technology, business audiology, and diagnostic audiology.

Educating and training patients to use hearing aid volume controls and memory buttons is a typical and often frustrating daily routine for hearing care professionals. With small memory buttons and even smaller volume control wheels becoming the industry norm, an increasing number of patients are finding the manipulation of these controls ever more challenging. Often, these challenges are complicated by peripheral neuropathy that may numb the fingers and force patients to remove their hearing aids to make adjustments. Innovative design and engineering could develop a more user-friendly means to manipulate a hearing aid's memory and volume controls.

Measurements from current behind-the-ear (BTE) hearing aids show that the average hearing aid volume control wheel has an accessible surface area of .04 inches and the average push button has a surface area of .08 inches. In the well established field of Human Computer Interface (HCI), the study of human and computer interaction, Fitt's law supports the conclusion that small controls decrease the speed and ultimately increase the difficulty of "acquisition."[1] Keeping this law in mind, it made perfect sense to explore how increasing the accessible surface area of a switch could improve the patient's ability to use these controls.

The recent success of Apple's iPod Touch and iPhone, using *capacitive surface* technology, presented an appealing possibility. The surface of a capacitive technology can be made of any conductive material and works by running a small voltage across the surface, establishing a miniscule electrical field. When a finger touches the surface, the body's natural capacitance disrupts the field, triggering the switch. When implemented into a hearing aid, a single touch sensitive surface, allowing for multiple adjustments without the need for mechanical switches or dials, could be imagined. Although the concept was sound in theory, much work remained to ensure that the application of this technology to hearing aids was appropriate.

The integration of capacitive switch technology into a hearing aid was a complex task. Understanding the application of this new control technique required a detailed analysis of patients' switching behaviour and preferences. For this reason, numerous

Figure 1. Two S Series behind-the-ear hearing aids are shown. The dark surface along the back of the hearing instrument is the Sweep Technology Control Surface.

Figure 2A. An S Series hearing aid is shown. The arrows illustrate the sweep motion that, by default, triggers a change in volume.

Figure 2B. An S Series hearing aid is shown. The arrows illustrate the tap motion that, by default, triggers a change in memory.

research and development studies were completed, analyzing patient behaviour and perception of their hearing aid controls. The result is a capacitive switch surface as shown in Figure 1. The switch surface is clearly differentiated by paint color on the hearing aid. This switch is a single seamless surface that gives patients full access to volume and memory adjustments. With a surface area of .16 inches this new form factor increases the available surface area of the memory and volume control by 5 and 10 times, respectively, thus improving the patients' ability to manipulate the switch. Two additional benefits of having no mechanical movement required for activation include no push buttons that oxidize and fail with time, and no seems around the volume control wheel that allow for easy access to moisture and dirt to enter the hearing aid.

Figures 2A and 2B show the combined functionality of this capacitive switching technology. Default volume adjustments are made by sliding a finger along the spine of the hearing aid. Completing an upward sweeping motion increases volume, whereas a downward sweeping motion decreases volume. Memory adjustments are made with a brief touch and release of the surface. The flexibility of Sweep Technology was designed to meet the needs of each individual patient. If a single function best suits the patient, various options are available. For instance, if a patient only needs access to volume control, this can be accomplished by only allowing adjustments via a sweep or touch. In contrast, if a patient only needs access to memory adjustments, the volume control can be disabled, leaving only the touch-based memory control. Finally, for patients where physical control of the hearing aid is not needed, the control can be deactivated.

To confirm the usability of this innovative hearing aid design feature, 15 hearing-impaired participants participated in a clinical evaluation. Each participant was asked to compare their preference for a traditional behind-the-ear (BTE) hearing aid

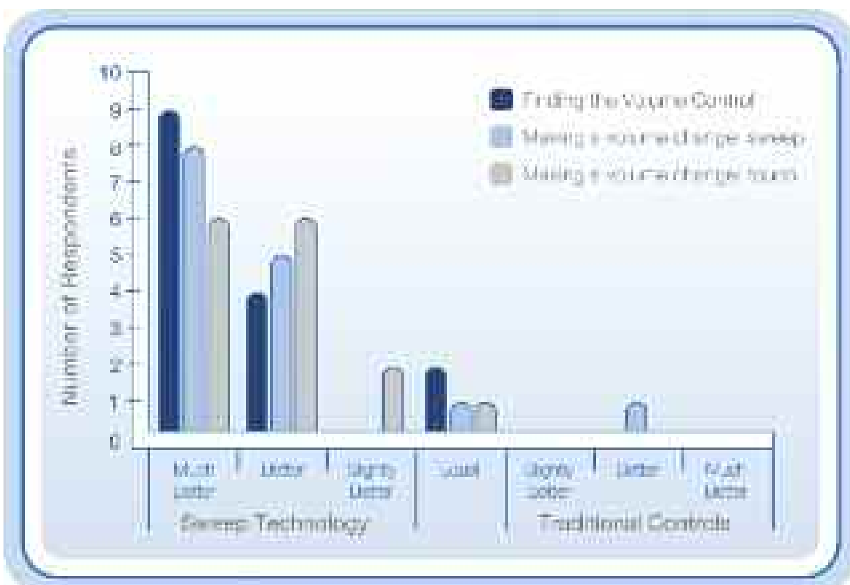

Figure 3. Individual preference ratings for finding the volume control and performing adjustments. Participants compared adjustments using the Sweep Control and a traditional volume wheel.

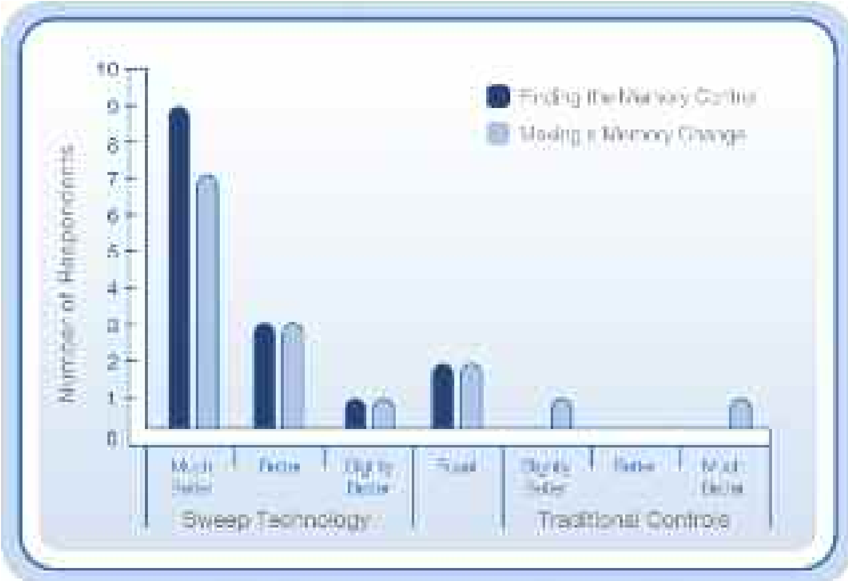

Figure 4. Individual preference ratings for finding the memory control and performing memory changes. Participants compared adjustments using the Sweep Control and a traditional memory button.

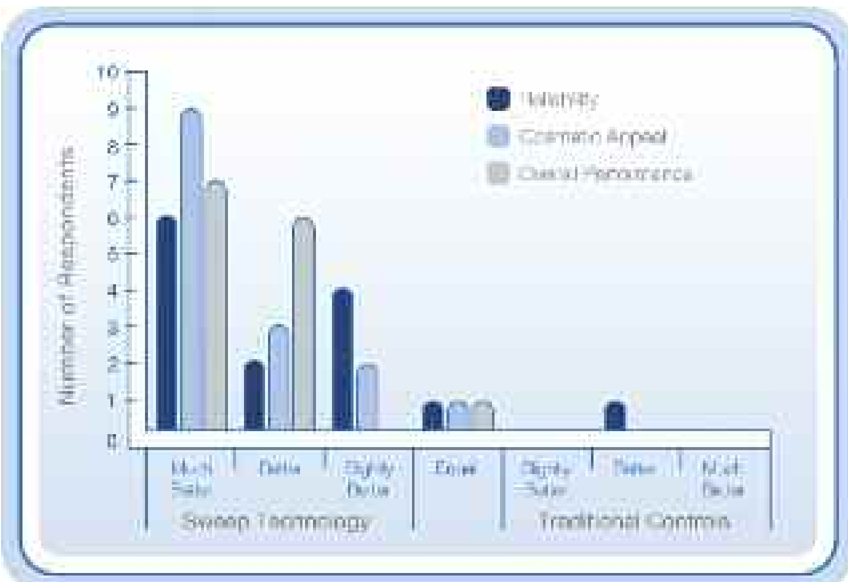

Figure 5. Individual participant ratings for reliability, cosmetic appeal, and overall preference. Sweep Technology and a traditional behind-the-ear hearing aid with both a volume wheel and memory button were compared.

equipped with both a volume control wheel and a traditional memory button to the newly implemented capacitive touch surface. Each participant rated their preference for eight different aspects of the hearing aid controls. Figure 3 provides individual preference ratings for questions regarding volume control adjustments. Participants not only rated the large surface area of the capacitive switch as easier to find, they also preferred completing volume control adjustments with this new technology, when compared to a traditional volume control wheel. Figure 4 shows data related to memory adjustments. Again, participants rated the capacitive control easier to find and preferred making memory adjustments with the control, when compared to the traditional memory button.

Figure 5 shows the individual judgments for quality, cosmetic appeal, and overall preference. As with the previous comparisons, the research participants preferred the capacitive control. When asked to explain their reasons for their cosmetic preference, participants stated that the new technology was "classy," "sleek," "more sophisticated," or that the "old hearing aids look obsolete and antique." These comments support the preference data and show that the capacitive control design complements the advanced technology provided by their hearing aids.

Starkey Laboratories has successfully designed, researched, and implemented this new capacitive control now known as Sweep Technology. Available in the new S Series behind-the-ear hearing aids, Sweep Technology offers a single, large control that provides access to both volume and memory adjustments. If a patient can find the back of their ear, they can now make adjustments to the hearing aid. As advances such as Sweep Technology bring modern conveniences to hearing aids, patients with specific needs will benefit and find advanced hearing technologies increasingly accessible.

CONFLICTS

Both of the authors are employed by Starkey Laboratories.

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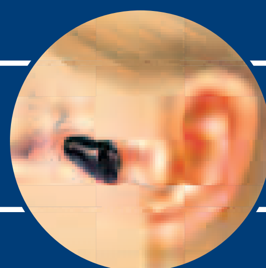
introducing:

OtoLens™



The only 100% custom, invisible, digital and fully programmable hearing aid.

OtoLens - Features and Benefits

- Leverages proprietary digital modeling and advanced micro-chip packaging techniques to minimize overall size
- Placement in second bend of ear canal combined with venting reduces occlusion issues
- Takes advantage of audio cues from the pinna for natural sound quality
- Fits patients with mild to moderately severe hearing loss
- Uses Starkey's proprietary Comfort Fit process which leverages information captured from millions of ears
- Voice iQ noise reduction and speech preservation system utilizes dynamic voice identification coupled with a spectral noise control that calculates appropriate gain on a per channel basis providing unprecedented sound quality
- T^2 Remote function allows patients to adjust volume and memories using a standard touch-tone phone
- Includes 16 channels and 16 bands for optimal high-resolution sound imaging
- Can be inserted and removed by patient to promote better ear health
- Enables more patients to benefit from a deep insertion device than ever before

Starkey®

Find out more at StarkeyCanada.ca
800 387 9353