OFFICIAL PUBLICATION OF THE CANADIAN ACADEMY OF AUDIOLOGY
PUBLICATION OFFICIELLE DE L'ACADÉMIE CANADIENNE D'AUDIOLOGIE

Canadian Hearing Report

Revue canadienne d'audition

Vol. 5 No 2

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

Infection Control

Basic Concepts in Functional Hearing Assessment

Clinical Application of WBR

Published by ANDREW JOHN PUBLISHING INC.
www.andrewjohnpublishing.com

Publications Agreement Number 40025049 | ISSN 1718 1860

This is a rather exciting issue in the sense that most of the contributions come from Canada. In earlier issues we were constrained to look far and wide for articles, but home-grown talent is always nice to see…obviously my Canadian enthusiasm is still remaining from watching the Olympics!

In this issue we have three articles with a research and development (R and D) focus – infection control, the use of wideband reflectance for middle ear assessment, and functional hearing assessment.

Infection control in our practices is obviously a topic that holds a special importance for us and A.U. Bankaitis is no stranger at writing about this important area. And if you can figure out what A.U. stands for, I will buy you a beer (or a Pinot Noir) at the next CAA meeting in Montreal. A.U. has also previously published extensively on middle ear implants.

And while we are talking about the middle ear, the second R and D focused article is by Navid Shahnaz at the University of British Columbia (whose program is currently celebrating their 40th anniversary). Dr. Shahnaz examines an alternative use of middle ear assessment using wideband reflectance. I recall earlier attempts in the 1980s to improve the assessment of the functioning of the middle ear and these included multi-tone impedance and complex multi-frequency impedance. These earlier approaches had some limitations (not to mention that the outputs were in both the real and the imaginary domains), but many have been addressed by the wide band reflectance approach.

The third R and D focused article is by a group of researchers at the University of Ottawa, in conjunction with Sigfrid Soli of the House Ear Institute (who some say looks like me, see page 30).They have submitted a wonderful article on basic concepts in functional hearing assessment. I understand that in the not too distant future, Dr. Soli will be moving up to Canada and will be taking up residence at Halfmoon Bay in British Columbia.

Dr. Lendra Friesen from the Sunnybrook Health Sciences Centre in Toronto has contributed another “Spotlight on Science” column on how the vestibular system may affect what we hear, at least rhythmically. Another column, “From the Classrooms” also appears in this issue with a critical literature review by Kelly Flannery, about whether hearing aid bandwidth should be extended over what is available with today’s technology. This review is one of many performed on a range of topics by the graduating students at the University of Western Ontario. These reviews are evidence-based and the information reported is predicated on well designed and controlled research studies. If, in the future, you are fortunate to work with some of these students, please ask them to let you read their reviews – they are all well thought out perspectives based on solid research and it’s my opinion that student’s work should be widely circulated. Most of the graduating audiology students at the various programs around Canada are required to spend a significant amount of their time working on a particular topic of interest and it would be beneficial to the wider audiological community to have access to their work.

And while we are talking about evidence-based practice, this year’s Seminars on Audition (which celebrated its 25th anniversary) was held in Toronto on February 27, and looked at that topic in detail with guest speakers Dr C. Palmer and Dr. S. Scollie (no relation to Dr. S. Soli). A review of their presentations and views on this important topic are provided.

Marshall Chasin, AuD,
Editor-in-Chief

Ce numéro est plutôt passionnant vu que la plupart des contributions viennent du Canada. Dans des numéros précédents, nous devions aller chercher des articles loin et large mais le talent produit maison est toujours beau à voir…évidement mon enthousiasme canadien ne s'est pas tari depuis les jeux olympiques !

Dans ce numéro, nous avons trois articles axés sur la recherche et le développement (R et D) – contrôle de l'infection, l'utilisation de la refléctance à larges bandes pour l'évaluation de l'oreille moyenne, et l'évaluation de la fonction auditive.

Le contrôle de l'infection dans nos cabinets est évidemment un enjeu spécial et A.U Bankaitis a déjà écrit sur ce sujet d'importance. Et si vous trouvez la signification du A.U, je vous offre une bière (ou un pinot noir) à la prochaine réunion de l'ACA à Montréal. A.U a aussi publié abondement auparavant au sujet des implants de l'oreille moyenne.

En parlant d'oreille moyenne, le deuxième article en R et D est de Navid Shahnaz de l'université de la Colombie Britannique (dont le programme célèbre le 40eme anniversaire). Dr. Shahnaz examine un usage alternatif de l'évaluation de l'oreille moyenne utilisant la réflectance à larges bandes. Je me souviens de tentatives précédentes dans les années 80 pour améliorer l'évaluation du fonctionnement de l'oreille moyenne et parmi ces tentatives l'impédance multi-son et l'impédance complexe à multifréquences. Ces approches antérieures avaient leurs limitations (sans mentionner que les résultats étaient tout autant du domaine du réel que de l'imaginaire), mais plusieurs ont été résolues par l'approche de la réflectance à larges bandes.

Le troisième article en R et D est par un groupe de chercheurs de l'Université d'Ottawa, en conjonction avec Sigfrid Soli de the house Ear Institute (qui me ressemble, aux dires de certains). Ces chercheurs ont présenté un article formidable sur les concepts fondamentaux de l'évaluation du fonctionnement auditif. Mon information est que bientôt, Dr. Soli va déménager au Canada et résidera à Halfmoon Bay en Colombie Britannique.

Dr. Lendra Friesen du centre Sunnybrook des sciences de la santé de Toronto a contribué à une autre colonne "Spotlight on Science "sur les systèmes vestibulaires et leur effets sur ce que nous entendons, au moins sur la rythmique. Une autre colonne, "From the classrooms" est dans ce numéro avec une analyse critique de la documentation par Kelly Flannery, quant à savoir s'il faut étendre les appareils auditifs à larges bandes au delà de la technologie disponible actuellement. Cette analyse est parmi plusieurs conduites sur plusieurs sujets par les étudiants (es) de dernière année de l'Université Western en Ontario. Ces analyses sont basées sur des preuves et l'information rapportée est prévisible sur une base de recherche contrôlée et bien conçue. Si, dans le future, vous êtes assez chanceux pour travailler avec certains de ces étudiants(es), demandez à ce qu'ils vous montrent leurs analyses – ce sont des perspectives bien solides basées sur une recherche solide et je suis d'avis que le travail des étudiants devrait être diffusé largement. La plupart des étudiants(es) de derrière année dans plusieurs programmes d'Audiologie à travers le Canada sont obligés de dévouer un temps significatif à des sujets d'intérêt particulier et il serait avantageux pour la communauté audiologique de prendre connaissance de leur travail.

En parlant de méthode basée sur des preuves, le Séminaire en Audition de cette année (qui a célébré son 25eme anniversaire) a eu lieu à Toronto le 27 février, et a étudié ce sujet en détail avec nos conférenciers invités Dr C. Palmer et Dr. S. Scollie (aucun rapport avec Dr. S. Soli). Leur présentations et opinions sur ce sujet important sont fournis.

Marshall Chasin, AuD,
Éditeur en chef

Canadian
Hearing Report
Revue canadienne d'audition
Vol. 5 No 2, 2010

Official publication of the
Canadian Academy of Audiology

Publication officielle de l'académie
canadienne d'audiologie
www.canadianaudiology.com

Canadian Hearing Report is published six times annually by Andrew John Publishing Inc. with offices at 115 King Street West, Dundas, On, Canada L9H 1V1.

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Publications Agreement Number 40025049
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"QUICK NOTES"

FROM THE EXECUTIVE DIRECTOR

Well, spring-like weather has sprung almost everywhere and the onset of warmer temperatures coincides with a flurry of activity by the Canadian Academy of Audiology.

The CAA is actively participating in the **Inter-organizational Steering Group for Audiology and Speech Language Pathology (ISG)**.

- The ISG's initial project focused on the development of **Infection Control Guidelines** for both audiology and speech-language pathology. A media launch announcing the release of the new guidelines was held in Ottawa on March 25, 2010.
- CAA is taking the lead role in the next project **– Guidelines for the Assessment, Diagnosis and Intervention/Mediation of Auditory Processing Disorders (APD)**. The committee chair/author is Pam Millett, PhD, assistant professor, Deaf and Hard of Hearing Program at York University in Toronto.

Planning is well underway for the **2010 CAA National Conference October 5-8 at The Sheraton Centre in Montreal, Quebec**. Look for more specifics on the CAA website (www.canadianaudiology.ca).

CAA's **strategic marketing and branding exercise** continues to advance the CAA and the profession to government agencies, universities, and colleges as well as the Canadian auditory 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.

CAA also hosted its first regional one-day **Audiology Seminar** on Saturday, March 27, 2010 in Richmond, British Columbia which featured Michael Valente, PhD, whose specialty area is "amplification." Michael is director of adult audiology at Washington University in St. Louis, Missouri. Next year's seminar will be held in Moncton, New Brunswick.

One final exciting development is that the CAA and CASLPA have submitted a joint bid to host the International Society of Audiology Conference in Vancouver, British Columbia in October 2016. We like our chances … more on this next issue!

Tom McFadden
CAA Executive Director

"NOTES ACCELEREES"

DU DIRECTEUR EXCECUTIF

Bon, le temps presque printanier est presque partout et l'arrivée des températures plus clémentes coïncide avec la rafale d'activités de l'Académie Canadienne d'Audiologie.

L'ACA participe activement au **groupe interorganisations pour l'Audiologie et l'Orthophonie (GDI).**

- Le projet initial du GDI s'est centré sur le développement de lignes directrices pour le contrôle des infections pour l'Audiologie et l'Orthophonie. Le lancement médiatique annonçant les nouvelles lignes directrices s'est tenu à Ottawa le 25 mars, 2010.
- L'ACA tient le rôle principal dans le prochain projet **–Les lignes directrices pour l'évaluation, diagnostique et ntervention/ médiation des troubles du traitement des informations auditives**. La présidente/auteure du comité est Dr. Pam Millet, chargée de cours, Programme des personnes Sourdes et malentendantes à l'université York de Toronto.

La planification est bien amorcée **pour la conférence nationale de l'ACA de 2010, du 5 au 8 Octobre au centre Sheraton de Montréal, Québec**. Vous trouverez plus d'information sur le site web de l'ACA (www.canadianaudiology.ca).

L'exercice markéting et image de marque de l'ACA continue d'avancer la profession auprès des agences gouvernementales, universités, collèges ainsi que l'industrie acoustique canadienne et le grand public. Un nombre de nouveaux outils d'audiologie et produits – affiches, autocollants, feuilles de coloriage "connecter les points " et blocs de test auditif– ont été produits pour les membres et sont disponibles sur le site web de l'ACA.

L'ACA a aussi été l'hôte du premier **Séminaire en Audiologie** régional d'une journée le samedi 27 mars, 2010 à Richmond, en Colombie Britannique qui a vu la participation du Dr Michael Valente , dont la spécialité est "l'amplification". Michael est le directeur de L'audiologie pour les adultes à l'université de Washington à St. Louis, dans le Missouri. Le séminaire de l'année prochaine aura lieu à Moncton, dans le nouveau Brunswick.

Notre dernier passionnant développement est que l'ACA et l'ACOA ont fait une soumission conjointe pour être les hôtes de la **conférence de la société internationale** d'Audiologie à Vancouver, en Colombie Britannique en Octobre 2016. Nous aimons nos chances........ Plus d'information dans notre prochain numéro !

Tom McFadden
Directeur exécutif de l'ACA

UBC School of Audiology and Speech Sciences Celebrates 40 Years

The UBC School of Audiology and Speech Sciences recently moved into the newly-renovated Friedman Building.

PhD students in a study lounge at SASS.

Director Valter Ciocca teaches a class.

The School of Audiology and Speech Sciences (SASS) at the University of British Columbia is marking 40 successful years this spring. The only program in BC to educate audiologists and speech-language pathologists, the school offers two degrees: the master of science and the doctor of philosophy. Located on UBC's Point Grey campus in Vancouver, the school is known for its strong theoretical component, and also for its stunning locale.

The school has much to celebrate as it enters its fourth decade. In 2008, SASS moved into renovated teaching and research facilities in the $19 million, energy-efficient Friedman Building. The new space includes state-of-the-art audiology labs, speech-language therapy observation rooms, large classrooms, more offices, and spacious study lounges. The cutting-edge facilities have expanded opportunities for research and education, and the school now enrols 35 new master's students each year. The school also has five to six PhD students, two post-doctoral fellows, a university-based faculty of 15, and a clinical faculty complement of over 170. Dr. Valter Ciocca is the director of the program. Needless to say, the school has come far since 1969, when it began as a division of the Department of Paediatrics in the UBC Faculty of Medicine. The division achieved independent status as a school in 1981, but remained small; for its first 20 years, the school's size remained constant at six faculty members and an average class size of 12. For 13 years, the program was funded by private donations and research grants alone, but in 1982 UBC assumed responsibility for a portion of the budget and salaries. Six years later, SASS won a **Funds for Excellence Award** from the Province of British Columbia. This funding allowed the school to double enrolment and add new faculty members. The school has only continued to grow and looks forward to a bright future.

This May, the school's community will gather to celebrate the 40th anniversary with a weekend of events. There will be a dinner on May 28 to which all alumni, faculty, students, and staff are welcome. The following day there will be an open house event at the Friedman Building, at which UBC President Stephen Toope will give the welcoming remarks along with Dr. Gavin Stuart, dean of the Faculty of Medicine. School founder John Gilbert will also be in attendance and will give a brief history. Guests will be able to tour the new facilities and to spend time meeting with faculty and reuniting with alumni and practitioners. Those at the school look forward to the opportunity to celebrate the considerable accomplishments SASS has achieved over the years.

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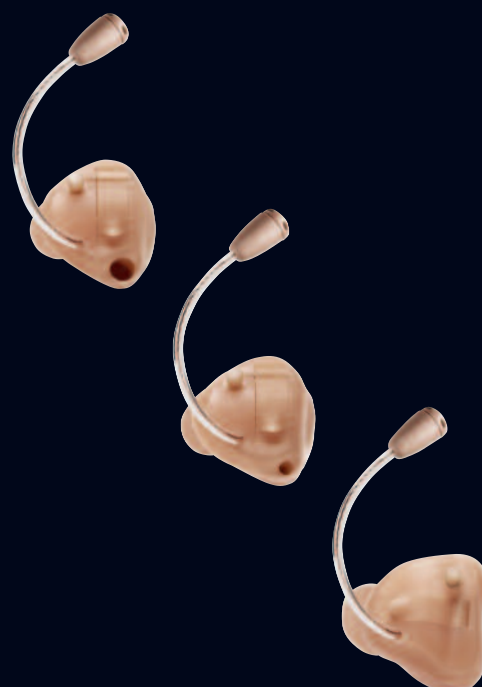

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Review of the 25th Annual Seminars on Audition

The 25th annual Seminars on Audition – a non-profit conference where all proceeds go to support the Seminars on Audition scholarship at the University of Western Ontario and the Poul B. Madsen scholarship at the University of Toronto – was held in Toronto on February 27, 2010. Conference speakers were Dr. Catherine V. Palmer and Dr. Susan Scollie.

Dr. Catherine V. Palmer, PhD is an associate professor in the Department of Communication Science and Disorders at the University of Pittsburgh and serves as the director of audiology and hearing aids at the University of Pittsburgh Medical Center. Dr. Susan Scollie, PhD, is an associate professor at the National Centre for Audiology at the University of Western Ontario in London, Ontario.

The following are brief summaries of Dr. Palmer's and Dr. Scollie's presentations. The day also included excellent questions and discussions around these matters.

Bringing the Evidence Base to the Patient

By Catherine V. Palmer, PhD, University of Pittsburgh

In order to bring the evidence base to the patient, there must be evidence, the clinician must be able to find the evidence, the clinician must be able to critically evaluate the evidence, and finally the clinician must be the bridge between the patient and the critically evaluated evidence. This is a brief review of the material presented at the February 27, 2010 Seminars on Audition.

FINDING THE EVIDENCE

Systematic reviews are an evidence-seeking clinician's best friend. These are specially designed reviews that ask specific clinical questions (e.g., Does the use of noise reduction increase speech intelligibility for a hearing aid user?) and gather the data to answer the question. The systematic review provides the clinician with an answer that may indicate no evidence, weak evidence, moderate evidence, or strong evidence for a particular treatment. It is the clinician's job to view the level of evidence and make a final recommendation based on the specifics of any given patient. The clinician's role is critical. Evidence cannot be applied to all patients equally because of the individual circumstances (e.g., listening demands, communication environments, abilities, etc.) of a particular patient.

There is not always a systematic review available that answers the clinical question at hand, so the clinician must be able to go to original sources for answers. Evidence based practice encourages the clinician to answer individual clinical questions. Cox[1,2] describes five steps for answering clinical questions efficiently: (1) ask an answerable question (comparing two treatments), (2) conduct an efficient (online) search of the literature to locate the available evidence relevant to the question, (3) evaluate the quality of evidence, (4) decide how the evidence applies to this particular patient and generate recommendations for treatment, and (5) evaluate the outcome of the treatment and seek ways to improve next time. If done correctly (and efficiently), this method should produce one to three articles that specifically answer the question and the entire process should take about 20 minutes. For a detailed description and sample question see Cox 2004.[1]

CRITICALLY EVALUATING THE EVIDENCE

Once the clinician has found the evidence, there is a need to critically evaluate the study to make sure it was designed in a way that can answer the clinical question. It is not safe to assume that just because something is published that it holds the answer needed. Further, many clinicians are faced with treatments (particularly amplification technology) that outpace published research. In these cases, the clinician will need to critically evaluate manufacturer literature until other sources are available. Palmer et al provide a guide to being a critical consumer of the literature.[3] The reader can find this complete work at www.audiologyonline.com. Briefly, the clinician should use a checklist to evaluate an article, including: (1) How many subjects should have been included? (2) How variable are the data? (3) Did the difference between groups/treatments reach statistical significance? (4) Does the difference between groups/treatments have practical significance? Investigators should provide a power analysis in order to determine how many subjects are needed to answer the proposed question or to determine if enough subjects were included after the fact. The critical consumer of literature should always demand to see mean data with standard deviation bars. Without seeing the variability it is very easy to think there is a large difference between treatments when there is not. Most studies will report whether there was a significant difference between treatments which is an important first step, but what the clinician wants to know is whether there is a clinically meaningful difference between treatments (or a practical difference). Ideally, the investigator will report the effect size associated with the difference between treatments. Once the clinician has evaluated the evidence, he/she can assign a level of evidence and a grade that indicates how strong the evidence is in answering the particular questions. The levels and grades are listed in Table 1.

Table 1. Levels and Grades of Evidence

Levels of Evidence

1. Systematic reviews and meta-analyses of randomized controlled trials
2. Randomized controlled trials
3. Non-randomized intervention studies
4. Descriptive studies (cross-sectional surveys, cohort studies, case-control designs)
5. Case studies
6. Expert opinion

Grades of Recommendation

A. Consistent level 1 or 2 studies

B. Consistent level 3 or 4 studies or extrapolations (data are being used in a clinically different situation) from level 1 or 2 studies

C. Level 5 studies or extrapolations from level 3 and 4 studies

D. Level 6 evidence or troubling inconsistencies or inconclusive studies at any level

BRIDGING THE GAP BETWEEN THE EVIDENCE AND THE PATIENT

Clinicians can use evidence based guidelines to assist in providing excellent care to their patients. The Adult Management of Hearing Loss guideline from the American Academy of Audiology now includes a chart providing the level of evidence that is associated with each of the recommendations in the guideline. The Pediatric Amplification guidelines currently are being revised and will include the same type of information so the clinician knows whether research is supporting the recommendations or whether the recommendations are expert opinion.

With the recent focus on evidence-based practice, the clinician must remember that some things are acoustic or physical facts (APFs) and do not require an investigation in order for the clinician to embrace them. For instance, it is a fact that children grow, therefore real-ear-to-coupler difference will need to be measured every time a new earmold is obtained in order to ensure proper hearing aid output in the individual ear. Batteries can be swallowed by young people and confused older people so the use of locking battery doors is recommended – no one needs to design a study to show that a certain number of people actually do swallow batteries. So while evidence-based practice is essential, using acoustic and physical facts to shape clinical practice is also critical. The clinician is the bridge between all of this information and the patient. Patients are depending on the clinician's expertise that is constantly informed and modified by evidence to guide them in their treatment decisions.

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Getting the Most from Evidence Based Practice … I Think There Are Some Problems

Susan Scollie, PhD, University of Western Ontario

Evidence-based practice (EBP) offers us a systematic approach for integrating new research findings with our clinical practice. In our current era of information, a systematic approach helps us to filter the vast array of information that is available, and guides us efficiently to use the best information when answering questions. But what about in Canada? Is EBP really a medical model or a south of the border trend? For Canadian audiology, I see some barriers and facilitators that mostly relate to the very small number of clinicians and researchers in our profession.

THOUGHT #1: WE ARE WEE

With only a few hundred of us in this vast country, we are seriously outnumbered by larger professions such as medicine, pharmacy, and nursing, but also by speech-language pathology, occupational therapy, and physical therapy. Often these larger fields have a research base supported by basic research in physiology, neurology, and psychology. We do as well, and also benefit from our colleagues in engineering, but still we have fewer clinicians, fewer training programs, and fewer researchers. When thinking about ways to efficiently organize, evaluate, and warehouse the evidence for our practice, the size limitation needs to be taken very seriously. These endeavours require human capital.

More so than ever, an EBP perspective leads me to the thought that collaboration across the provincial boundaries and looking to internationally developed documents could be an important source of increase in our efficiency. Currently, if a practice guideline is developed in one province, is it shared with the others? Do we have a national strategy for doing this? If a regulatory body in one province needs to develop a new practice guideline, do we first check to see if another province or country has done the same? If a group of us goes to the work of developing an EBP-based guideline, do we know how to submit this guideline to international warehouses to be shared with the world? Yes, such things do exist – check out www.tripdatabase.com and find 557 documents related to "hearing aid," sorted by quality of evidence. Informally, I am sure there have been "yes" answers to some of the above, but do we have a clear ***national*** strategy for efficient EBP in Canadian audiology?

THOUGHT #2: THE CONTINUING DIFFICULTY OF CHANGE

Change is hard. Reflecting upon the huge changes in practice that I've witnessed in my not-that-long-yet career, I am staggered by the rate at which new information, new technology, and new procedures are developed. Does it seem to be getting faster to you? The strength of the EBP practices described by Dr. Palmer is that they offer us a structured approach to managing and appraising the scientific evidence that informs practice changes and decisions, while keeping the client's needs and values at the centre of our decisions. However, a sporadic, passive approach to change management is not likely to be successful in ensuring that best practice is universal. All professions struggle with whether their EBP initiatives are going well. The larger professions have recognized that active change management strategies are needed to keep a profession well-integrated with its science and vice versa. What is our strategy, in Canadian audiology, for managing change in the science that supports our practice?

One of the changes that we've made in our training program is to include specific coursework in EBP procedures for our students. Working in small groups, each student defines a PICO (population, intervention, control, outcome) question that they'd like to be able to answer, and completes a systematic review of the literature to develop the answer. The procedures they follow are essentially those described by Dr. Palmer. In my experience teaching this course, the students are typically surprised by how little direct evidence there is to guide practice, but also that they are able to find answers and future directions nonetheless. As instructors, we struggle sometimes to balance the need and ability to draw reasonable conclusions from sometimes imperfect information with the goal of training a future generation of clinicians who are equipped to harvest the literature. One important outcome of this, I hope, will be that larger numbers of us will already know the EBP process before we serve on a guideline development committee. I served on two such committees shortly after entering practice. We did our best, but really did not have any procedures to follow for amalgamating the information we read, and struggled more with process than with content. Will practice guidelines of the future benefit from more audiologists being trained in EBP?

THOUGHT #3: THE SOUND BOOTH MENTALITY

I work in a building filled with people from other professions – SLP, OT, PT, engineering. What I notice about my own profession of audiology, is that we seem to stand apart from these other fields, acting more on our own and less in concert with the others. Some of this is probably due to legitimate differences in practice – we rarely keep therapy-based clinic schedules, we rarely assess people in their homes, we function in many ways as a diagnostic/prescriptive profession more than a therapy-based profession. My colleagues who work intensively with aural rehabilitation will rightly disagree with some of these statements, and, I've noticed, seem to have more detailed contact and collaboration with our colleagues in these other fields. As a whole though, audiology is a bit unusual. Many of us spend a lot of our days alone in a sound booth with our patients and not in frequent contact with our colleagues. I sometimes wonder if that's why we always seem to think that audiology has to do everything for ourselves – do we live in a sound booth mentality? We rarely attend shared professional conferences or draw upon solutions developed by our colleagues … You know: if it wasn't developed from within audiology, then it won't apply to us, so why bother with it.

In stark contrast, our colleagues in these other professions are quite collaborative – they attend shared conferences, read each other's journals, and have shared initiatives for something they call – wait for it – "interprofessional education" (IPE). The general idea here is that health care happens in complex environments, that different professionals must communicate with each other to make it happen, and that a little training on how to do this well might help. There are many large-scale, Canadian initiatives to enhance IPE, but they are largely unknown within audiology. One great example is the Canadian Interprofessional Health Collaborative (www.cihc.ca), which offers resources to clinicians or researchers trying to effectively exchange knowledge. Have you ever been frustrated when a colleague from another profession just doesn't get what you do? Try having a look at this agency's information to gain a broader, systems-based perspective.

One strong motivator for looking at IPE initiatives is that they lead you to better information on EBP than what you will find just from within audiology. My recent introduction to this has been through Sheila Moodie's doctoral work within the UWO Health and Rehabilitation Sciences program. She is applying concepts from the field of "Knowledge Translation" to research problems in audiology. This gets into how information moves between clinicians and researchers. Let's take two examples: practice guidelines, and communities of practice. Standardized methods exist for the development and clinician appraisal of practice guidelines that are more detailed than most of us would imagine. They allow the clinicians who may use the guideline to comment upon its cost implications, feasibility, and clarity, as well as whether or not the procedures within the guideline appear to be valid. One well-accepted appraisal tool is the Agree instrument, soon to be revised to the Agree II (http://www.sign.ac.uk/methodology/agreeguide/agree/criteria.html#applic).

This type of instrument is important because it helps us to place practice guidelines in the clinical context in which they must work, rather than assuming that an evidence-based recommendation will necessarily be feasible. This collaborative mindset places a great value on the clinician's experience and judgement, and attempts to avoid a system in which the evidence is used in isolation.

Another interesting concept from the knowledge translation field is that of a "community of practice" (CoP). Generally referring to a group of like-minded clinicians (from one or more than one profession), a CoP has some agreed-upon procedures and common goals for either patient management or research collaboration. Individuals in the CoP are linked by their mutual interest, creating a community in which information exchange can occur in multiple ways. Sheila's doctoral project involves the creation of a CoP for pediatric audiology in Canada, with all the challenges of our small numbers and vast geography. She has banded together a wonderful, talented, and motivated group of clinicians who are working to pool their resources to answer questions of practice that are important to them. Even at a more local level, this type of team approach gets us out of our sound booths and talking to each other about how we practice. Do we have enough of this kind of dialogue?

BARRIER #4: ACCESS TO INFORMATION

I sometimes ask my students how they will access new information once they graduate. Typically, they haven't really thought about that. We're spoiled at the university – it is pretty easy to get our hands on just about any journal article or search engine that we need. How easy is it for most Canadian audiologists to find scientific studies that can inform practice decisions? Do we have the time? Do we have the resources? For some of the answers to that, I'll again refer you to Sheila's thesis work, as she's looking at some survey data on this. In the meantime though, can we think about the importance of routine access to at least one good peer-reviewed journal? I am a member of CAA and proud to be, but one thing that worries me is that we do not have routine subscription to a scientific journal with our memberships. We get this great magazine, with more scientific content than ever before (thanks, Marshall!). But should we consider taking that a step further? What are the long-term consequences of many Canadian audiologists having no routine access to a scientific journal? It just doesn't seem like a healthy long-term strategy for our profession as a whole.

SUMMARY

We are a high-tech profession, faced with practice change, often through technology change. Reflecting on this, how can we best manage information change? EBP practices give us one set of tools, but there are issues in implementation. Access to information is as important as the ability to factor in the source and/or strength of the information. Human capital is another major issue. With our few numbers, perhaps we need to seriously consider national strategies as much as possible, along with interdisciplinary approaches that avoid invention of wheels. I was encouraged to read about the Canadian Hearing Health Care Initiative in *Canadian Hearing Report 5-1*. Let's all support and look forward to sharing the load across our country, in this small but mighty profession.

In the News

PUMPING IT UP TOO MUCH

Many people listen to an iPod while working out; however, Bill Hodgetts, PhD, says we need to consider the listening levels on our earphones while working up a sweat at the gym.

"People generally listen to music at reasonable levels of volume, but we've found that exercising, mainly because of the background noise, can influence people to turn up the volume to potentially unsafe levels for the ear," explains Hodgetts, assistant professor, Department of Speech Pathology and Audiology, Faculty of Rehabilitation Medicine at the University of Alberta.

In his study, published in the International Journal of Audiology in December, participants listened to the same song on an iPod while resting in a quiet environment, resting in a noisy environment and while exercising on a stationary bike in a noisy environment (as if they were in a gym). Using iPod earphones, or "earbuds," the participants' listening levels were recorded and results showed that preferred listening levels increased during rest in a noisy environment to potentially dangerous levels and the addition of exercise induced even further increases.

http://www.expressnews.ualberta.ca/article.cfm?id=10748

IN CLOSING ITS DOORS AFA CLAIMS MISSION ACCOMPLISHED

Lafayette, Ind — After more than two decades spent tranforming audiology to a doctoring profession with a single unifying designator, the Audiology Foundation of America (AFA) has announced it is closing its doors.

”Our mission has always been about upgrading the profession with improved education, more autonomy and independence for practitioners, and quality care for consumers from audiology professionals,” said AFA Executive Director Susan Paarlberg. “With the number of AuDs in the profession now over 50 percent, we feel confident that time and momentum will continue to propel the profession forward. It’s a real victory for the profession.”

http://www.hearingreview.com/insider/2010-03-11_05.asp

BONE-ANCHORED HEARING AIDS HELP YOUTH WITH SINGLE-SIDED DEAFNESS

Surgically implanted hearing aids anchored to the skull bone appear to be a durable treatment option that noticeably improves hearing among children with deafness in one ear, according to a report in the February issue of Archives of Otolaryngology -- Head & Neck Surgery.

http://www.sciencedaily.com/releases/2010/02/100215174131.htm

GOOD NEWS FOR BABY BOOMERS: HEARING LOSS MAY NOT BE AS LIKELY WITH AGE

According to a recently released study at the University of Wisconsin School of Medicine of 5,275 adults born between 1902 (when wax covered tubes were the music media of the day) to 1962 (and the advent of headphones for home use), Baby Boomers are still hearing well – healthy hearing – longer than their parents did.

http://www.healthyhearing.com/articles/45443-hearing-loss-baby-boomers?utm_source=Healthy+Hearing+Newsletter&utm_campaign=44c2c0a106-HH_Update_02182010&utm_medium=email

APPLE IS NOT TO BLAME FOR HEARING LOSS CAUSED BY IPODS, RULES U.S. APPEAL COURT

A U.S. judge has ruled that Apple is not responsible for hearing loss caused by music played too loud on iPods.

The San Francisco appeal court upheld a 2008 ruling, as the company warns users of the dangers of playing music too loud.

It also reasoned that iPod users had the option to choose how loud they raise the volume.

http://www.dailymail.co.uk/sciencetech/article-1240010/Apple-blame-hearing-loss-caused-iPods-rules-U-S-appeal-court.html#

ANTIBIOTIC FOUND TO PROTECT HEARING IN MICE

A type of antibiotic that can cause hearing loss in people has been found to paradoxically protect the ears when given in extended low doses in very young mice.

The surprise finding came from researchers at Washington University School of Medicine, St Louis, who looked to see if loud noise and the antibiotic kanamycin together would produce a bigger hearing loss than either factor by itself. The results will appear in an upcoming issue of the Journal of the Association for Research in Otolaryngology.

"The protective effect of this type of antibiotic is a previously unknown phenomenon that now leads to at least a dozen important questions about what mechanisms cause hearing loss and what mechanisms could be protective," says senior author William W. Clark, PhD, professor of otolaryngology and director of the Program in Audiology and Communication Sciences, a division of CID at Washington University School of Medicine.

http://www.sciencedaily.com/releases/2010/01/100128091840.htm

Does the Vestibular System Affect What We Hear?

By Lendra Friesen, PhD, Sunnybrook Health Sciences Centre

Across cultures people move their bodies to rhythms, whether it is through drumming, singing, dancing, or rocking a baby. Musical ideas are often expressed by using movement metaphors such as "a flowing melody" or "the music is slowing down." Such observations suggest that there is a relationship between body movement and the perception of rhythm. Is there a scientific explanation for this link? Recent evidence indicates that this body movement-rhythm connection is a multisensory effort that has implications for human development. Also, through body movement, the vestibular system plays an important role in determining musical rhythm.

Rhythm is characterized by the regular recurrence of an accent or beat and is associated with movement. In music, this consists of alternations of strong and weak beats and created perceptual groupings. Musical rhythm is a part of our daily lives. For example, we experience a simple rhythm through the regularly timed movements or tempos of our legs during walking. Interestingly, the range of walking tempos and other locomotion tempos such as arm and head movements, is similar to the range of beats that humans can easily recognize acoustically (pulses separated by 300 to 900 ms).[1,2] At slower and faster tempos, it is difficult to recognize auditory patterns or rhythms. Furthermore, one's preferred auditory beat rate corresponds to human body measurements such as height and leg length which are also related to an individual's locomotion tempo,[3] suggesting a link between the cues from locomotion and auditory rhythm perception.

Body movement involves many different sensorimotor contributions, including tactile, proprioceptive, motor, and vestibular inputs. The inputs vary depending on the type of movement such as passive (no effort exerted by the participant) versus active movement, or full-body rotation versus head tilt. The tactile input serves to provide feedback on the body movement, while the motor system functions to regulate and control contractile muscle activity. The proprioceptive system is responsible for the perception of body position and movement, whereas the vestibular system controls the detection of head motion in space. This detection of head movement in space allows us to perceive or react to size, depth, or distance aspects of our surroundings and is necessary for balance and movement in day-to-day life.

Recent study results show a strong multisensory connection between body movement and auditory rhythm processing.[4] Babies were initially trained to listen to a rhythmic pattern without accented or emphasized beats. One group of infants was bounced on every second beat, while another group was bounced on every third beat. The infants were then tested for their preferences by having them listen to two different versions of the rhythmic patterns which included accents on either every second (as in a march) or third beat (as in a waltz). The pattern they listened to longer indicated their choice. Infants chose to listen longer to the auditory stimulus matching the beat accents with which they were trained. Similar results were obtained with the addition of blindfolding during training, indicating that visual information did not affect the result. A third study revealed that movement of the baby's own body is necessary for the effect. Because the vestibular system is the first system to develop in the womb, together with the observation that infants enjoy being bounced to play songs and rocked to lullabies, the authors suggest that there is a strong early vestibular-auditory interaction that is essential for the development of human musical behaviour.

While the previous study demonstrated a multisensory interaction between movement and auditory perception, it did not indicate which aspects of movement are critical to the results. Therefore, another series of experiments was designed to isolate vestibular input from motor, proprioceptive and tactile information.[5] The results suggested that vestibular input may be crucial to the multisensory interaction between movement and auditory rhythm.

Trainor and colleagues conducted another study where they provided evidence that a vestibular signal alone was sufficient for the interpretation of auditory musical rhythm. In the training phase, normal hearing adult subjects listened to stimuli with rhythm patterns that could be perceived as either a waltz (accent on every third beat), or a march (accent on every second beat).[6] Galvanic vestibular stimulation, consisting of a small current applied to electrodes on the mastoid behind the ears, was applied simultaneously on every second or every third beat of an auditory rhythm pattern containing no accented beats.

During the testing phase of the experiments, only the auditory stimuli were presented. The two auditory test stimuli were identical to the training stimuli except that the rhythm was physically accented on every second or third beat. The participant was given a task where they were asked to choose which of the two stimuli was the same as, or most similar to, the rhythm they had heard in the training phase of the experiment.

Most of the responses matched the vestibular training with the corresponding rhythm. In other words, if they were trained with the galvanic vestibular stimulation on every second beat, in the test session, they selected the stimuli physically accented on the second beat.

These studies provide evidence regarding the fundamental role that physical movement has on the perception of auditory rhythm and that this connection is mediated through the vestibular system. That there are strong auditory-vestibular connections has been established, but at what stage of development these links are formed and where in the nervous system the vestibular inputs join with auditory rhythmic experience is still unknown.

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Critical Review: Is Extended Bandwidth in Hearing Instruments Associated with Improved Auditory Skills Compared with Limited Bandwidth in the Pediatric Population?

By Kelly Flannery, M.Cl.Sc. (AUD) Candidate

About the Author

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This critical review examined the effect of an extended bandwidth signal on the improvement of auditory skills in children with hearing loss. Children are in the process of learning speech and language. Many speech sounds occur in the high frequency range.[1] Limited audibility of these high frequency sounds may cause inconsistent exposures, resulting in possible phonological delays.[2] It is important for children, especially those with hearing loss, to receive the full auditory signal. One way to provide children with more high frequency information would be to extend the bandwidth available in commercial hearing instruments.

After conducting a computerized database search, five articles were discovered that met the requirement of investigating the effects of extended bandwidth on the detection, recognition, or word learning abilities of children. Four studies used a within-group design with repeated measures, and the other study was a mixed design.

A study by Kortekaas and Stelmachowicz[3] was the only study to examine detection and clarity of word final /s/ morpheme for children and adults with normal hearing. Both detection ability and clarity ratings were measured as bandwidth was varied. For the bandwidth detection threshold, nonparametric tests showed a significant difference between all age groups. Clarity ratings only produced a significant difference for correlation between younger children and adults.

Stelmachowicz et al.[4] measured children's ability to repeat nonsense words heard in either a 5 kHz or 10 kHz bandwidth condition. A group of children with normal hearing aged 6–7 participated. Nonsense words were created and spoken by a male and female talker. A repeated measures analysis of variance (ANOVA) found a significant performance effect for the male talker ($p < .01$) and for bandwidth ($p < .001$).

The studies conducted by Pittman and colleagues[5] and Pittman[2] both examined word learning effect. Both studies had a group of normal hearing children and a group of hearing impaired children. Nonsense words were presented in 4 kHz and 9 kHz bandwidth conditions. The Pittman et al. study measured number of correct responses by the children.[5] Both the normal hearing and hearing impaired groups showed a small increase in performance as bandwidth increased. However, a univariate ANOVA indicated no significant effect of bandwidth. The Pittman study measured the number of exposures required to learn the words.[2] A univariate ANOVA showed that a bandwidth effect was present, but not for the hearing status. Children required fewer exposures to learn the new words when in the extended bandwidth condition, regardless of hearing status.

Stelmachowicz and colleagues examined the effects of bandwidth on a range of auditory skills.[6] Children participated in tasks of nonsense syllable perception, word recognition, novel word learning, and listening effort. Thirty-two children with normal hearing and 24 children with mild to moderately severe hearing loss, aged 7 to 14 years, participated in this study and were grouped according to hearing status. The percent correct score for each task was recorded. Three-way mixed ANOVA was calculated for each task. A bandwidth effect was present for the nonsense syllable perception and word recognition tasks, which are simpler and do not involve memory. Novel-word learning and listening effort did not show an effect of bandwidth.

Based on the articles discussed above, children experience benefit from listening to a wider bandwidth signal. Children with both normal hearing and hearing loss perform better when listening in an extended bandwidth condition. Even though all studies did not find a significant bandwidth effect, all studies demonstrated that children's performance improved when listening in the extended bandwidth condition.

Currently, hearing aids on the market do not provide much high frequency information. Most commercial hearing aids provide a bandwidth range of 5 to 6 kHz. However, hearing instruments that can process a wider signal should continue be developed. There are a few difficulties that may need to be resolved for the implementation of the extended bandwidth in hearing instruments. First, no studies have been conducted to determine whether children with a severe hearing loss or greater would benefit from the broader bandwidth. These children may benefit more from other strategies (e.g., frequency lowering). Second, due to the presence of standing waves, it is difficult to determine accurate real ear measurements above 4 kHz.[2] Finally, excessive loudness may occur when high frequencies are amplified. However, the children in the studies discussed above seem to appreciate hearing in the higher frequency condition. Most children with sensorineural hearing loss should be encouraged to wear these extended bandwidth hearing instruments. Not every child may find benefit from the broader signal. However, as shown in the studies, no child experiences detrimental effects from the extra high frequency information. Most children should find benefit in the use of these hearing instruments, especially in regards to skills that are important for learning language.

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Review: Clinical Application of Wideband Reflectance (WBR) in Infants, Children and Adults

By Navid Shahnaz, PhD, Aud (C)

About the Author

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In order for humans to hear, sound must pass through the external ear canal, the tympanic membrane, the middle-ear, and into the cochlea. In doing so, some of the sound is absorbed by these structures and some is reflected back out of the ear canal. Wideband reflectance (WBR), a relatively new middle-ear analysis technique, can easily quantify the absorbed and reflected sound energy in the external ear canal. Energy reflectance (ER) has been used in the evaluation of normal middle-ear function for two decades[1,2]; however, its application in clinical assessment of the middle ear has just been emerging in the literature.[3–11] ER has the advantage over tympanometry in that the location of the probe in the ear canal is not as critical, especially at higher frequencies.[12–14] Furthermore, ER compared to standard 226 Hz tympanometry may provide a more sensitive test in evaluating middle-ear disorders and conductive hearing loss.[6,7,15,16] Another advantage of reflectance measurements is that the frequency could be tested up to 10 kHz for adults and 20 kHz for infants due to small ear-canal diameter and length in young infants.[2]

Pressure reflectance R(f) obtained during ER is a complex number that is the ratio of the forward-moving (incident) pressure wave to the reflected (retrograde) pressure wave (Figure 1). ER is the square of the pressure reflectance magnitude (power reflectance $|R(f)|^2$) and varies from zero, where all sound energy is absorbed by the middle ear, to one, where all sound energy is reflected by the middle ear.[3]. Contrary to the magnitude of the impedance, the magnitude of the energy reflectance does not depend on the distance between the probe tip and the eardrum provided that loss and scatter of energy in the ear canal is minimal.[13] With middle-ear pathologies that decrease the stiffness of the middle ear, such as ossicular discontinuity and monomeric (hypermobile) tympanic membrane, ER at low frequencies is reduced (closer to zero), and with middle-ear pathologies that increase the stiffness of the middle ear, such as otosclerosis, ER at low frequencies is elevated or closer to one.[6,10] ER mean obtained from different studies are shown in Figure 2. In all these studies, the mean ER is high at low and high frequencies. It approaches its lowest value (closer to 0) around 3000 Hz.

Power-based measures such as WBR provide important information about middle ear function[2] and can explain variations in how the middle ear receives, absorbs, and transmits sound energy. The middle ear is most efficient

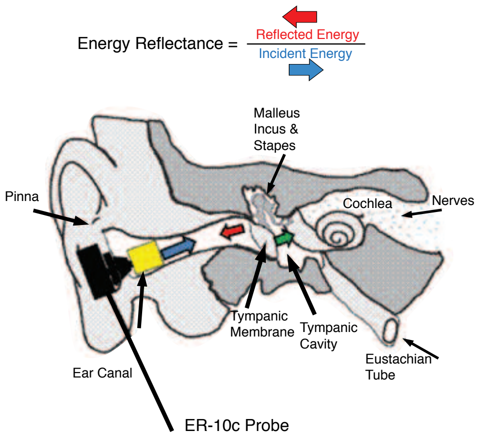

Figure 1. Energy reflectance is a ratio of reflected pressure wave over incident pressure wave. This ratio varies between 1, where all energy is reflected back by the middle ear, to 0, where all energy is absorbed by the middle ear (Modified from Voss, Moonshiram, and Horton, 2008).[18]

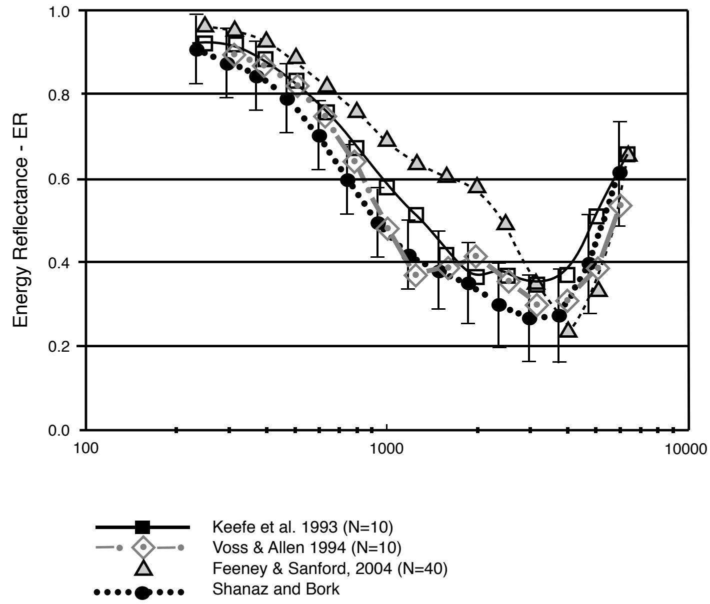

Figure 2: Comparison of group ER mean as a function of frequency between Feeney et al. (2004),[6] Keefe et al. (1993),[2] Voss and Allen (1994),[14] and the Shahnaz and Bork, 2006.[19] Vertical bars denote 1 SD.

at absorbing energy in the 2–4 kHz range.[2] Preliminary studies have shown that WBR has real potential for detection of otitis media with effusion (OME) and for prediction of conductive hearing loss in adults, children, and newborns.[8–10,15,16,20] As more research is performed to evaluate the use of WBR in clinical practice, WBR may find its way into clinical practice not only as a tool for differential diagnosis of the middle-ear pathologies but also as a good predictor of presence or absence of a conductive component. This review paper will briefly summarize the potential clinical application of WBR in newborns, children, and adults.

INSTRUMENTATION

Currently there are two available systems capable of measuring WBR. The first system, the Middle-Ear Power Analyzer (MEPA) from Mimosa Acoustics consists of an IBM-compatible laptop computer with audio data acquisition and delivering sound card for digital signal processing, a Probe Interface Cable (PIC) which connects the probe to the PC board and functions as the pre-amplifier for the probe, and an ER-10C probe (acoustical probe) with two output transducers and one input transducer (microphone). A four-cavity calibration device, which is supplied with the WBR instrument, is also required (Figure 3). The calibration procedure and the system are similar to the one described and used by Voss and Allen.[14] The MEPA system is only capable of measuring ER or related parameters at ambient pressure. The second system, is Wideband Tympanometry (Reflwin software) which is a research system developed by Douglas Keefe at Boys Town National Research Hospital and being commercialized by Interacoustics (Figure 4). Prototypes of wideband tympanometry available through Interacoustics (For more information contact Bue@Interacoustics.com) are purely a research system that consists of a personal computer, CardDeluxe sound card, AT235 impedance instrument, and Titan probe assembly. Two sets of tubes, short and long, are used for calibration of the system for adults and newborns. This system is capable of measuring ER or related parameters at ambient pressure as well as multiple pressure points (wideband reflectance tympanometry). Wideband tympanometry can also be used to conduct tympanometry as well as measuring middle-ear muscle reflex. The calibration procedure and the system are similar to the one described and used by Keefe et al[2] and Keefe and Levi.[7]

ENERGY REFLECTANCE IN NEWBORNS

Keefe and Levi[7] measured ER in normal adults, healthy 1-month and 6-month-old infants. Their results revealed a clear separation in ER between 1-month-old infants and adults for responses below 700 Hz, with infants

Figure 3. Middle-Ear Power Analyzer (MEPA3) Clinical Reflectance System from Mimosa Acoustics (Source: http://www.mimosaacoustics.com/products/mepa.html).

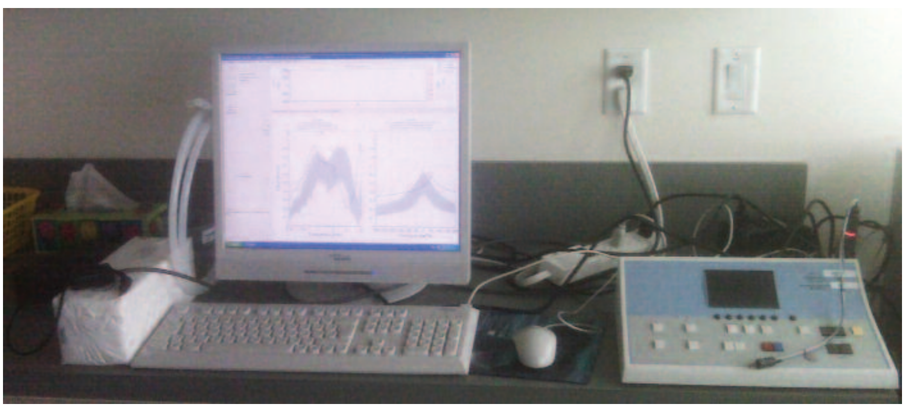

Figure 4. Wideband tympanometry (Interacoustics) setup at School of Audiology and Speech Sciences, University of British Columbia.

having lower ER values than adults. Ear-canal cross-sectional area was considered to be major contributing factor in distinguishing infant from adult responses. Keefe et al measured ER in 4,031 neonatal ears.[21] They found that left ears and female ears are acoustically stiffer than right ears and male ears, respectively. Although the air pressure is often not changed in ER measurements, the quality of recording requires a good probe seal in the ear canal. Keefe et al also noticed that ER may be sensitive to the presence of vernix and other material in the external and middle ears that clears up within the first couple of days after birth.[21] They reported that ER "shows promise providing information on the middle-ear status of neonates, which may be useful in interpreting neonatal tests for screening hearing loss."

Wideband reflectance was successfully measured in 49 ears of 26 NICU babies who passed both AABR and TEOAE screening protocols and had a normal tympanogram at 1 kHz.[9] As in Keefe and Levi,[7] there was a clear separation in ER between NICU babies and adults for responses below 727 Hz with NICU babies having lower ER values than adults (Figure 5). Keefe and Levi attributed this separation to larger energy losses in infant's ear canal.[7] There was also a clear separation at higher frequencies, adults have smaller (closer to zero) ER values compared with NICU babies. This could partly be explained by differences in the mechano-acoustical properties of the middle ear between the two age groups. The overall mass of the middle ear will be decreased post-natally due to reduction and absorption of amniotic fluid and mesenchyme. Both amniotic fluid and mesenchyme are present in the middle-ear cavity at birth and may last for several weeks after birth.[22] Mass elements control the conduction of the high-frequency response of the middle ear. Moreover, the overall maturation of the middle ear may result in an increase in mass at birth which will gradually decrease as infants become older. If overall mass of the middle ear is higher in NICU babies than adults, then more incident energy will be reflected and less will be absorbed at higher frequencies. This is consistent with ER patterns observed in NICU babies.

Shahnaz demonstrated that in most NICU babies who failed TEOAE, ER values were closer to one (most incident energy was reflected) below 3000 Hz.[9] This is consistent with ER findings in adult cases[6] and children[20] with confirmed middle-ear effusion. Case 2 (Figure 6) and 3 (Figure 7) from Shahnaz (2008)[9] are interesting cases as only the left ears failed AABR and EOAE. In both cases, the left ear passed

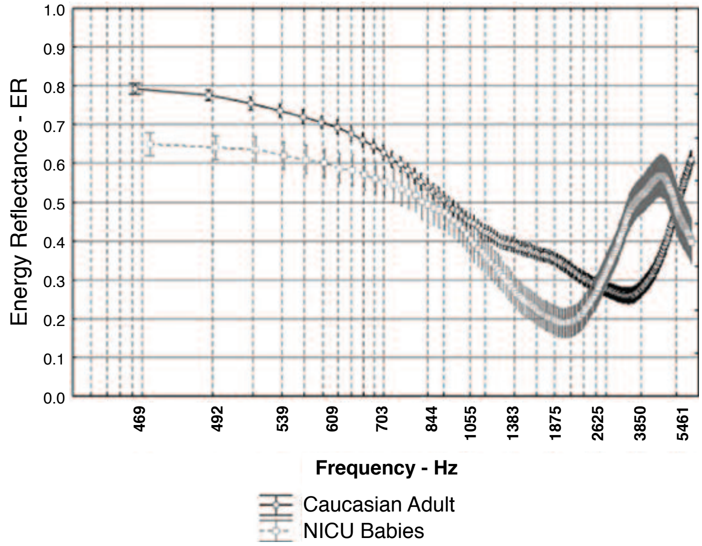

Figure 5. Energy reflectance (ER) in neonatal intensive-care unit (NICU) babies and adults. The 95% confidence interval (CI) and the mean values are shown in each group.[9]

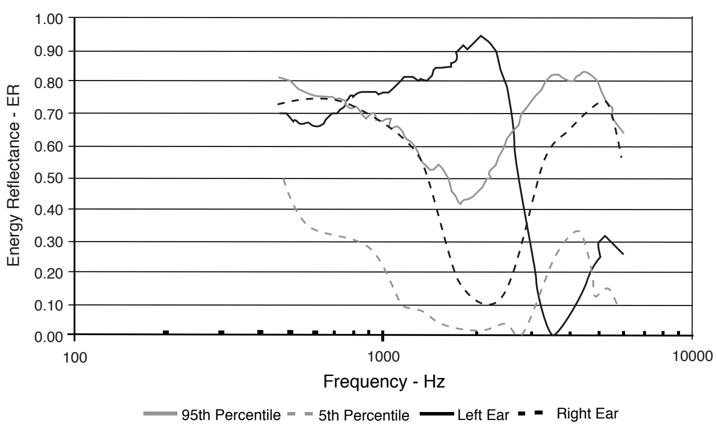

Figure 6. Energy reflectance (ER) from a neonatal intensive-care unit (NICU) baby, who referred on automated auditory brainstem response (AABR) and transient otoacoustic emission (TEOAE) screening for the left ear and passed on AABR and TEOAE for the right ear.[9]

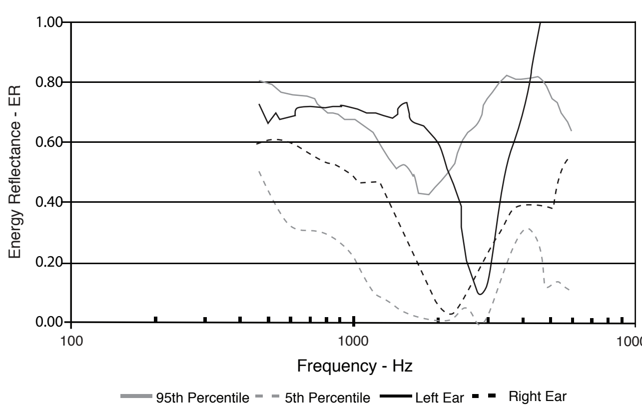

Figure 7. Energy reflectance (ER) from a neonatal intensive-care unit (NICU) baby, who referred on automated auditory brainstem response (AABR) and transient otoacoustic emission (TEOAE) screening for the left ear and passed on AABR and TEOAE for the right ear.[9]

AABR on second stage. In both cases, right ear tympanograms were normal and left ear tympanograms were abnormal at 1-kHz probe tone frequency. The ER (Figures 6 and 7) falls within normal range in the right ear in both cases. In Case 2, ER is below the 95th percentile (i.e., most incident energy has been reflected) between 750-2625 Hz and above the 5th percentile (i.e., most incident energy has been absorbed) between 3211–4711 Hz in the left ear. In Case 3, ER is below the 95th percentile (i.e., most incident energy has been reflected) between 820–2203 Hz and above 4195 Hz. Y values (Figure 6 and 7) in both cases were also within normal range in the right ear and were lower than the 5th percentile in the left ears (below 2156 Hz in Case 2 and below 2320 Hz in case 3). In both cases, the tympanograms at 1 kHz as well as ER and Y measures suggest a normal middle-ear in right ear and a middle-ear problem in the left ear.

ENERGY REFLECTANCE IN CHILDREN

Evidence suggests a useful role for ER in the diagnosis of ears with otitis media – OM.[7] Hunter et al found improved test performance of ER in correctly identifying MEE in an infant population compared to conventional and high-frequency tympanometry, with a lower incidence of inconclusive results.[23] A case study by Hunter and Margolis (1997) revealed that the presence of MEE resulted in abnormal ER when conventional tympanometry indicated normal middle ear admittance.[24] In addition to distinguishing between normal and pathological middle ears, WBR can provide information about the nature of middle ear pathology.[3] Unlike tympanometry, Piskorski et al found that WBR is able to predict conductive hearing loss.[16] The authors reported that ER between 2 and 4 kHz is a sensitive indicator of middle ear status, and is a more accurate predictor of conductive impairment at 0.5 kHz than reflectance scores at 0.5 kHz. Jeng et al used WBR to assess middle ear status in three children aged 2.5 to 5-years-old with histories of chronic OME.[20] They found that power absorption (1-ER) was reduced in the OME group compared to the control group (*n* = 15), which was most abnormal from 1 to 2.5 kHz. In a study of 17 infants and toddlers with a cleft palate, who were tested pre-palate repair and prior to myringotomy and tympanostomy surgery, average ER was significantly higher than age-matched healthy infants from 1 to 4 kHz, and the largest ER difference existed at 2 kHz.[23]

Beers et al examined WBR patterns from seventy-eight children with normal middle ear status (average age of 6.15 years) and 64 children with abnormal middle ear status (average age of 6.34 years).[25] In the early stages of middle ear pathology, from normal middle ear status to a mild degree of negative pressure, changes in energy transmission are most evident over the low frequency range (from approximately 400 to 1800 Hz), which may be attributable to the increased stiffness of the middle ear system (Figure 8). This is consistent with the findings of Margolis and colleagues who demonstrated changes in ER patterns due to induced pressure changes within the ear canal.[8] More recently, Hunter et al have shown that increased or decreased tympanometric peak pressure results in an ER increase, primarily below 1000 Hz.26

From negative middle ear pressure to effusion (Figure 8), the presence of fluid within the middle ear cavity increases the mass as well as the stiffness of the middle ear system. Because ER over the low frequency range is already minimal, the most notable increase in ER between the negative pressure and effusion conditions is over the mid to high frequency range (from approximately 1000 to 6000 Hz). The measured increase in ER at higher frequencies may be a direct result of the increased mass load on the middle ear system. This is consistent with Hunter and colleagues' findings who demonstrated a significant difference in middle ear reflectance from 1 to 4 kHz in children three days to 47 months of age with clinically defined OME.[23] Moreover, Voss et al found that variations in middle ear cavity volume can largely affect ER, especially below 1000 Hz (larger ER values, closer to 1, exist in smaller cavities).[18] This is consistent with the increase in ER found in our study for MEE group, as fluid reduces middle ear cavity volume. Data in this section suggest that ER measurements are sensitive to a range of changes in middle ear status.

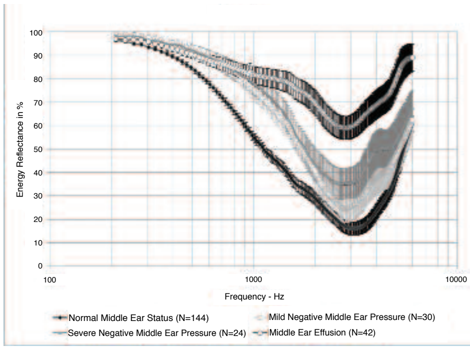

Figure 8. Mean energy reflectance as a function of frequency for different middle ear condition groups. Vertical bars denote 0.95 CI.[25]

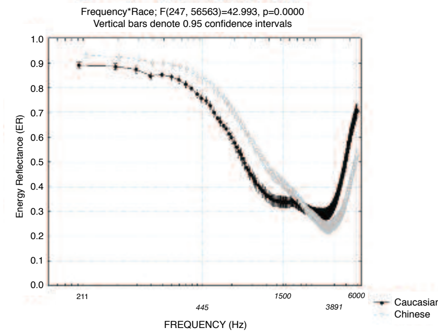

Figure 9. Mean ER as a function of frequency for Caucasian and Chinese groups. Vertical bars denote 0.95 CI.[19]

ENERGY REFLECTANCE IN ADULTS

The group ER mean for the normal Chinese and Caucasian adults is shown in Figure 9 to range from 211–6000 Hz.19 The ER ranges from 0, where all energy is absorbed by the middle-ear, to 1 where all the energy is reflected by the middle-ear. The vertical bars denote 0.95 confidence intervals (CI) in the Caucasian and the Chinese groups. In both groups the mean ER is high at low and high frequencies. It approaches its lowest value (closer to 0) around 3000 Hz. In examining energy reflectance plots from both groups (Figure 9), it seems that at lower frequencies (469–1500 Hz) the Caucasian group transferred more energy into their middle-ear system than the Chinese group; however, at higher frequencies (3891–6000 Hz) the Chinese group transferred more energy into their middle-ear system than the Caucasian group. Some of the observed differences between the two groups could be explained by potential differences in body size indices which in turn may result in differences in the size of the ear canal and middle-ear volume between the two groups. It should be noted that factors other than body size may have contributed to the observed differences. Chinese individuals may simply have different middle-ear characteristics than Caucasian individuals that could affect WBR.

Initial findings with ER in the evaluation of ears of two patients with otosclerosis have shown that below 1000 Hz the ER is higher than the 95th percentile of normal ears.[6] Allen and colleagues evaluated the acoustic transmission properties of the middle-ear system in a patient with bilateral otosclerosis.[3] It was noted that most of the energy below 0.8 kHz was reflected back into the ear canal. Shahnaz and colleagues compared ER between 62 normal hearing adults and 28 patients with surgically confirmed otosclerosis.[10] ER below 1 kHz was significantly higher in otosclerotic ears than normal ears. This indicates that most of the incident energy below 1 kHz is reflected back into the ear canal in otosclerotic ears. ER patterns exceeding the 90th percentile of the normal ears across all frequencies were able to correctly identify 82% of the otosclerotic ears while maintaining a reasonable false alarm rate. As can be seen in Figure 10, ER in four cases of surgically confirmed otosclerotic ears fell below the 95th percentile of normal adult group, that is, roughly below 1000 Hz.

Feeney et al reported ER patterns in two cases of ossicular discontinuity (one live ear and one cadaver ear). In both cases there was a sharp drop in ER value at low frequencies (< 1 k Hz).[6] Voss and colleagues measured ER patterns in four cadaver temporal bones in which incudo-stapedial joint disarticulation was surgically simulated.[18] They reported a large reduction in ER below 1200 Hz. The postoperative ER patterns in otosclerotic ears (Figure 11) are strikingly similar to these findings at low frequencies.[27] The ossicular discontinuity short circuits the stapes and cochlea from the middle ear. The total impedance of the human middle ear at lower frequencies is largely determined by the rigidity of the annular ligament.[28] Both stapedectomy and stapedotomy eliminates the contribution of the annular ligament to the total impedance of the middle ear at low frequencies; therefore, the ossicular chain and the prosthetic device with its smaller contact area can vibrate much more readily at equivalent sound pressure level at the tympanic membrane.[28] This is evident in the large and sharp reduction in the ER value at low frequencies. The reduction in ER at low frequencies is most likely reflecting a shift in the resonance of the middle ear after the surgery and the sharp nature of this reduction is consistent with a decrease in the resistance of the middle ear following the surgery. This finding is also consistent with tympanometric findings following the stapes surgery that have shown significant reduction in the resonant frequency of the middle ear.[29,30]

CONCLUSION

Incorporating ER in regular practice could potentially improve the detection of middle-ear pathologies when tympanometry may fail to do so. WBR shows promise as a clinical diagnostic tool for measuring the mechano-acoustic properties of the middle ear and the changes that result in the presence of different middle ear pathologies.

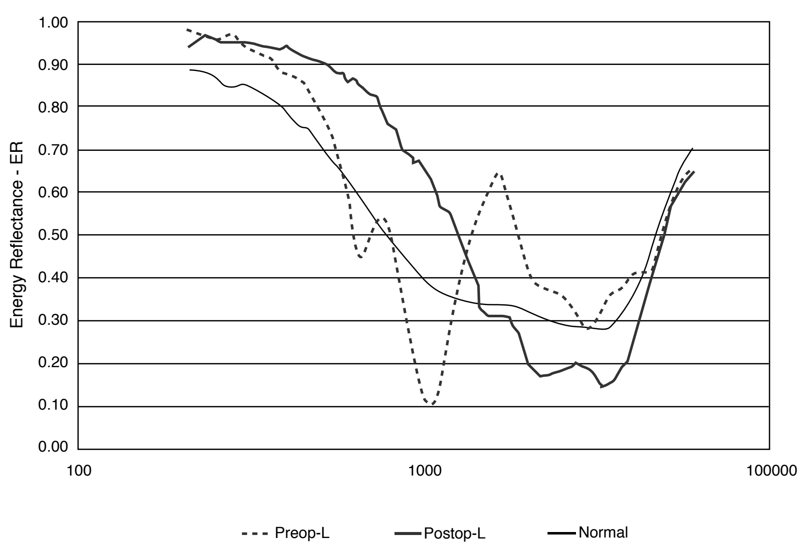

Figure 10. Mean and 90% range (5th and 95th percentiles) of ER as a function of frequency for the Caucasian group. The ER results for four Caucasians with surgically confirmed otosclerosis are plotted against the Caucasian norm.[19]

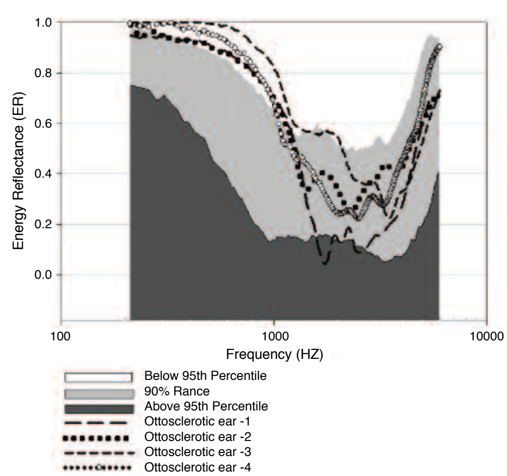

Figure 11. Energy reflectance (ER) in a 50-year-old female for operated ear (Left) before and after the stapedectomy surgery. Mean ER for a group of normal hearing adults are also shown.[27]

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Basic Concepts in Functional Hearing Assessment

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Portions of this paper are taken from a paper prepared by Sigfrid D. Soli while under contract to the Division of Behavioral and Social Sciences and Education, National Research Council, United States National Academy of Science, for the Committee on Disability Determination for Individuals with Hearing Impairment (October 2003).

DEFINITION OF FUNCTIONAL HEARING

Hearing is unique among the human senses in its ability to sustain our contact with the sound environment that surrounds us and to enable social communication through the development and use of spoken language.[1] This description captures the functional aspects of hearing in general terms. More specifically, functional hearing refers to the set of hearing abilities that enable a person to perform normally their daily activities that require hearing – especially those activities for which hearing is critical.[2]

The functional abilities that allow us to maintain contact with the sound environment include sound detection, sound recognition, and sound localization, while speech perception defines the functional hearing ability underlying social communication through spoken language. One uses these functional abilities in real-world sound environments that often include background noise. Functional hearing is best when both ears are used together binaurally. Binaural hearing is, in fact, necessary for all but the most rudimentary sound localization and plays a significant role in speech perception when communication with language takes place in background noise. Finally, functional hearing abilities may be affected significantly by hearing impairment, the use of prosthetic devices such as hearing aids and cochlear implants, and by the use of hearing protection devices.

DISTINCTION FROM DIAGNOSTIC MEASURES OF HEARING

It is important at the outset to contrast the functional aspects of hearing with the diagnostic aspects that are evaluated in clinical settings to determine the etiology, progression, and severity of hearing impairment. Diagnostic evaluations of hearing rely primarily on the audiogram, which expresses monaural pure-tone thresholds at octave frequencies from 250 Hz to 8000 Hz. While the audiogram is a highly useful clinical diagnostic tool, its relationship to the functional hearing ability in individuals with hearing impairment has been questioned on several grounds.[2,3] The audiogram is a monaural measure of peripheral auditory function, performed independently on each ear, while functional hearing is in large part a binaural ability. Likewise, the audiogram is a threshold measure taken in quiet, while functional hearing usually occurs at suprathreshold levels in the presence of background noise.

Killion and Niquette examined data from previous studies to discuss the relationship between an indicator of hearing sensitivity based on the audiogram, the pure-tone average (PTA), and a measure of functional hearing.[4] Speech perception in noise was the functional hearing ability under study and the signal-to-noise (S/N) ratio at which 50% of the speech material is repeated correctly was used as an indicator of this ability. Their objective was to determine if SNR loss, defined as an increase in the S/N ratio required for 50% correct repetition as compared to normal performance, could be predicted from audiometric results. The single most important finding in each of the studies reviewed by Killion and Niquette is the spread of 15 to 20 dB in the speech reception threshold (SRT) results for similar pure-tone averages.[4] Such results prohibit predictions of SNR loss from the audiogram, as 15 to 20 dB differences between predicted and measured values could be observed for some individuals with mild-to-moderate PTA losses.

Furthermore, the current body of research findings clearly indicates weak predictive correlations between pure-tone thresholds, no matter how they are weighted and combined, and self-reports, questionnaires, and laboratory measures of functional hearing.[3,5–8]

Most of the correlations, while statistically significant, indicate that pure-tone thresholds predict less than half of the variance in outcome measures. Stronger predictive relationships are necessary for any measure that is to be used to make decisions about individuals regarding their ability to perform hearing-critical jobs in noisy environments.

It should be noted, however, that conflicting results have been reported in the literature on the relationship between pure-tone thresholds and speech recognition in noise ability. In an attempt to resolve these conflicting results, Vermiglio re-analyzed data from previous studies using the Hearing in Noise Test (HINT).[9] They classified individuals from previous studies as either experiencing complete stimuli audibility or only partial audibility. The latter would be typical of an individual with significant high frequency hearing loss whose pure-tone thresholds in the high frequency range exceed the noise stimulus used for testing. In such a case, the test materials often are only partially available to the listener. Data re-analysis revealed that when subject samples include a greater number of individuals experiencing partial audibility, stronger relationships between pure-tone threshold averages and speech recognition in noise ability are obtained. On the other hand, weak relationships are obtained when the test materials are fully audible or accessible to the individuals (complete audibility). Conflicting results on the relationship between the audiogram and speech recognition in noise ability could therefore be attributable, at least partly, to differences in hearing status among subject samples.

EFFECTS OF HEARING IMPAIRMENT ON FUNCTIONAL HEARING

Any type of hearing impairment can impede functional hearing. Based on studies of the SRT, Plomp suggested that any hearing loss can be interpreted as the combination of two distinct components that can both contribute to decrease functional hearing: an audibility or attenuation component (Class A hearing loss) and a distortion component (Class D hearing loss).[10] The consequences of both components differ significantly; whereas the first attenuates all sounds reaching the ear, the second acts to distort these sounds. The SRT is defined as the sound pressure level of the speech at which half the speech material is correctly understood, and can be measured in both quiet and noise.

According to this conceptualization of hearing loss, the audibility component of hearing loss manifests itself mostly as an elevated SRT in quiet. The distortion component affects speech recognition in both quiet and noise. Although the SRT in quiet may be affected, the greatest manifestation of the distortion component is an elevated SRT in noise.

The four panels of Figure 1 illustrate the effects of each component, as compared to the normal function relating SRT for sentences and noise

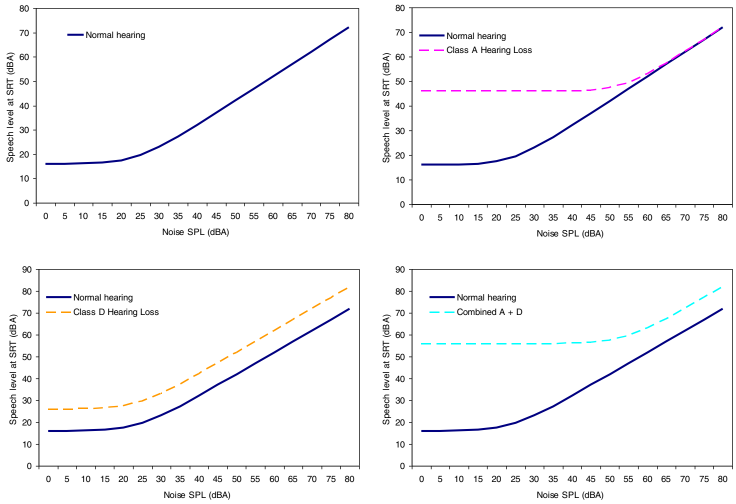

Figure 1. Speech reception threshold as a function of noise level. The right-most curve in every panel represents the normal function (Adapted from Plomp[10]).

level (the rightmost curve in every panel). These curves are based on similar curves reported by Plomp and Duquesnoy and Plomp.[10,11] As both audibility and distortion components are reflected in the vast majority of hearing losses, the bottom right panel of Figure 1 shows the combined effect of both components.

The normal performance curve (top left panel) indicates that as the level of the background noise is increased, the SRT increases by similar amounts. For example, a 20 dB increase in the noise level from 40 to 60 dB typically yields a 20 dB increase in the SRT. In a case of reduced audibility (top right panel), the SRTs in quiet and in low noise levels are elevated and remain stable until the noise level is audible and becomes the dominant factor as for normal hearing. In contrast, the distortion component (bottom left panel) elevates the SRT at all noise levels. The curve illustrating this condition is therefore shifted from the normal performance curve, in this case by approximately 10 dB. The bottom right panel reflects a more typical situation where both audibility and distortion components come into play.

As described by Plomp, the underlying source of the distortion factor remains rather vague.[10] Indeed, many factors can contribute to elevate the SRT in noise, including: the noise's spectrum, the noise's temporal fluctuations, informational masking, the noise's spatial orientation relative to the source of speech, contextual, cognitive and aging effects, reduced auditory functions (i.e., spectral and temporal resolution), as well as the contribution of visual cues to speech understanding in noise. In their review article, Houtgast and Festen summarized how various auditory and cognitive functions relate to the distortion component.[12] Typically, 70% of the observed variance in the SRT in noise can be explained with current predictive factors.

ASSESSMENT OF FUNCTIONAL HEARING: THE HEARING IN NOISE TEST

The Hearing in Noise Test (HINT) was developed by Nilsson et al.,[13] and is based on the earlier work by Plomp and colleagues on the measurement of SRTs for sentences.[14] The HINT assesses speech recognition by means of SRT measurements using an adaptive method.[15,16] Binaural measures of speech recognition are administered in quiet and in three conditions of noise: (1) noise front – NF (speech and noise in front at 0º azimuth), (2) noise right – NR (speech in front and noise at 90º to the right), and (3) noise left – NL (speech in front and noise at 90º to the left). A SRT is calculated for each HINT condition as the S/N ratio for 50% sentence. An overall score for the three noise conditions, the composite score, is determined from the following formula: [(2*NF + NR + NL)/4].

Stimuli for the HINT consist of 12 lists of 20 short sentences equated for difficulty and a 65 dBA masking noise that matches the long-term spectrum of the sentences. The HINT can be administered under headphones or in the soundfield. For soundfield administration, two loudspeakers are placed 90º apart, one meter from the centre of the listener's head. Processing of the signals by head-related transfer functions (HRTFs) allows testing with a simulated soundfield using headphones.

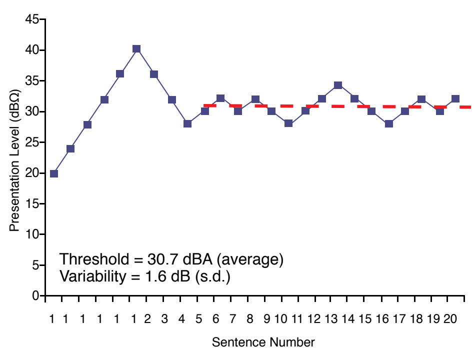

Figure 2. The HINT adaptive method for SRT measurement.

The adaptive nature of the HINT ensures its usability over a wide range of speech reception abilities and can therefore be used to evaluate individuals with normal hearing and those presenting different degrees and profiles of hearing impairment. The adaptive method used in SRT measurements is illustrated in Figure 2.

The first sentence of a 20-sentence list is presented at a level well below the suspected SRT value and is gradually increased in 4-dB steps until it is repeated correctly. Thereafter, the level of the next sentence depends on the previous response. Following a correct repetition, the level is decreased, whereas it is increased after an incorrect response. Steps of 4 dB are used for adjusting the level of the first four sentences, after which 2 dB steps are used for the remaining sentences in a list. The SRT is the level where half the sentences are repeated correctly and is computed by averaging the presentation level associated with sentences 5 to 21. Although no 21st sentence is presented, its level is known from the response to the 20th sentence.

The HINT is norm-referenced and available in 13 languages, with additional languages currently under development.[16] The test is useful for documenting threshold and supra-thresholds speech communication abilities, with particular focus on binaural listening.

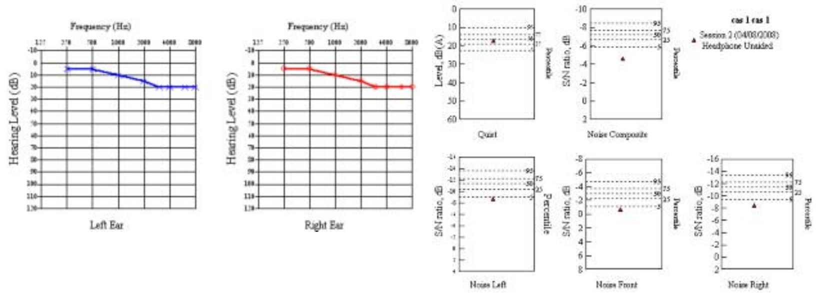

Figure 3. Air conduction pure-tone audiometry and HINT results for a French-speaking individual with audiometrically normal hearing.

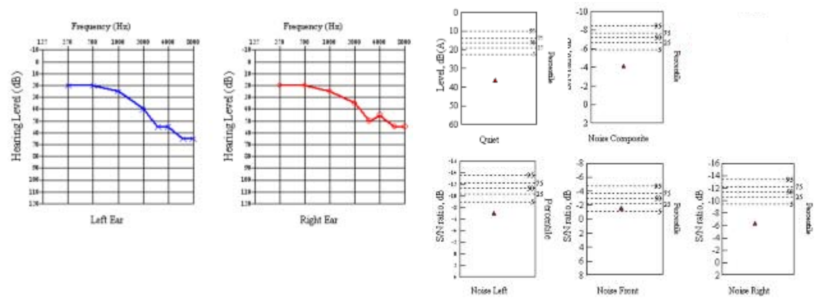

Figure 4. Air conduction pure-tone audiometry and HINT results for a French-speaking individual with moderate to moderately severe high-frequency hearing loss.

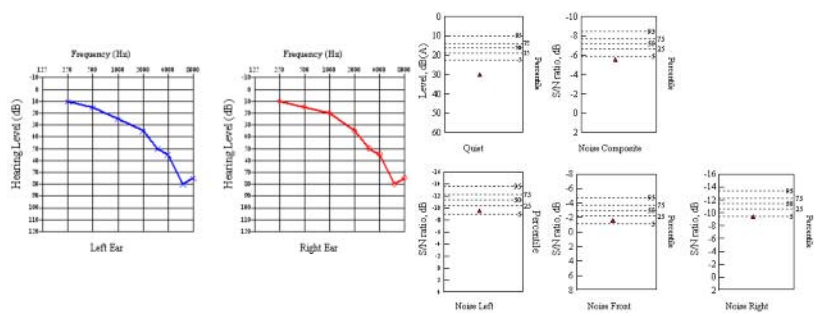

Figure 5. Air conduction pure tone audiometry and HINT results for a French-speaking individual with moderate to severe high-frequency hearing loss.

Average HINT values indicate that speech is more intelligible when spatial separation of the speech and noise prevails (noise side vs. noise front). Indeed, a 6–10 dB SRT improvement can be noted in normal hearing listeners when speech is spatially separated from the noise source by 90°, emphasizing the importance of binaural hearing for speech recognition in noise.[16–18]

Figures 3 to 8 show example results of SRT measurements using the HINT protocol. The left panel in each figure displays the individual's air conduction pure-tone thresholds for the right ("O") and left ("X") ears, whereas the right panel shows the HINT results (triangles) relative to average SRT values for sentences, a measure also referred to as reception threshold for speech (RTS). The graph also displays the average SRT value (mean), as well as 90% (5th and 95th percentiles) of the results obtained with normally hearing French-speaking young adults.

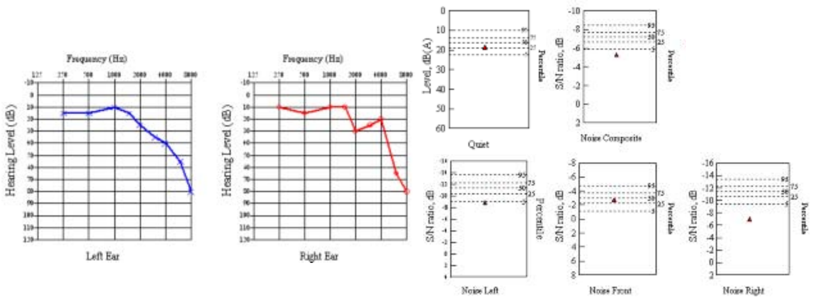

Figure 6. Air conduction pure-tone audiometry and HINT results for a French-speaking individual with an asymmetric hearing loss.

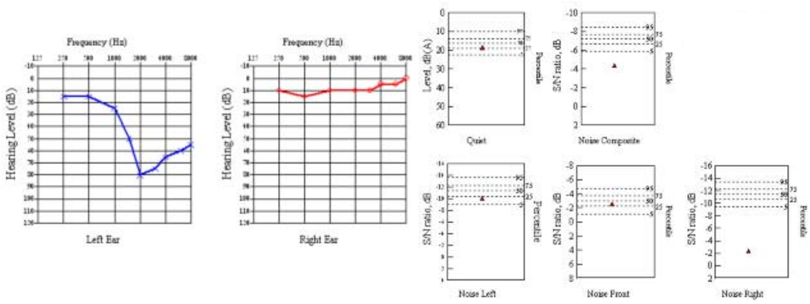

Figure 7. Air conduction pure-tone audiometry and HINT results for a French-speaking individual with a unilateral hearing loss.

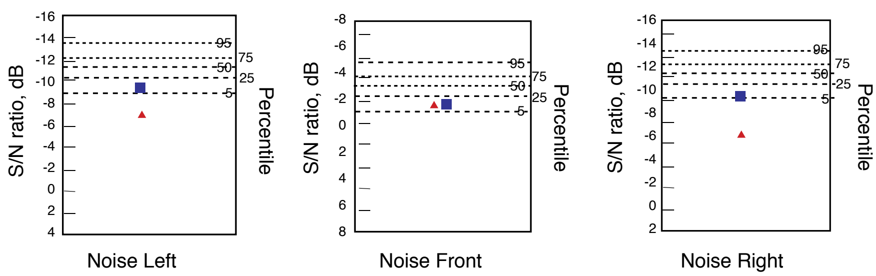

Figure 8. Aided HINT results for a French-speaking individual with bilateral, symmetric hearing loss. The triangles represent scores obtained with the individual's previous hearing aids, whereas the squares represent aided scores with new hearing aids.

Although most would expect an individual with normal pure-tone thresholds to have normal functional hearing abilities, this is not always the case. Exceptions do occur, such as illustrated in Figure 3. Despite normal pure-tone thresholds and normal speech reception abilities in quiet, an elevated SRT is noted in all three noise conditions of the HINT for this individual. Figures 4 and 5 show the results of two individuals with high-frequency hearing loss. The individual in Figure 5 presents a more severe degree of hearing loss in the high frequencies. Nevertheless, this individual displays near normal SRTs for all noise conditions of the HINT, whereas elevated SRTs are noted in two out of the three noise conditions in the individual with a lesser degree of high-frequency hearing loss (Figure 4). Such results can be surprising, as most of us would generally associate poorer speech recognition in noise with greater hearing loss in the high frequency range when hearing in the low frequencies is relatively the same in both individuals. Figures 6 and 7 demonstrate the need to test in noise originating from various positions relative to the listener and the speech source, rather than limiting the assessment of speech reception abilities to quiet conditions or to a single noise condition such as Noise Front. Both individuals show normal SRT values in quiet but elevated SRT values in some or all noise conditions. Testing in noise therefore provides the evaluator additional, valuable information.

Figure 8 shows another use of the HINT where an individual's speech reception abilities in noise were evaluated using his/her previous hearing aids and while trying new hearing aids. By performing speech testing in a single noise condition such as Noise Front, no benefit would have been demonstrated by the new hearing aids since the SRT remained unchanged. With speech testing in additional noise conditions, the added value of the new hearing aids could be easily demonstrated and explained to the patient.

Although the HINT is described in this paper, other speech in noise tests are available and useful to quantify hearing in noise difficulties in particular situations (e.g., low versus high context, fluctuating noise), by comparing an individual's performance to that achieved by normal hearing individuals under the same conditions.

ESTIMATION OF HEARING DISADVANTAGE FROM FUNCTIONAL HEARING ASSESSMENT

Hearing disadvantage can be estimated from assessments of functional hearing. Indeed, a hearing disadvantage results when a difference in speech recognition performance is noted between a given individual and normal hearing counterparts. Figures 9 to 11 illustrate how a deviation in the SRT from normative values can lead to a hearing disadvantage.

Figure 9 shows the function relating speech recognition and level of background noise for normal hearing individuals. Here, the talker is assumed to adjust their speech level as a function of the background noise levels according to data from Pearson's model.[18] Speech recognition remains high (100%) until background noise levels reach approximately 80 dBA, after which point it decreases with further increases in noise levels. Speech recognition initially remains high despite increases in interfering noise levels. This can be explained by the fact that individuals tend to increase their vocal effort to compensate for increases in background noise levels in order to maximize the speech signal. This compensation is, however, limited by the maximum vocal effort that can be exerted by the talker. When further increases in speech levels are no longer possible, speech recognition decreases with increasing background noise levels. As speech recognition starts to be affected by noise, individuals will begin to experience difficulties understanding speech. To define the region of difficulty for normal hearing individuals, a 5% drop in speech recognition was used as a criterion.

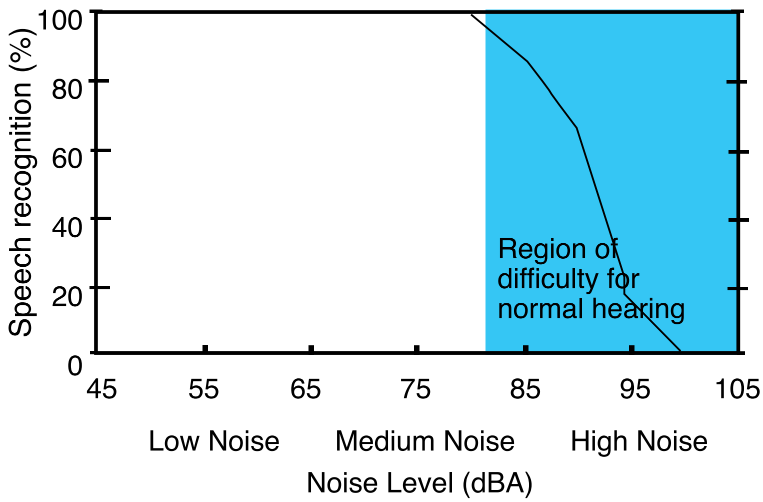

Figure 9. Functional hearing ability and region of difficulty for individuals with normal hearing (from Soli 2003).[2]

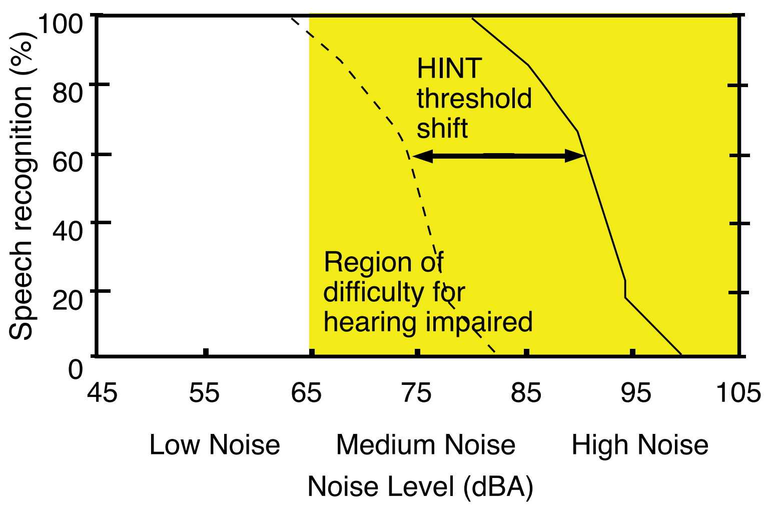

Figure 10. Functional hearing ability and region of difficulty for a given individual with hearing impairment.

Hearing impairment can elevate SRTs above normative values. One manifestation of such an elevation in SRT is illustrated in Figure 10. The dotted line represents the function relating speech recognition and background noise levels for an individual with a given degree of hearing impairment. This function is shifted to the left from the normal function (solid line) by an amount equivalent to the deviation of the individual's HINT score from the normative value. As a consequence, the individual with hearing impairment will begin to experience difficulties in understanding speech at lower levels of background noise than individuals with normal hearing, as noted by the drop in speech recognition as the noise levels increase beyond 65 dBA. Higher degrees of hearing impairment will shift the speech recognition curve to the left

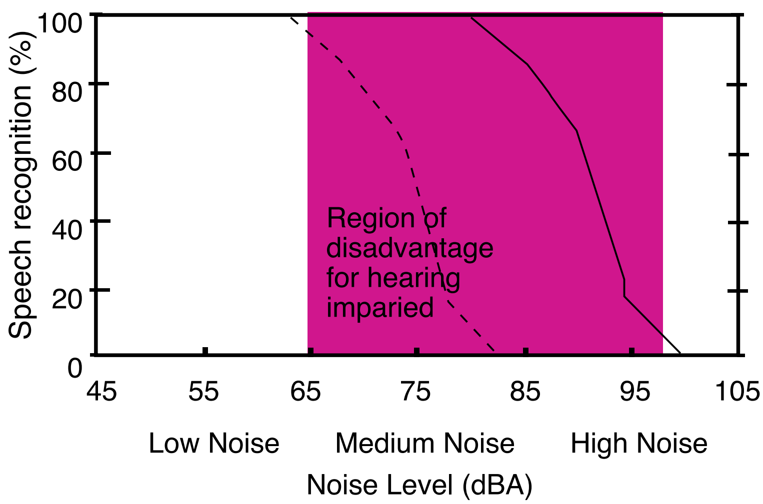

Figure 11. Hearing disadvantage for a given individual with hearing impairment.

by greater amounts and result in difficulties understanding speech at yet lower levels of background noise.

As mentioned above, a hearing disadvantage exists when a difference in speech recognition performance is noted between a given individual and normal hearing counterparts. A 5% difference in performance between the individual and normal hearing counterparts was used in Figure 11 to characterize the region of disadvantage for the given individual, although other criteria could be used.

In background noise levels between approximately 65 dBA and 98 dBA, the individual with hearing impairment experiences greater difficulty understanding speech compared to individuals with normal hearing, with a difference of at least 5% in performance, albeit the difference is generally greater in midrange level values (for example, there approximately a 80% difference in performance at 85 dBA in this particular situation, illustrated in Figure 11). It can therefore be said that a hearing disadvantage exists for the hearing impaired individual for those levels of noise (65–98 dBA). In contrast, higher noise levels will bring forth similar difficulties for both the individual with hearing impairment and with normal hearing, while low noise levels will not cause difficulties for neither individuals.

CONCLUSION

The audiogram is a poor predictor of functional hearing abilities. As such, it is important to measure and document hearing abilities (other than pure-tone sensitivity) used daily during leisure and workplace activities, thereby allowing a better identification of potential situations of handicap and/or hearing disadvantage.

The Hearing in Noise Test is a useful tool in assessing speech reception in noise, although other speech in noise tests can be used. It has recently been used to predict performance in hearing-critical tasks carried out in various noisy environments of the Department of Fisheries and Oceans Canada (DFO).[3] In future applications, it could be used to predict performance in a variety of daily activities performed in noisy settings.

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Infection Control

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From the ancient smallpox upsurge and bubonic plague to the evolution of antimicrobial resistant organisms such as methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE), and to the more recent, unanticipated appearance of H1N1 flu (swine flu), disease outbreaks have exemplified the human body's vulnerability to communicable disease. This was most profoundly demonstrated during the early 1980s with the emergence of acquired immunodeficiency syndrome (AIDS) and the subsequent discovery of the human immunodeficiency virus (HIV). Consequently, the concept of infection control became a pressing issue, leading to the development of recommendations along with federally mandated guidelines specifically designed to minimize the spread of disease.[1] As defined by Bankaitis and Kemp,[2,3] and Bankaitis et al,[4] infection control refers to the conscious management of the environment for the specific purposes of minimizing or eliminating the potential spread of disease, regardless of how remote the possibility may be perceived. The definition of infection control is relatively straightforward; however, as a conscious process, it requires clinicians to stop and think through procedures that have otherwise become so second-nature in order to determine if and how the procedures must be modified for purposes of achieving objectives associated with infection control initiatives. Unfortunately, this may lead audiologists down a path of frustration whereby infection control principles are either over-analyzed resulting in unrealistic and/or exaggerated implementation of necessary protocols, or completely dismissed since the path of least resistance would involve completely abandoning infection control efforts. To minimize potential frustrations inherently to implementing infection control principles in the clinical environment, the purpose of this article is to provide practical information relating to infection control standard precaution applications in the audiology and/or dispensing environment.

REGULATORY AGENCIES ASSOCIATED WITH INFECTION CONTROL POLICY

Infection control guidelines and mandates have been issued by a variety of worldwide governing bodies and agencies whereby adherence to established guidelines are expected and/or legally required.[1] In the United States, several different agencies oversee various aspects of infection control. For example, the Centers for Disease Control and Prevention (CDC) is the federal epidemiological agency whose mission is to compile and disseminate information related to health promotion, prevention of disease, and preparedness for new health threats.[5] The CDC works with other federal agencies in the United States including the Occupational Safety and Health Administration (OSHA), an entity responsible for overseeing and enforcing established federal standards related to workplace safety including infection control.

Throughout Canada, the Public Health Agency of Canada (PHAC) represents the agency comparable to the CDC in the United States; the role of this agency is to promote health, prevent and control chronic and infectious disease, and to prepare for and respond to public health emergencies.[6] Similarly, regulatory oversight for occupational health and safety in Canada, including infection control, resides across federal, provincial, and territorial governments.[7] On a more global scale, the World Health Organization (WHO) represents a specialized agency of the United Nations (UN) and serves as a coordinating authority as it pertains to international public health, including the issuance of its own infection control guidelines.[8] Certainly, each country will be obligated to abide by the specific infection control requirements mandated by authorized governing bodies. The scope of this article is to focus on a handful of infection control principles universally recognized by these governing bodies as critical and to apply the intention of the principle directly to audiology.

STANDARD PRECAUTIONS

Basic infection control precautions are grouped into a category of safety measures referred to as standard precautions. Standard precautions represent an extension of the original universal blood and blood borne pathogen precautions, more commonly referred to as "universal precautions," issued by the CDC in 1987.[9] Whereas universal precautions were formalized to protect health care workers from blood and blood borne pathogens, standard precautions expanded universal precautions to include all potentially infectious substances beyond blood including body fluids, secretions, excretions, non-intact skin, and mucous membranes. Furthermore, standard precautions are to be applied to all patients at all times, regardless of diagnosis or infection status since the notion of treating all patients with the same basic standard precautionary level represents an essential element of patient care (WHO, 2004).[10] Specifically, standard precautions include the following:

Hand hygiene;

- Use of personal protective equipment when handling blood, body substances, excretions, and secretions;
- Appropriate handling of patient care equipment;
- Prevention of needlestick/sharp injuries;
- Environmental cleaning and spills-management; and
- Appropriate handling of waste.

The standard precautions listed above are relatively straightforward. While each safety measure represents a critical aspect of infection control, the importance of hand hygiene must not be minimized.

Hand Hygiene

Currently, hand hygiene is considered the most important measure for preventing the spread of disease.[11–13] Normal skin is colonized by both resident and transient microbial forms on superficial layers of hand surfaces.[14] Resident microbes include those considered part of the normal skin surface flora such as various types of Staphylococcus (e.g., ***S. epidermis, S. hominis***), coryneform bacteria, and some fungi.[15] Transient forms also reside on skin surfaces however these microorganisms are not necessarily a component of normal skin flora. These microbial forms accumulate as a result of direct and indirect contact with patients, objects, and/or contaminated surfaces.[13] For instance, inadvertently touching an infected or draining ear with bare hands directly transfers pathogens onto the finger tips, fingers, and/or palms of the clinician. While this particular example represents an obvious case whereby hands may come in contact with transient microorganisms, it is important to note that equally pathogenic microorganisms may accumulate on hand surfaces from touching normal and intact skin of healthy patients.[16] Similarly, handling contaminated objects such as hearing instruments, earmolds, and used immitance tips will lead to a similar degree of microbial transfer. Furthermore, studies have illustrated the viability for these microorganisms to survive on hands.[17] As such, hand hygiene remains and important measure in minimizing the potential spread of disease.

Over the past several decades, various public health agencies have published hand washing or hand hygiene recommendations and guidelines.[12,13,18] Initial techniques recommended washing hands with soap and water for one to two minutes before and after patient contacts with the use of no-rinse hand de-germers (i.e., antiseptic agents) reserved for instances of emergencies or situations where access to a sink with running water was not available.[18] Over time, the role of hand de-germers expanded beyond worst-case-scenario situations, emerging as a recognized hand hygiene technique. For example, in the United States, the CDC in conjunction with the Healthcare Infection Control Practices Advisory Committee (HICPAC) issued updated hand washing guidelines in 2002 that identified alcohol-based hand de-germers as the standard of care as it pertains to hand hygiene practices in health care settings.[11] According to the WHO (2005),[12] alcohol-based hand rubs represent the preferred model for routine hand hygiene in clinical situations where ***hands are not visibly soiled***.

Indications for Hand Hygiene

Specifically, the WHO has outlined indications for hand washing (i.e., soap and water only) and hand hygiene (soap and water or no-rinse hand de-germers). Hands must be specifically washed with soap and water when any one of the following conditions is met:

1. Hands visibly dirty
2. Hands visibly contaminated with proteinaceous material
3. Hands visibly soiled with blood or other body fluids
4. Exposure to potential spore-forming organisms strongly suspected or proven
5. After using the restroom

Furthermore, hand hygiene must be performed in each of the following instances:

1. Before and after having direct contact with patients
2. After removing gloves
3. Before handling an invasive device (regardless of whether or not gloves are used) for patient care
4. After contact with body fluids or excretions, mucous membranes, non-intact skin, or wound dressing (only if hands are not visibly soiled)
5. If moving from contaminated body site to a clean body site during patient care
6. After contact with inanimate objects (including medical equipment) in the immediate vicinity of the patients
7. Prior to handling medication
8. Prior to preparing food[11]

In the case of hand-hygiene, the use of either traditional soap and water, or no-rinse hand de-germers may be used in each instance with a preference cited by the WHO toward no-rinse hand de-germers.

Hand Hygiene Technique

Proper hand washing techniques using soap and water, or no-rinse hand de-germers have been reviewed in various publications within the hearing industry.[2,3] With the relatively recent endorsement of no-rinse hand de-germers as a recognized hand hygiene technique along with the tendency for various public health authorities to express preference in the use of such products over traditional hand washing techniques when appropriate,[11] illustration of recommended hand hygiene technique is beneficial. As shown in Figures 1 through 7, once an appropriate amount of de-germer is dispensed into the palm of one hand, the solution must be adequately rubbed across hand surfaces and in-between fingers for approximately 30 seconds, until the hands are dry.

Personal Protective Equipment

Personal protective equipment encompasses a range of items designed to protect clinicians from bodily fluids, secretions, excretions, and other

Figure 1. Illustration of appropriate hand-hygiene technique using no-rinse hand de-germer as recommended by World Health Organization.[11] First, apply necessary amount of product in hand.

Figure 2. Second, rub hands palm to palm.

Figure 3. Next, rub in between fingers with right palm over backside of left hand, interlacing fingers. Repeat for the other hand.

Figure 4. Then rub palm to palm with fingers interlaced.

Figure 5. Now you can do the back of fingers to opposing palms with fingers interlocked.

Figure 6. Finally, rub thumb of one hand clasped in the palm of the opposite hand. Repeat with the other thumb.

Figure 7. Once the hands are dry of product, hand hygiene procedures have been successfully complete.

potential contaminants; and includes but is not limited to gloves, masks, eye protection, gowns, and hair and shoe covers. Personal protective equipment reduces the risk of spreading disease; however, its application is not foolproof; clinicians must continue to adhere to basic infection control measures such as hand hygiene even when personal protective equipment is used effectively and correctly.[10] With regard to the audiology and/or dispensing clinic, gloves represent the most relevant personal protective equipment.

Indications for Glove Use

As outlined by the WHO, indications for glove and other personal protective equipment depends on the task at hand and the associated risk of exposure. With that in mind, gloves must be worn when touching blood, body fluids, secretions, excretions, mucous membranes, and/or nonintact skin (WHO, 2004).[10] Hearing instruments, earmolds, and other objects inserted and removed from the ear canal will become contaminated with cerumen, and unless specific precautions are taken to clean and disinfect surfaces prior to handling with bare hands, gloves should be worn prior to personally handling such instruments or objects. Cerumen is a bodily substance and considered potentially infectious when contaminated with blood, dried blood, blood byproducts, mucus, or ear drainage.[19] Given the colour and viscosity of cerumen, it is not possible to determine with 100% visual accuracy whether or not cerumen is contaminated; as such, it must be treated as a potentially infectious bodily substance.[20] Furthermore, several recent studies have documented the presence of bacterial and fungal growth on both hearing instrument and earmold surfaces.[21,22] The microbial composition recovered from these surfaces did include bacterial and fungal growth typical of normal ear canal flora; however, most of the recovered microorganisms were not consistent with ear canal flora.[20] A handful of microorganisms recovered from hearing aid surfaces included extremely virulent bacteria or fungi (i.e., *S. aureus, Pseudomonas aeruginosa*) while other recovered pathogens were exceptionally unhygienic.[23] Specifically, some hearing instruments were contaminated with light to heavy amounts of a bacterium (enterococci) specifically found in fecal matter.[22] From this perspective, clinicians must be diligent in their infection control practices when handling various objects, including hearing instruments, in the clinic.

Handling Patient Care Equipment

As outlined in the WHO's practical guidelines for infection control in health care facilities,[10] reusable equipment must be cleaned and reprocessed prior to reuse. This recommendation remains vague; whereby "cleaning" represents a well defined term, the term "reprocessing" may be interpreted in multiple ways that may or may not be appropriate. As such, reliance on requirements outlined by the CDC in the United States as it relates to cleaning, disinfecting, and sterilizing may be more appropriate to consider.

Cleaning, Disinfecting, and Sterilizing

Cleaning involves the removal of gross contamination from surfaces without necessarily killing germs.[2,3,20] It is a critical prerequisite to disinfecting and sterilizing; in other words, objects must first be cleaned prior to disinfection or sterilization. By definition, disinfection refers to a process in which germs are killed with the degree of germ-killing directly related to the specific product used. Finally, sterilization involves killing 100% of vegetative microorganisms, including associated endospores.[2,3,20] Whereas disinfection may kill some germs, sterilization, by definition, kills all germs and associated endospores each and every time.

Indications for Disinfecting versus Sterilizing

Once an item has been cleaned, it will be necessary to either disinfect or to sterilize the object. Whether to disinfect or to sterilize a reusable object will depend on the intended use of the object or instrument. The process of disinfection is appropriate for those objects and surfaces that do not make contact with blood or other potentially infectious substances.[20] Examples include the arm rests of the chair in the audiometric booth, horizontal surfaces such as counselling tables and/or work surfaces in the patient care room, and loaner assistive listening devices (excluding components that require insertion into the ear canal) – these items should be cleaned and disinfected prior to reuse. In contrast, reusable objects or instruments introduced directly into the bloodstream (i.e., needles), or that come in contact with intact mucous membranes or bodily substances (blood, saliva, mucous discharge, pus), or that can penetrate the skin from use and/or misuse must be cleaned and then sterilized prior to reuse.[2,3] In other words, reusable items that come in contact with cerumen and are intended to be re-used with multiple patients should be cleaned and then sterilized, including but not limited to immittance probes, reusable specula, curettes used for cerumen removal, and/or tools used to clean hearing aid ports.[20]

There are several different sterilization techniques although audiology and hearing instrument dispensing clinics are mainly limited to utilizing cold sterilization techniques since reusable rubber, silicone, plastic, and acrylic objects will not withstand traditional heat pressurization associated with sterilization techniques.[1] Cold sterilization involves soaking instruments in approved liquid chemicals (sterilants) for a specified number of hours. In the United States, only two ingredients have been approved as sterilants: (1) 2% or higher concentrations of glutaraldehyde, and (2) 7.5% or higher concentrations of hydrogen peroxide.

Prevention of Needlesticks/Sharp Injuries

Clinicians must exhibit caution when handling sharp instruments. Within the confines of the audiology or dispensing environment, care must be used when handling scalpel blades and/or razors. Sharp instruments must not be thrown away in the regular waste; rather, these types of instruments or objects must be disposed of in puncture-resistant, disposable containers more commonly known as sharps containers. Ideally, the sharps container should be located where these items are used until final disposal.[1]

Environment Cleaning and Spills Management

As outlined in the section addressing the handling of patient care equipment, horizontal surfaces residing in patient care rooms should be cleaned and disinfected after each patient appointment. Furthermore, routine cleaning and disinfection of environmental or other frequently touched surfaces should occur.[10] Finally, steps should be proactively outlined as what should be done in the event that an accident occurs and individuals are exposed to bloodborne pathogens or other potentially infectious agents. This includes addressing potential patient accidents (i.e., patient falling, getting a nosebleed, or someone getting sick and vomiting) such that every staff member knows how to appropriately handle the situation with regards to following necessary infection control protocols.

Appropriate Handling of Waste

Safe management of waste involves treating contaminated waste appropriately. Within the context of the audiology or hearing aid clinic, items contaminated with blood, blood byproducts, mucous, discharge, or cerumen may be disposed of in regular waste receptacles; however, in the event the item is contaminated with copious amounts of any of these substances, it should first be placed in a separate, impermeable bio-hazard bag and only then discarded in the regular trash.[2,3] This practice will separate the contaminated waste from the rest of the trash, minimizing risk of maintenance or cleaning personnel to come in direct contact with such material.[1]

CONCLUSION

Healthcare professionals involved in the delivery of audiological and/or hearing aid services routinely execute procedures associated with some risk of exposure to bodily fluids including blood, blood byproducts, saliva, and cerumen. These associated risks may be significantly minimized with the implementation and execution of appropriate infection control protocols as outlined by the standard precautions.

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