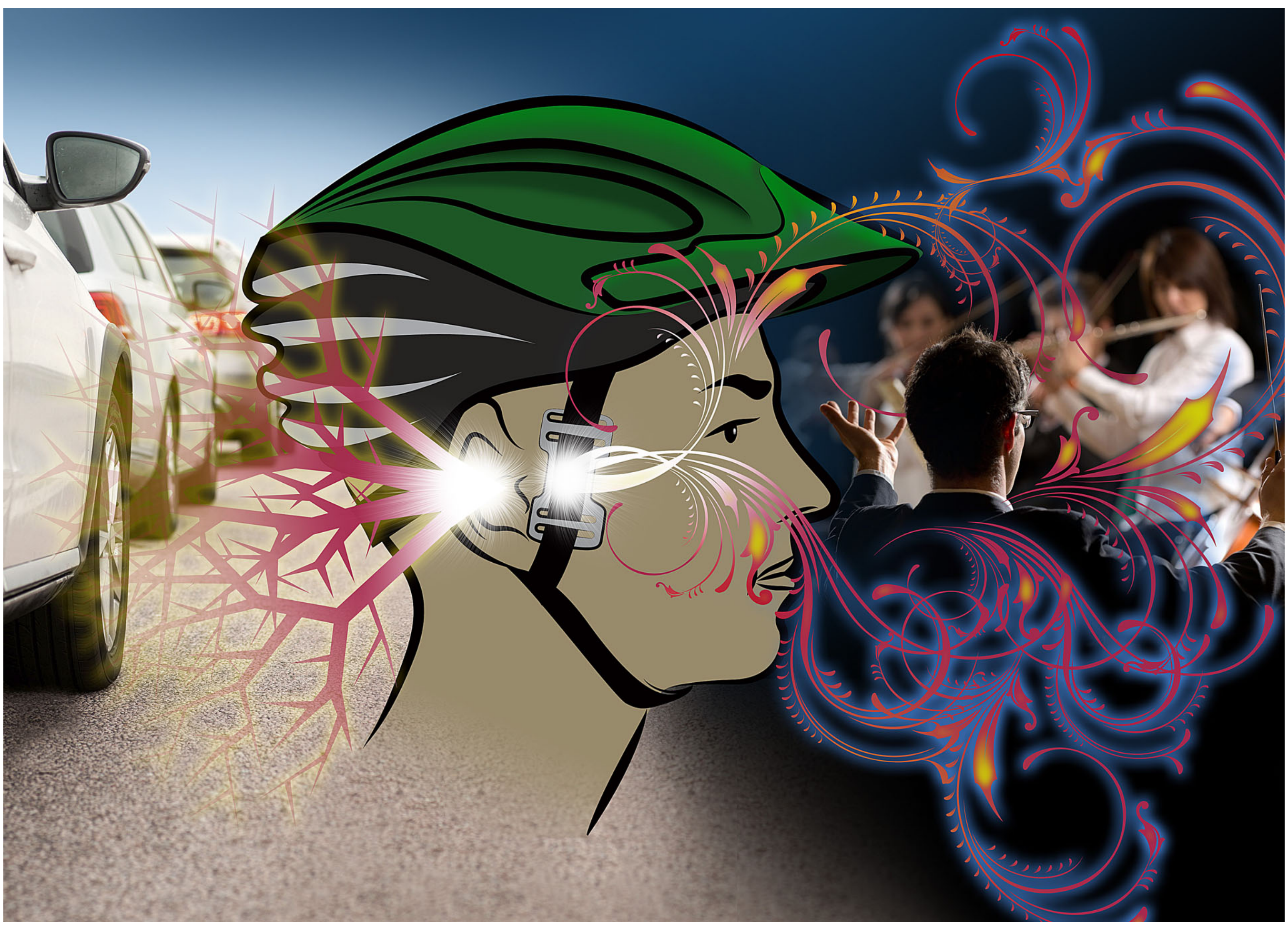
ISSN 0711-6659

canadian acoustics
acoustique canadienne

Journal of the Canadian Acoustical Association - Revue de l'Association canadienne d'acoustique

MARCH 2016 MARS 2016
Volume 44 - - Number 1 Volume 44 - - Numéro 1



canadian acoustics

acoustique canadienne

Canadian Acoustical Association/Association Canadienne d'Acoustique P.B. 74068 Ottawa, Ontario, K1M 2H9

Association canadienne d'acoustique B.P. 74068 Ottawa, Ontario, K1M 2H9

Canadian Acoustics publishes refereed articles and news items on all aspects of acoustics and vibration. Articles reporting new research or applications, as well as review or tutorial papers and shorter technical notes are welcomed, in English or in French. Submissions should be sent only through the journal online submission system. Complete instructions to authors concerning the required "camera-ready" manuscript are provided within the journal online submission system.

L'Acoustique Canadienne publie des articles arbitrés et des informations sur tous les aspects de l'acoustique et des vibrations. Les informations portent sur la recherche, les ouvrages sous forme de revues, les nouvelles, l'emploi, les nouveaux produits, les activités, etc. Des articles concernant des résultats inédits ou des applications ainsi que les articles de synthèse ou d'initiation, en français ou en anglais, sont les bienvenus.

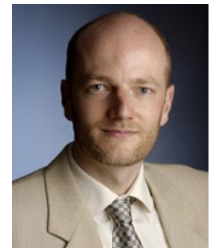
Canadian Acoustics is published four times a year - in March, June, September and December. This quarterly journal is free to individual members of the Canadian Acoustical Association (CAA) and institutional subscribers. Canadian Acoustics publishes refereed articles and news items on all aspects of acoustics and vibration. It also includes information on research, reviews, news, employment, new products, activities, discussions, etc. Papers reporting new results and applications, as well as review or tutorial papers and shorter research notes are welcomed, in English or in French.The Canadian Acoustical Association selected Paypal as its preferred system for the online payment of your subscription fees. Paypal supports a wide range of payment methods (Visa, Mastercard, Amex, Bank account, etc.) and does not requires you to have already an account with them. If you still want to proceed with a manual payment of your subscription fee, please use the application form from the CAA website and send it along with your cheque or money order to the secretary of the Association (see address above). - Canadian Acoustical Association/Association Canadienne d'Acoustique P.B. 74068 Ottawa, Ontario K1M 2H9 Canada - - - secretary@caa-aca.ca - Dr. Roberto Racca

Acoustique canadienne est publié quantre fois par an, en mars, juin, septembre et décembre. Cette revue trimestrielle est envoyée gratuitement aux membres individuels de l'Association canadienne d'acoustique (ACA) et aux abonnés institutionnels. L'Acoustique canadienne publie des articles arbitrés et des rubriques sur tous les aspects de l'acoustique et des vibrations. Ceci comprend la recherche, les recensions des travaux, les nouvelles, les offres d'emploi, les nouveaux produits, les activités, etc. Les articles concernant les résultats inédits ou les applications de l'acoustique ainsi que les articles de synthèse, les tutoriels et les exposées techniques, en français ou en anglais, sont les bienvenus.L'Association canadienne d'acoustique a sélectionné Paypal comme solution pratique pour le paiement en ligne de vos frais d'abonnement. Paypal prend en charge un large éventail de méthodes de paiement (Visa, Mastercard, Amex, compte bancaire, etc) et ne nécessite pas que vous ayez déjà un compte avec eux. Si vous désirez procéder à un paiement par chèque de votre abonnement, merci d'utiliser le formulaire d'adhésion du site de l'ACA et de retourner ce dernier avec votre chèque ou mandat au secrétaire de l'association (voir adresse ci-dessus). - Canadian Acoustical Association/Association Canadienne d'Acoustique P.B. 74068 Ottawa, Ontario K1M 2H9 Canada - - - secretary@caa-aca.ca - Dr. Roberto Racca

Contents - Table des matières

For Digital Recorders
Introducing
For USB A/D Systems
PHANTOM POWER
7052PH
Measurement Mic System
7052H Type 1.5TM
Titanium Diaphragm
3Hz to >20 kHz
<20 dBA > 140 dBSPL
MK224 (<14 dBA to >134 dBSPL) Optional
4048 Preamp
Superior
IEC 1094 Type 1
Long-term Stability
Temperature and Humidity
Performance
Now in Stock
Phantom
to IEPE/ICP
Adaptor
Supplies 3-4 mA
Power
Accelerometers
Microphones
ICP1248
ACOustics
Begins with ACO
MATTtm Family
MATT TM
Mic
Attenuator
Handle Higher Sound Pressure Levels
ACO Pacific, Inc., 2604 Read Ave., Belmont, CA 94002
Tel:(650) 595-8588 FAX: (650) 591-2891 E-Mail: sales@acopacific.com
Web Site: www.acopacific.com
TM

Éditorial
Editor's note



Appel à l'action... encore!

Ce numéro de mars sera le dernier, avant décembre, contenant des articles de fond, puisque le numéro de juin sera consacré à un numéro spécial consacré à l'acoustique dans la grande région de Toronto tandis que celui de septembre contiendra les actes de notre conférence, la Semaine canadienne de l'acoustique.

Nous avons également corrigé une erreur de script dans l'annuaire des membres qui faisait en sorte qu'aucun des membres dont le champ affiliation était vide n'apparaissait. Nous sommes désolés pour cette erreur et nous vous invitions à vérifier que vos coordonnées, soient bien à jour. Ainsi que vous le réalisez, nous sommes une association de bénévoles et nous comptons maintenant beaucoup sur nos membres pour visiter notre site web à http://jcaa.caa-aca.ca, certainement pour y lire leur journal sous forme électronique ou y consulter chacun des articles paru durant les 41 dernières années, mais aussi pour maintenir leurs coordonnées à jour!

Jérémie Voix
Rédacteur-en-chef

Call for action... again!

This March issue will be the last one, before December, that will include peer-reviewed articles, as the upcoming June issue will be a special one dedicated to acoustics in the greater Toronto area and as the September issue will be used for the proceedings of our Acoustics Week in Canada conference.

We fixed a database script glitch in the membership directory that prevented members with an empty affiliation field to show up. We are sorry for that mistake and we now invite you to make sure that your contact information is up-to-date. As you know, we are a volunteer-based association and we now count on our members to visit the journal's website, at http://jcaa.caa-aca.ca to read their electronic journal issues (or access one of any articles published over the last 41 years), but also to maintain their contact information up-to-date!

Jérémie Voix
Editor


WE CAN MAKE WHATEVER YOU MAKE
BETTER.
SAFER.
QUIETER.
The blueprint of good sound control starts with ROXUL® Core Solutions (OEM) insulation. Made from basalt rock, our insulation provides excellent acoustical dampening and fire resistant properties. So whether you're designing a car muffler, music studio or modular office – our team of experts will work with you before, during and after fabrication to create the custom sound solution you're looking for. Visit us at roxul.com/oem
ROXUL®
The Better Insulation™

President's Message
Message du Président

Special thanks to last year's conference organizing team led by Sean Pecknold, Michael Kiefte and Steve Aiken. The meeting, held in downtown Halifax, featured two and a half days of engaging plenaries, technical papers, and exhibitor showcases, as well as memorable social events at the Halifax Central Library and Pier 21. Hearty congratulations to our student presentation award winners: Fabien Bonnet, Graham Warner, and Jessica McKellar.

This year, the Acoustics Week in Canada will travel west to Vancouver. Kathy Pichora-Fuller and Clair Wakefield are serving as co-conveners. The abstract deadline is June 15th and the actual meeting will take place Sep 21-23. More information is available at http://awc.caa-aca.ca. Please note that these dates are slightly out of step with our usual timeframe. This change reflects our intention to allow AWC to dovetail with the World Congress of Audiology (WCA), which is also taking place in Vancouver (Sep 18-21). Information about WCA is available here: http://www.wca2016.ca

One other important meeting taking place this year is the International Congress of Acoustics. The triennial meeting will be held in Buenos Aires (Sep 5-9). Go to http://ica2016.org.ar/ for more information. The abstract deadline is March 1st, 2016.

At the last general meeting, we voted to maintain a slate of 12 directors in total (including the 4 officers). Karen Turner (Protec Hearing) did not seek re-election. All prior members of the board were acclaimed, as was our new director Joana Rocha from Carleton's Department of Mechanical and Aerospace Engineering.

Frank A. Russo, CAA President

Un grand merci à l'équipe organisatrice de la conférence de l'an dernier, dirigée par Sean Pecknold, Michael Kiefte et Steve Aiken. La rencontre, qui s'est tenue au centre ville d'Halifax, comportait deux journées et demi de séances plénières, d'articles techniques, de présentations d'exposants, ainsi que de mémorables évènements sociaux à la Bibliothèque centrale d'Halifax et au Pier 21. Nous présentons nos sincères félicitations aux lauréats des prix des meilleurs présentations étudiantes: Fabien Bonnet, Graham Warner, et Jessica McKellar.

Cette année, la Semaine canadienne de l'acoustique voyage vers l'ouest jusqu'à Vancouver. Kathy Pichora-Fuller et Clair Wakefield seront les coorganisateurs. La data limite de soumission pour les résumés est le 15 juin. La rencontre aura lieu du 21 au 23 septembre. De plus amples informations sont disponibles sur http://awc.caa-aca.ca. Vous remarquerez que ces dates sont légèrement décalées par rapport à notre calendrier habituel. Notre intention est de suivre le Congrès mondial d'audiologie qui a lieu à Vancouver du 18 au 21 septembre. Vous pourrez trouver plus d'information sur leur site internet : http://www.wca2016.ca.

La réunion triennale du Congrès international de l'acoustique se tiendra à Buenos Aires (5-9 sept.). Pour plus d'information veuillez visiter http://ica2016.org.ar/. La date limite pour envoyer un résumé est le 1er mars 2016.

À la dernière assemblée générale, nous avons voté et décidé de maintenir un conseil de 12 administrateurs (dont 4 officiers). Karen Turner (Protec Hearing) n'a pas posé sa candidature pour la réélection. Tous les autres membres du conseils ont été réélus par acclamation, incluant le nouvel administrateur Joana Rocha, du Département de génie mécanique et aérospatial de Carleton.

Frank A. Russo, Président de l'ACA

THE NEW CSA Z94.2 STANDARD: HEARING PROTECTION DEVICES — PERFORMANCE, SELECTION, CARE, AND USE IS NOW PUBLISHED

Alberto Behar (Ryerson University) and Tim Kelsall (Hatch)
albehar31@gmail.com / tkelsall@hatch.ca

Abstract

One of the most widely referenced acoustical standards in Canada is CSA Standard Z94.2, "Hearing Protection Devices – Performance, Selection, Care, and Use". CSA issued the 7th edition in 2015 and there have been significant changes. The standard still has the ABC system but adds significant discussion on NRR and SNR (SF84) including the appropriate methods and derating needed in estimating actual noise exposure from these descriptors. It also discusses "Field Attenuation Estimation Systems (FAES)", which allow performance measurement on actual users. It also meshes with the new standard Z1007, Management of Hearing Loss Prevention Programs, which should be out in 2016.

1 Introduction

After 12 years there is now a new version of CSA Standard Z94.2, "Hearing Protection Devices – Performance, Selection, Care, and Use". Here is how CSA describes the new standard:

"This is the seventh edition of CSA Z94.2, Hearing Protection Devices - Performance, Selection, Care, and Use. It supersedes previous editions published in 2002, 1994, 1984, 1979, 1974, and 1965.

This edition expands on performance requirements and the rating schemes that might help the user select hearing protection devices. It now includes the widely used noise reduction rating (NRR) and an applicable derating scheme.

This edition no longer includes physical performance and related testing requirements (such performance is no longer sought by Canadian users). It addresses acoustical performance measurements and includes revisions in the packaging marking requirements to clarify the use of the various ratings.

Clauses 8 to 12 regarding the selection, care, and use of hearing protection devices (HPDs) have been expanded to include issues related to style and functions of hearing protectors not mentioned in previous editions, as well as the potential use of field attenuation estimation systems (FAES). Table 4, which specifies the selection of HPDs based on noise exposure levels, now requires octave-band noise measurements at exposures greater than 105 dBA.

Although users of hearing protection devices are required to follow the criteria in Clauses 8 to 12 in order

projection obtained in the field. However, they have to be kept for different reasons: the NRR is very popular and, as requested by the EPA in the USA, every protector has to have it written in the package. As for the Class, it is mandated in the legislation of some provinces in Canada.

Data obtained using ANSI S12.6-1997, Method B are used to compute a new estimate, called the Single Number Rating (Subject Fit 84th Percentile), abbreviated SNR (SF84). SNR (SF84) is the protection provided at a nominal 84% confidence interval. For instance, a protector with SNR (SF84) = 20, will provide 20 dB or more attenuation to 84% of the users in a well-run hearing conservation program. Calculations of the sound level of the protected ear using SNR (SF84) yields results much closer to what is obtained in the real world.

Procedures for the calculation of the three indices: Class, NRR and SNR (SF84) are included in the Standard.

Probably the most important sections for the user is Section 9 "Selection of Hearing Protection Devices" that provides guidance to persons using or preparing Hearing Protection Programs for a workplace. It gets into details of the different types of hearing protectors, their characteristics and applications. It touches subjects such as sound attenuation, attenuation at frequency extremes, double protection, overprotection, etc.

Section 9 deals also with the touchy issue of NRR and its derating. Derating is the procedure to obtain more realistic attenuation value of the protector. It is well known that NRR over-estimates real protection. Table 2 in the Standard provides directions on how to derate it, when using single and also double protection. In summary, the derating scheme is as follows:

For ear plugs - 50% of the nominal NRR

For ear muffs - 70% of the nominal NRR

For double protection (plug and muff) - 65% of the sum of the NRR that has the higher NRR +5 dB

Also, if the measurement of the environmental noise is performed in dBA, there is an additional 3 dB penalty (not the 7 dB as per NIOSH) based on updated typical industrial spectra.

Numerical examples are included to illustrate the procedure.

Section 10 "Specialized hearing protection devices" expands greatly the information provided in the previous standard and now covers devices using active noise control, flat frequency response, etc. to comply with this standard, reference should also be made to applicable local occupational health and safety regulations, which can require additional or superior performance.

The CSA Subcommittee on Hearing Protection recognizes that significant variations in performance (as great as ± 20 dB attenuation) can occur depending on how an HPD is used. This Standard emphasizes the importance of a comprehensive hearing loss prevention program, including hazard assessment and instruction on the careful selection, proper wearing, and high-quality maintenance of hearing protection devices. It is the opinion of the Subcommittee that wearing HPDs without proper selection, care, and use can result in significantly lower attenuation for the user than that obtained from the tests specified in this Standard.

This Standard should be used in conjunction with CSA Z1007, Management of Hearing Loss Prevention Programs, which is currently under development. CSA Z1007 covers all aspects of the creation and management of hearing loss prevention programs."

2 The New Standard

Following are brief descriptions of some of the highlights of the standard:

"Test Procedures" requires tests to be performed following the procedures in any of the ANSI standards S3.19-1974 or S12.6-1997, Method B. The first of them was already required in the previous edition. It is included again, since it is needed for the calculation of the Class and the NRR of the protectors. Both descriptors usually overestimate considerably the

A brand new issue is treated in Section 13 "Field Attenuation Estimation Systems (FAES)". NRR, Class and SNR (SF84) are obtained by calculations from results of test on many subjects and shouldn't be applied to individuals. E.g., NRR = 20 doesn't mean that every user will get 20 dB attenuation from using that particular protector. FAES, instead, is used to estimate the attenuation provided to an actual user of the protector. The result applies to that particular user at the time of the measurement.

FAES are becoming popular because of the speed and ease of their use and also because they can be useful for training. For instance, a worker can be retested after the technician has explained the proper way of fitting the protector. At this time, most FAES are for ear plugs only. However, there are works in progress to extend their use for muffs too.

3 Certification

The issue of how to certify that a given hearing protector device meets the requirement of the Z94.2 standard is a very important one. However, CSA does not have at the present a process for certification of hearing protectors. In this present standard, certification is not a requirement. However, user may request from the manufacturer a document to ascertain that the results quoted, are obtained at a certified laboratory using standard procedures. Appendix C gives an example of how laboratory test results should be presented. The standard is written in a way to make it easy to include such a certification requirement in a future edition. Such a requirement would only be included if regulators, users and suppliers agree that there is a need for it.

4 Relation to Other Standards

Presently, CSA is involved in the writing of an all-encompassing standard, Z1007 - Hearing Loss Prevention Program Management. Hearing protection devices are an important part of this standard. Every effort was made to ensure that, although the emphasis of both standards is different, the technical content would still be the same.

5 In Summary

This new version of the standard provides more guidance to health and safety professionals by offering reliable, up-to-date information on hearing protection. The working group is hopeful that the new version will soon be mandated in provincial regulations, as the last version has been.

DESIGN AND VALIDATION OF A BONE CONDUCTION MUSIC PLAYBACK FOR BIKE HELMET

François Rochon *1, Jérémie Voix †2

[1]École Nationale Supérieure d'Ingénieurs du Mans (ENSIM), Université du Maine, Le Mans, France

[2]Département de génie mécanique, École de technologie supérieure (ÉTS), Montréal (QC), Canada

Abstract

This paper presents a proof of concept to develop a system of bone transducers that would equip a bike helmet and provide music directly to the cochlea by bone conduction. The purpose of this design is to allow the ears of the wearer to remain unobstructed to ensure a comfortable music listening while maintaining auditory awareness and localisation capabilities. A review of the scientific literature about bone conduction shows that of all possible skull locations, the condyle of the jaw presents the lowest threshold level of auditory perception when excited. This determined the choice for the final mounting system and the process for the audiometric measurements. The main result is a digital filter obtained with the output magnitude of the transducers and designed to provide comfortable and unobstructed music listening.

Keywords: Product design, bone conduction, sound reproduction, vibrator, consumer product, hearing threshold

Résumé

Cet article présente une preuve de concept liée au développement d'un nouveau produit, un système d'ostéovibrateurs équipés sur un casque de vélo permettant de fournir directement une écoute musicale à la cochlée par conduction osseuse. L'objectif de ce design de produit est d'obtenir une écoute musicale confortable et sécuritaire en maintenant les oreilles de l'utilisateur non-obstruées et en garantissant que ses capacités de vigilance et de localisation auditives restent intactes. Une revue de la littérature scientifique et technique au sujet de la conduction osseuse montre que parmi toutes les localisations crâniennes possibles, les condyles au niveau du haut des mâchoires possèdent le plus bas seuil de perception auditive lors-qu'excités. Cela détermine le choix de système de fixation et la procédure à suivre pour les mesures audiométriques. Le résultat principal est un filtre obtenu en mesurant l'amplitude en sortie des transducteurs et conçu pour fournir une écoute musicale confortable et sécuritaire.

Mots-clés: Design de produit, conduction osseuse, reproduction sonore, vibrateurs, produit de consommation, seuils auditifs

1 Introduction

Accidents involving people wearing headphones while biking are frequent [1]. To resolve this safety issue and still permit bicyclists to listen to music, a music playback device that allows for the external ear to be unobstructed can be designed [2]. Bone conducting headphones are a viable type of system that could resolve this issue [3].

This work aims to ensure comfortable and safe music listening while bicycling. In order to choose the most reliable device to equip a bicycle helmet, research of different types of bone transducers adapted to music listening was required.

One aspect of the product design consisted in characterizing the bone transducers in terms of frequency response. The objective of this modeling is to see if the filter obtained could be used for the equalization of the sound emitted by the transducers.

Another aspect of particular interest is the skull behavior for this kind of excitation in the context of finding the ideal location where to affix the bone transducers within the helmet.

Issues that will be addressed in this study:

- How will the bone transducers be attached to the bicycle helmet once the ideal bone conduction location on the skull has been identified?
- How to bypass the fact that the instrumentation used for the measurements will probably not be calibrated for the studied bone transducers?
- Will the filter obtained after the measures be usable for the equalization of the sound emitted by the transducers?

After enunciating the main issue, the bibliographic studies pertaining to bone conduction will now be reviewed. Research includes documents dealing with the vibro-acoustic sensitivities of the skull and with the concept of headphones using a bone transducer.

This article begins with a background summary of the theory causing the bone conduction then the methodology and methods implemented during the feasibility study. This feasibility study determines on the one hand if the desired osteo-vibratory level is accessible by verifying those generated by different types of bone transducers. On the other hand the modeling of the selected bone transducers shows their characteristics such as the input voltage required and the vibratory output pressure applied on the skull together with the intracranial frequency response. This step is crucial for

* francoisrbleu@aol.com
† jeremie.voix@etsmtl.ca

choosing the most appropriate location to place the bone transducers before subsequent measurements are taken.

In the concluding section this article presents the project results and an analysis dealing with the interpretation of these results and the validation of the concept.

2 Background

Bone conduction is a phenomenon in which sound propagates from an extra-cranial point to the cochlea through the skull.

Bone conduction is one of the reasons why someone's voice seems different for him or her when it is recorded and reproduced. Because the sound leaving the vocal chords (especially low frequencies) is also transmitted via skull bones to the inner ear, people perceive their own voice lower and deeper than others.

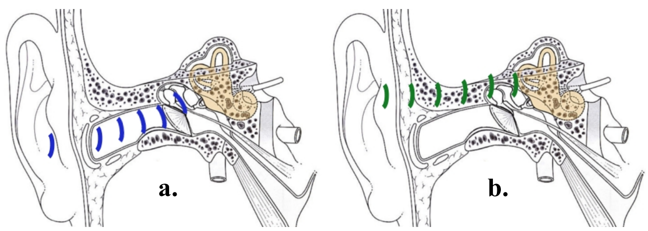


Figure 1: Air vs. bone conduction (adapted from Descouens [9])

The sound propagation of classical headphones (Figure 1.a.) is created by the vibrations of the molecules in the air and these vibrations are collected and concentrated by the pinna, which is the visible part of the ear. The waves then follow the ear canal and create vibrations in the eardrum. The middle ear ossicles amplify the signal and deliver it to the cochlea whose role is to analyse the sound wave before transmitting the relative information to the brain.

In the case of bone conduction headphones (Figure 1.b.), bone conduction transducers are placed onto the skull. The waves then propagate from the skull bones to the cochlea, which processes the sound signal.

Thus the major difference between bone conduction and the traditional headphone system is that the music and ambient sounds do not follow the same path. With bone conduction it is possible for the inner ear to perceive both sound sources almost simultaneously:

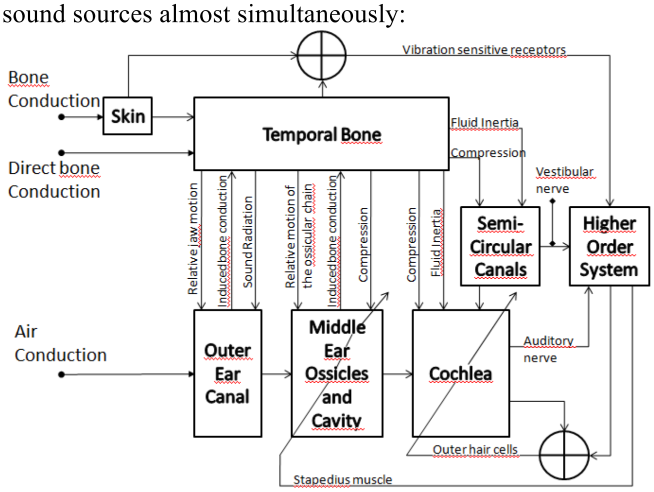
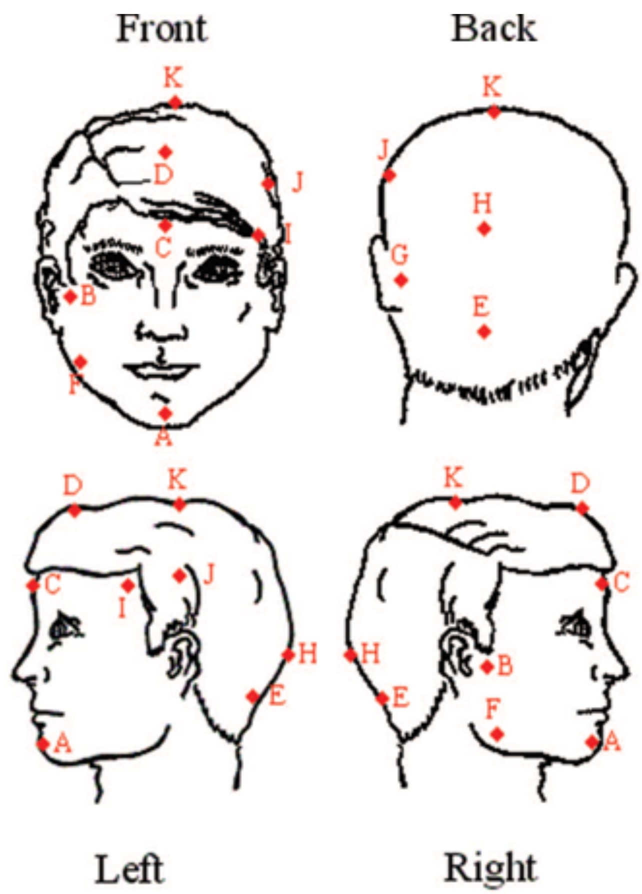


Figure 2: Modeling of the sound paths including bone and air conduction (adapted from Stenfelt [5])

3 Materials & Methods

3.1 Human skull susceptibility to vibrations

Past studies have demonstrated that the human skull has different frequency responses depending on where the vibratory force is applied [6] [7]. To see where this frequency response is the least attenuated, it was necessary to compare the values of threshold levels in the results of these studies for each application point. The cartography showing these different application points is displayed in Figure 3:



Key

A	Chin
B	Condyle
C	FPz
D	Fz
E	Inion
F	Jaw Angle
G	Mastoid
H	Pz
I	Temple
J	T3
K	Vertex

Figure 3: Cartography of application points studied on a human skull (adapted from McBride [6])

Four of these application points were selected and compared:

- The condyle (B)
- The mastoid (G)
- The temple (I)
- The vertex (K)

These four application points present the lowest threshold levels according to the two consulted studies. The jaw angle (location F) point also has a suitable threshold level but as it is located in the lower jaw as chin (location A) point, it is subject to a greater standard deviation than the other locations and was not retained because of the unpredictable micro-deviations of the temporomandibular joint.

These results are crucial for knowing exactly where the mounting system for the transducers is to be placed on the bicycle helmet, so that it also stays in contact with the condyles.

3.2 Measurement of the auditory thresholds with the proposed transducers

After the bone transducer was selected, measurements of the auditory hearing thresholds were taken for 23 third octave band frequencies on fifteen normal hearing subjects aged 25 years on average (age range : 20 to 33 years of age). These subjects were self-reported as not suffering from any hearing impairments and can be therefore considered representative of the typical end-user of the developed technology. Yet the measurements were performed with a functional prototype of headphones staging the bone transducers exciting the condyles. The equipment used includes an audiometric booth (ECKEL Model C-27 S) and a clinical audiometer (Interacoustics Model AC 40).

As the audiometer used was calibrated for a clinical audiometric bone vibrator very different from the one used in this study, the hearing levels values acquired by the audiometer in dB HL could not be used directly nor could be adjusted for the proposed transducer, as such calibration curve did not yet exist. Instead, a more straightforward direct voltage measurement was performed as detailed in Section 3.3.

3.3 Measurement of the bone transducers frequency response

As the hearing thresholds were established using the proposed transducer for normal hearing test-subjects, it was assumed that the average response would correspond to a 0 dB HL level. It was then possible to measure with a true-RMS multimeter (AMPROBE Model 34XR-A) connected to the bone transducers, the RMS voltage that was generated by the audiometer when generating that average 0 dB HL stimuli across all third octave-band center frequencies. These voltage values could then be paired with the values of the auditory threshold levels measured earlier in order to assess the proposed bone transducer frequency response.

3.4 Design of an equalizing filter

To equalize the output level of the transducers following the frequency response established previously, a digital filter was set using the magnitude of the input voltage curve established in Section 3.3. The coefficients of the impulse response of the digital filter are obtained using a filter design and identification toolbox available within MATLAB computing software.

4 Results

4.1 Bone conducting hearing thresholds as a function of the application points

Human skull behaviour for the four chosen application points is illustrated on Figure 4 for each octave frequency band from 125 Hz to 8 kHz. The values were extracted from tables in the results sections of the previous cited articles [6] [7]:

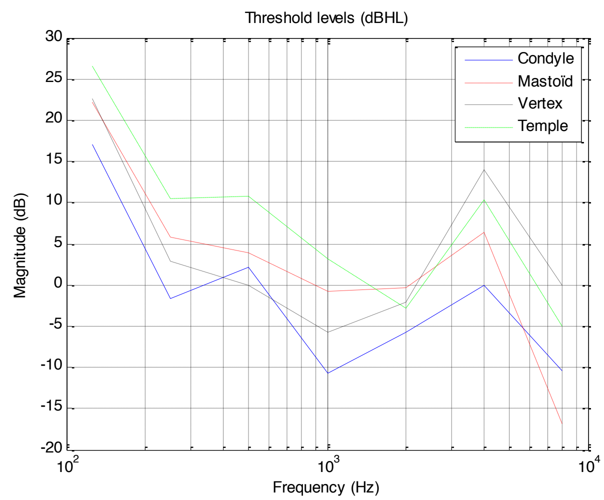


Figure 4: Hearing threshold levels at different locations on the human skull

Using these curves, it is possible to rank the application points from the lowest to the highest threshold level in order to find the most sensitive location for the bone transducers placement:

Table 1: Relative sensitivity of the chosen application points

F (Hz)	[125 ; 500]	[500 ; 2k]	[2k ; 8k]
Condyle	#1	#1	#1
Mastoid	#3	#3	#2
Vertex	#2	#2	#4
Temple	#4	#4	#3

4.2 Mechanical modeling of the proposed transducers and its fastening system

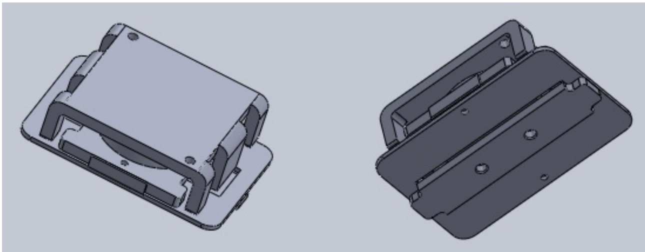


Figure 5: Bone transducers selected for the proposed application

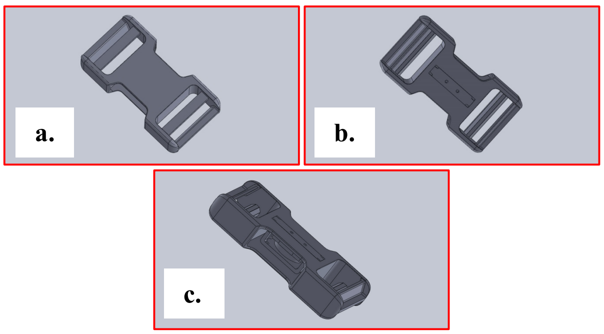


Figure 6: 3D model of the proposed fastening system a) back, b) front, c) sideways

The fastening system proposed for encapsulating the bone transducers modeled in Figure 5 is shown in Figure 6. The shape of this fastening system has been adapted to fit with the bicycle helmet straps. So it can be adjusted along the straps to ensure the contact with the condyles of any user.

4.3 Experimental validation of the proposed transducers design

Hearing threshold levels:

Figure 7 is an illustration of the result of the subjective measures of hearing threshold levels that were measured on fifteen normal hearing subjects. These measures were performed on each condyle for each third-octave band frequency from 125 Hz to 8 kHz:

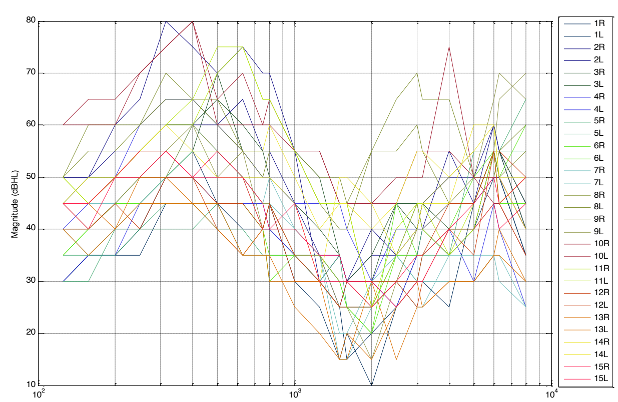


Figure 7: Individual audiometric levels measured on the 15 normal hearing subjects

The group average response curve presented in Figure 8 is an intermediate result that will be used to access the "zero" for the calibration of each bone transducer on the audiometric equipment. It is also a way to verify that the left and right bone transducers do indeed have the same frequency response:

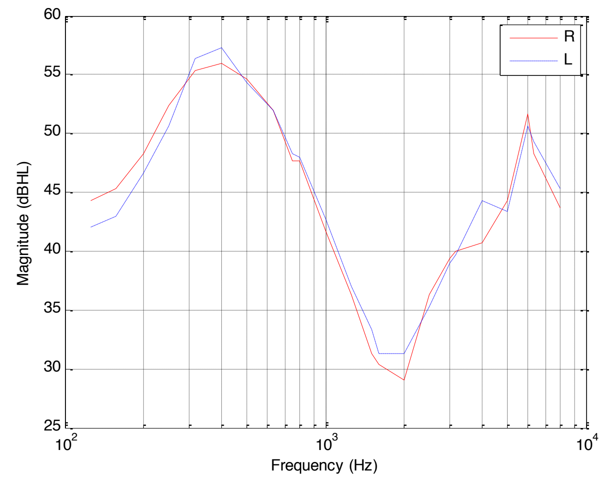


Figure 8: Audiometric levels – Left transducer in blue and right transducer in red

Average audiometric threshold levels for the left and right transducers are shown on Figure 9 as well as the statistical standard deviation of the hearing threshold measurements per third-octave band frequencies on the group subjects:

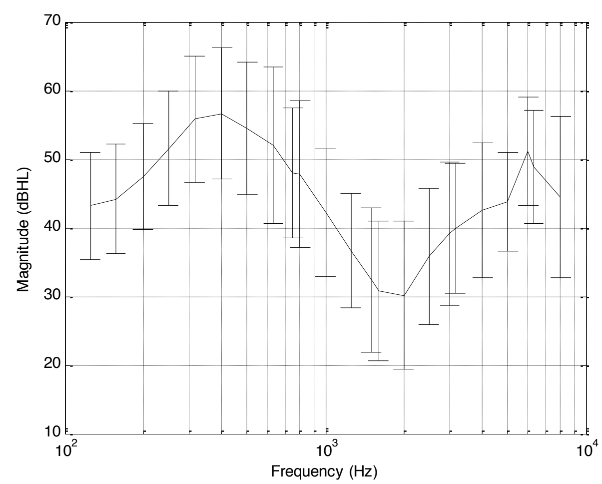


Figure 9: Audiometric threshold levels – Group mean and standard deviation per third-octave band frequencies

Input voltage:

The left and right input voltage of the bone transducers when generating a "flat" uniform stimulation are shown on Figure 10, reusing the response curves obtained in Figure 8:

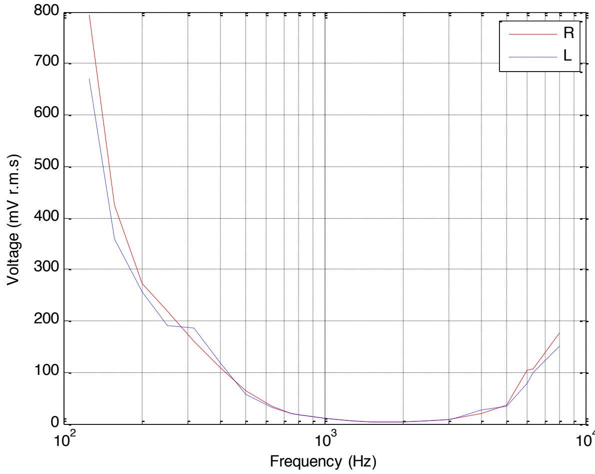


Figure 10: Bone transducers input voltage for a "flat" uniform bone stimulation – Left transducer in blue and right transducer in red

As can be seen on Figure 10, to generate a "flat" uniform stimulation much more electrical power is needed in the low-frequencies than in the medium frequencies because of the low efficiency of the transducers in low frequencies.

The magnitude of these values at each third-octave band frequency represents the frequency response of the transducers and can be used to design a filter model.

Design of an equalizing digital filter:

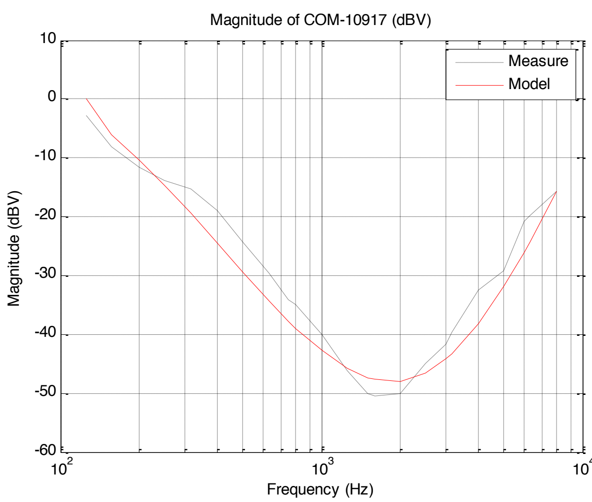


Figure 11: Magnitude of the bone transducers frequency response (in black) and of the fitted digital filter (in red)

The magnitude of the average response from Figure 9 and of a corresponding theoretical transfer function modeled under MATLAB Filter Design Toolbox is illustrated on Figure 11.

This model is an order 3 notch filter defined with two cut-off frequencies:

- A low cut-off frequency of 125 Hz.
- A band frequency equal to 2.4 kHz.

With the defined model, it is possible to calculate the coefficients of a digital filter and plot its impulse frequency response. The coefficients were calculated with a reverse Z-transform starting from the equation of the model curve (red line in Figure 11). This equation is the reason for creating a model before calculating the coefficients, because it is not possible to obtain the filter directly with the results of the measures.

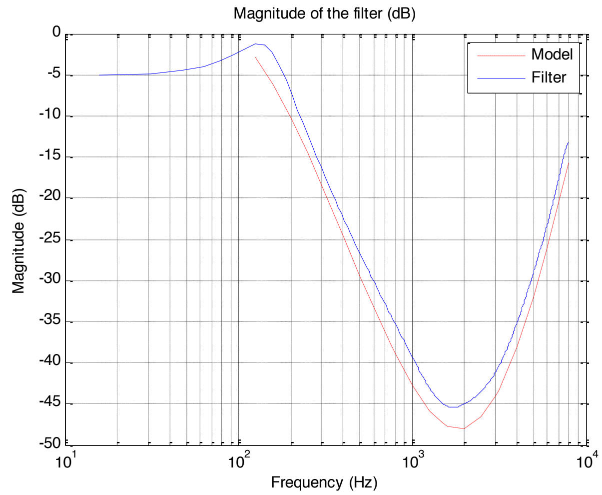


Figure 12: Frequency response of the filter (in blue)

Validation of the filter:

To verify that the digital filter actually improves the quality of the sound signal, a subjective comparison was conducted using an excerpt of a test song. First, the excerpt was played non-filtered, then filtered. The criteria of comparison included the relative sound level, restitution of low, medium and high frequencies and comprehension of the lyrics.

The comparison between the not filtered and the filtered song excerpts has shown that the sound quality was often preferred when the signal was not filtered. Indeed, it appears that the equalization that was conducted at threshold levels do not correspond to an equal loudness perception at higher levels.

For illustration, the ear is less sensitive to low-frequencies at low level, but this sensitivity increases as the level of the music playback increases. As a consequence, an equalizing filter that would flatten the response at 0 dB HL would sound way too “boomy” when listened to at higher levels.

Since this higher level playback of the music is highly variable among individuals, it is not possible to fix the loudness correction that is to be applied to the equalizing filter. To address that issue, one last development was conducted, where the user can adjust the loudness correction manually using the graphical equalizer illustrated in Figure 13.

This graphical equalizer is equipped with a popup menu containing the settings relative to most of the musical styles and also with a custom mode allowing users to adjust by himself or herself the preferred playback sound level. In doing so, simply manipulate the sliders representing each frequency (displayed here per octave bands from 31.25 Hz to 16 kHz) in order to modify the corresponding sound level by providing it a variation between -12 and +12 dB.

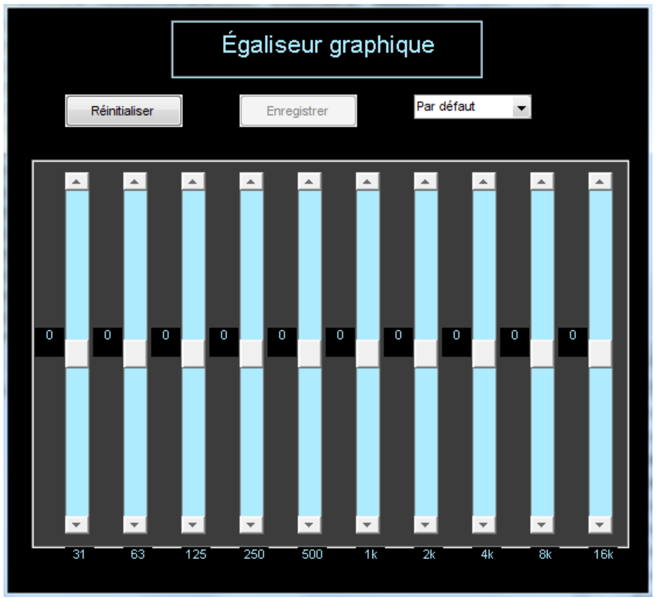


Figure 13: Graphical equalizer interface for the required loudness correction

5 Analysis and Discussion

The proposed mounting system displayed in Figure 6 stages a simple way to encapsulate the bone transducers. The system can be glided along the front helmet webbing, which proves a simple way of adjusting its position against the skull. Another benefit of the proposed design is that it can be retrofitted on any existing helmet.

The standard deviation of the curves displayed in Figure 7 and which is shown on Figure 9 may appear to be large but was not felt to be a concern as the aim of the audiometric measurements was to obtain the general shape of the equalizing filter, knowing that individuals may indeed have a different hearing sensitivity that would be anyway later on adjusted through the loudness correction mechanism described in Section 4.d.

Finally, one can foresee that the loudness correction required on top of the equalization filter could be implemented on a portable music player as most of these devices now support “apps”. It would even be feasible to have the app adjusting automatically the loudness correction as a function of the actual music playback level, as the frequency response of the proposed transducer has been properly identified and that loudness correction models are easily programmable in modern digital signal processors.

6 Conclusions

This project's objective was to develop a system of bone transducers that would equip a bike helmet and able to excite the skull via bone conduction. This technological development would ensure comfortable music listening, while enabling the ears to remain unobstructed so that the wearer may retain awareness and localisation capabilities.

The main result of this project is a functional bicycle helmet prototype validated in laboratory staging two components mounted onto the helmet straps and containing the bone transducers.

Future research needs are to validate the proposed bike helmet prototype on a larger number of test-subjects, as inter-individual differences in perceived audio quality can be significant [8]. Future developments should be conducted to encode the equalization filter as well as the loudness correction into an “app” that could be running on the portable music player. Wired connections could be also replaced with wireless link such as a Bluetooth protocol, as more and more cell-phones and music players feature that music streaming capability.

Figure 14: Final prototype

Acknowledgments

The first author would like to thank the members and researchers of ÉTS industrial acoustic laboratories for their continuous support during his engineering internship.

References

[1] "Ten-year-old cyclist killed in collision with t..." | Welland Tribune, http://www.wellandtribune.ca/2008/09/04/ten-year-old-cyclist-killed-in-collision-with-trolley. (Downloaded August 19, 2014).

[2] Emmanuel Delacour, *tvanouvelles*, July 25, 2012. http://tvanouvelles.ca/lcn/infos/national/archives/2012/07/20120725-070001.html. (Downloaded March 2014)

[3] "Bike headphones that don’t distract from cycling safely | Environment | theguardian.com", http://www.theguardian.com/environment/bike-blog/2012/mar/26/bike-headphones-music-cycling. (Downloaded August 19, 2014).

[4] Steve Hemmerstoffer, "Un casque audio par vibration osseuse", *www.nowhereelse.fr*, September 07, 2011. http://www.nowhereelse.fr/test-casque-audio-vibration-osseuse-53254/. (Downloaded March 2014)

[5] Stefan Stenfelt and Bo Håkansson, "Air versus bone conduction: an equal loudness investigation", *Hear. Res.*, vol. 167, #1‑2, p. 1‑12, May 2002.

[6] M. McBride, T. R. Letowski, and P. K. Tran, "Bone Conduction Head Sensitivity Mapping: Bone Vibrator", *Army Research Lab Aberdeen Providing Ground MD*, July 2005.

[7] M. McBride, T. Letowski, and P. Tran, "Bone conduction reception: Head sensitivity mapping", *Ergonomics*, vol. 51, #5, p. 702-718, May 2008.

[8] A. Gabrielsson and H. Sjögren, "Perceived sound quality of sound-reproducing systems", *J. Acoust. Soc. Am.*, vol. 65, #4, p. 1019-1033, April 1979.

[9] Descouens, D. (2009, November 07). Oreille interne. Downloaded June 28, 2015, on Wikipedia: https://upload.wikimedia.org/wikipedia/commons/b/ba/Place-del%27Oreille-Interne-Schema.jpg

EFFECTS OF MOUTHING AND INTERLOCUTOR PRESENCE ON MOVEMENTS OF VISIBLE VS. NON-VISIBLE ARTICULATORS

Katie Bicevskis[*1], Jonathan de Vries[1,2], Laurie Green[1], Johannes Heim[1], Jurij Božič[1], Joe D'Aquisto[1], Michael Fry[1], Emily Sadlier-Brown[1], Oksana Tkachman[1], Noriko Yamane[1], Bryan Gick[1,3]

[1] Department of Linguistics, University of British Columbia, Vancouver, BC, Canada

[2] Interdisciplinary Studies Graduate Program, University of British Columbia, Vancouver, BC, Canada

[3] Haskins Laboratories, New Haven, CT, USA

Résumé

Les locuteurs prennent en compte l'information qu'un partenaire de conversation nécessite pour mieux comprendre une expression. Malgré l'évidence grandissante que les mouvements d'articulateurs visibles (comme les lèvres) sont augmentés dans l'articulation silencieuse par rapport à l'articulation vocalisée, peux d'études ont comparé cet effet dans les articulateurs visibles contre les articulateurs non visibles. De plus, aucune étude n'a examiné si l'engagement de l'interlocuteur changera ces résultats. En élaborant un conception d'expérience présent/non présent, nous avons testé si la présence d'information audible et/ou d'un interlocuteur affecte les mouvements des lèvres et de la langue. Les participants ont parlé trois syllabes, avec et sans production audible, dans chacune des conditions interlocuteur-présent et interlocuteur-non présent. Les mouvements des lèvres et de la langue étaient enregistrés avec la vidéo et l'échographie. Nos résultats montrent que la protubérance des lèvres était plus grande dans les conditions non audibles par rapport à ceux audibles et que les mouvements de la langue étaient atténués (/wa/) ou non affectés (/ri/, /ra/) par ces mêmes conditions, indiquant les effets différents pour les articulateurs visibles et non-visibles dans l'absence d'un signal auditif. Une interaction significative entre les conditions d'engagement sociale et d'audibilité de vocalisation avec référence à la fermeture orale a montré que les participants ont produit des fermetures plus étroites dans les conditions de vocalisation audible, interlocuteur-non présent (par rapport à la condition interlocuteur-présent). Cependant, les mesures de protubérance des lèvres n'étaient pas affectées par condition d'engagement sociale. Nous concluons que les locuteurs utilisent à la fois les modalités auditives et visuelles dans la présence d'un interlocuteur, et lorsque l'information acoustique n'est pas disponible, les augmentations compensatoires sont réalisés dans le domain visuel. Nos résultats soulignent encore le caractère multimodal de discours, et posent des nouvelles questions au sujet des adaptations différentielles faites par les articulateurs visibles et non visibles dans les différentes conditions de parole.

Mots clefs: production de la parole, effets interlocuteur, parole silencieuse, feedback auditif et visuel, échographie

Abstract

Speakers take into account what information a conversation partner requires in a given context in order to best understand an utterance. Despite growing evidence showing that movements of visible articulators such as the lips are augmented in mouthed speech relative to vocalized speech, little to date has been done comparing this effect in visible vs. non-visible articulators. In addition, no studies have examined whether interlocutor engagement differentially impacts these. Building on a basic present/not-present design, we investigated whether presence of audible speech information and/or an interlocutor affect the movements of the lips and the tongue. Participants were asked to a) speak or b) mouth three target syllables in interlocutor-present and interlocutor-not-present conditions, while lip and tongue movements were recorded using video and ultrasound imaging. Results show that lip protrusion was greater in mouthed conditions compared to vocalized ones and tongue movements were either attenuated (/wa/) or unaffected (/ri/, /ra/) by these same conditions, indicating differential effects for the visible and non-visible articulators in the absence of an auditory signal. A significant interaction between the social engagement and vocalizing conditions in reference to lip aperture showed that participants produced smaller lip apertures when vocalizing alone, as compared to when in the presence of an interlocutor. However, measures of lip protrusion failed to find an effect of social engagement. We conclude that speakers make use of both auditory and visual modalities in the presence of an interlocutor, and that when acoustic information is unavailable, compensatory increases are made in the visual domain. Our findings shed new light on the multimodal nature of speech, and pose new questions about differential adaptations made by visible and non-visible articulators in different speech conditions.

Keywords: speech production, interlocutor effects, mouthed speech, auditory and visual feedback, ultrasound imaging

---

* k.bicevskis@alumni.ubc.ca

1 Introduction

This study examines how the motion of visible articulators (e.g. the lips) and non-visible articulators (e.g. the tongue) are affected by two factors: (1) the presence of proprioceptive auditory feedback and (2) the presence or absence of an interlocutor. A large body of literature now points to the importance of the visual modality in speech perception [3, 8, 14, 15, 16, 21, 22, 24]. Perceptual accuracy generally increases when the perceiver can both hear and see a speaker. In light of such results, we ask whether an articulator's visibility (i.e. visible or less visible) will affect its magnitude of movement when information from the visual modality becomes more important.

Because of the non-trivial contribution of vision to speech perception, it is perhaps not surprising that speakers tend to increase facial movements in environments where the auditory signal is degraded [5, 6, 10]. Hazan & Kim [10] found that speakers visually enhanced their articulation of /æ/, /i/ and /ɛ/ (indicated by an increase in inter-lip area) when they were required to carry out a communicative task in noise. Increases in visible articulator movement could be interpreted as a mechanical side-effect of the increased effort required to speak louder in noisy settings. This increase in speech effort, usually referred to as Lombard Speech, was first noted by Lombard [13], who found an immediate and involuntary vocal increase as a response to noise. Interestingly, Herff, Janke, Wand & Schultz [11] found increased facial movement in noisy conditions in silent as well as vocalized articulation. These findings suggest that visible articulator movements increase in order to compensate for a degraded or absent auditory signal, even in the case of the relatively unnatural condition of silent speech. Furthermore, Ménard, Leclerc, Brisebois, Aubin & Brasseur's [17] study comparing blind and sighted speech found that in the production of French vowels, blind speakers demonstrated less difference in upper lip protrusion than sighted speakers and Cvejic, Kim & Davis [4] found that speakers made auditory cues (e.g. to prosody) more salient when it was known that visual cue information was unavailable to their conversation partner. Together, such findings imply that speakers take into account what type of information an interlocutor will require to best understand a given utterance in a given context. In the present study, rather than using noise to effect signal degradation, we include mouthed and vocalized utterances in order to examine how the *absence* or *presence* of an auditory signal affects the visible and non-visible articulators, respectively. Similar to previous work, we hypothesized that the movement of visible articulators would increase while mouthing, that is, when the auditory signal is absent.

While previous work has illustrated that the movement of visible articulators tends to increase when the visual modality is more important, such as when auditory information is degraded or absent, very little attention has been paid to the role of non-visible articulators (tongue).Though some work has been done examining the impact of visibility on articulator movement, samples have been small (i.e. a single participant in [7]). It has been suggested based on this data that tongue movements that are less visible do not increase in magnitude in noise, and that lip movements are not more enhanced in noise when interlocutors can see each other. However, these results should be seen as suggestive rather than conclusion due to the study's small sample size, a problem we attempt to rectify. A relatively clear prediction for the movement of articulators carrying less visual information may be formulated, namely that the movements of less visible articulators such as the tongue should be significantly less affected by changes in the environment which require increased attention to visual information. An alternative hypothesis would maintain that, as speech in noise is augmented in a variety of ways not exclusively visual [23], the augmentation should not be sufficiently sensitive to the modality-specific needs of an interlocutor, and should extend equally to both visible and non-visible articulators. To test our hypotheses, we employ simultaneous ultrasound and video imaging to capture the behaviour of the lips and tongue.

Considering visible and non-visible articulators also mandates consideration of social context, as previous studies indicate that visible articulator movements increase in saliency in the presence of an interlocutor [6, 10]. For example, Hazan & Kim's [10] study found that the size of lip gestures increased in magnitude when participants could see each other. The effect can also be found in hand gestures, which are larger when an interlocutor is present [1, 18]. The present study includes a social engagement condition where either an interlocutor is present and engaging with the participant, or the participant is alone. We hypothesized that while the movements of visible articulators would increase (interpreted as greater lip protrusion and smaller lip aperture) in the presence of an interlocutor, the movements of non-visible articulators should not be so affected.

Our experimental design involves simultaneous ultrasound imaging of the tongue and video imaging of the lips, capturing their behaviour in the presence of auditory information (vocalized condition), absence of auditory information (mouthed condition) and in the presence and absence of an interlocutor. We predict that: 1) tongue movements will be unaffected by speech condition (mouthed/vocalized) and the presence/absence of an interlocutor; 2) lip movements will increase in magnitude in mouthed conditions; 3) lip movements will increase in magnitude with the presence of an interlocutor.

2. Methods

2.1. Participants

22 students at the University of British Columbia participated in the study. All were native speakers of a North American variety of English. All participants self-reported normal or corrected-to-normal vision and hearing. All participants were paid for their services at a rate of $10 per hour.

Data from male participants with beards were excluded due to the effects of hair growth on ultrasound image quality. Since these exclusions significantly reduced the number of male participants compared to female participants, all males were ultimately excluded. Ultrasound image quality was also the major factor for excluding data obtained from a number of other participants: despite our efforts to keep subjects in a stable position, some subjects still moved away from the ultrasound probe, which resulted in poor image quality. Ultimately, 12 of 22 participants had to be excluded on these grounds. The final analysis was performed on the data obtained from 10 female participants (age range 18-24; *M* = 20; *SD* = 1.70).

2.2. Procedure

Participants were tested individually in a sound-attenuated booth. Seated in a dentist's chair, participants positioned their heads on a headrest to minimize head movement. An Aloka SSD-5000 Doppler Ultrasound Equipment with a UST-9118 endo-vaginal 180 degree electronic curved array probe on a microphone arm was positioned under a participant's chin. The ultrasound machine was connected to an iMac computer via a firewire port which displayed and recorded the video within the iMovie program. A small table with a computer screen was placed approximately 0.5m in front of the participant. A JVC GZ-E300AU camcorder was set up approximately 1.25m in front of the participant and adjusted to capture the entire face and head area. A 5mm x 5mm sticker was positioned on the zygomatic bone immediately anterior of the left ear in order to serve as a stable starting point from which to measure lip protrusion. An 18 x 21cm mirror was positioned at a 45 degree angle to the participant's face so that a side view of her lips was visible in the viewer of the camcorder. A Blue® Yeti USB Microphone (Model 1950) was placed inside the sound booth in omnidirectional mode. This was connected to a speaker outside the sound booth so that the experimenter could hear the participant's speech and the sound cue that signalled the end of a block. Participants were seated facing the door of the sound booth. This guaranteed the participants' awareness of the experimenter's presence inside the booth.

The experiment elicited both mouthed and vocalized utterances across a 4-stage continuum of interlocutor engagement (Social Engagement). In the first stage, there was no interlocutor present (Not Present); in the second, the interlocutor (a role performed by the experimenter, who was male) was present in the sound booth but did not engage with the participant (Not Engaged); in the third, the interlocutor was present in the sound booth and asked the participant some questions regarding the comfort of the equipment (Present and Engaged); in the fourth, the interlocutor was present and responded to each utterance with a matching hand gesture (Present and Gesturing). Each of the four stages constituted a Social Engagement condition. There were two conditions for speech production (Speech Production): vocalized and mouthed. This yielded a total of 8 conditions. A pilot study with 7 participants was run to test our experimental setup and conditions. An informal evaluation of that pilot data failed to yield promising results for Not Engaged and Present and Engaged. This was confirmed based on preliminary analysis of the first two experimental participants. In the resulting design, these two intermediate points were retained as fillers, and only the two endpoints of the interlocutor enhancement continuum (Not Present and Present and Gesturing) were included in the final analysis, yielding only 4 conditions.

We focused on three Target Syllables: /wa/, /ɹa/ and /ɹi/. The consonants /w/ and /ɹ/ were chosen as they are known to vary in their degree of lip and tongue constriction depending on their position in the syllable, exhibiting the greatest degree of constriction in onset position [2, 9]. /w/ was selected to induce lip aperture constriction (rounding) and tongue-dorsal movement while /ɹa/ and /ɹi/ were selected to induce lip protrusion and tongue-blade (for /ɹa/) and tongue-dorsal (for /ɹi/) movements. The reason for two /ɹ/ initial syllables was to avoid coarticulatory effects between the consonant and following vowel. In /ɹi/ the tongue anterior gesture of /ɹ/ is largely blended with that of the following high front vowel, while in /ɹa/ a similar blending occurs with the tongue root [20]. Analysis of each syllable was therefore focused on the position of the tongue less affected by vowel coarticulation.

Prior to the beginning of the experiment, participants were instructed to "read the item aloud in your normal speaking voice" for the vocalized conditions and "mouth the items without making a sound" for the mouthed conditions. Each block was initiated by the experimenter offering the participant a sip of water. Test items were presented using Psychtoolbox (version 3.0.11) (http://psychtoolbox.org) for MATLAB with a 1 second minimum presentation of each item. The order of the tokens with each block was pseudo-randomized. Participants controlled the transition between items with the space bar on a keyboard. Each run was comprised of 24 test blocks (3 for each of the 8 conditions) with 5 utterances per token per trial. This resulted in 15 tokens per utterance per condition. After the recording portion of the experiment, subjects completed a questionnaire on the experience of participating in the study. Participants rated the friendliness of the experimenter (*M* = 6.80, *SD* = 0.42), as well as the naturalness of their speech production for both mouthing (*M* = 4.3, *SD* = 1.06) and vocalizing conditions (*M* = 5.00, *SD* = 1.05), on a 7-point Likert scale.

2.3. Analysis

Analysis of the lips

Using Final Cut Pro 10.1.1 (http://www.apple.com/final-cut-pro), one frame per token was extracted from the video at the most constricted closure point of /w/ for /wa/ tokens (as determined visually using the front view of the participant) and the most protruded point of /ɹ/ for /ɹi/ and /ɹa/ tokens (as determined visually using the side-view of the participant). Analysis proceeded in ImageJ 1.48 (http://imagej.nih.gov/ij/index.html). For each frame, the red channel was filtered out and "Default" or "Percentile" threshold settings applied to produce a bi-tone black and white image.

Lip protrusion and lip aperture were measured with the straight line tool. Lip protrusion was measured by drawing a line (on the side mirror image) from the sticker on the side of the participant's face to the most protruded point (taken to be the most rightward pixel) on a participant's upper lip. When the most protruded point spanned more than one pixel, the most protruded pixel closest to the mouth opening was selected. Lip aperture was measured by drawing a 90 degree line in approximately the centre of the lip opening as seen in the front view image. As ImageJ measures in pixels, the measurements were then converted to centimetres. A scale was possible by comparing the width (in pixels) of the ultrasound probe tip in the image to its known physical width of two centimetres.

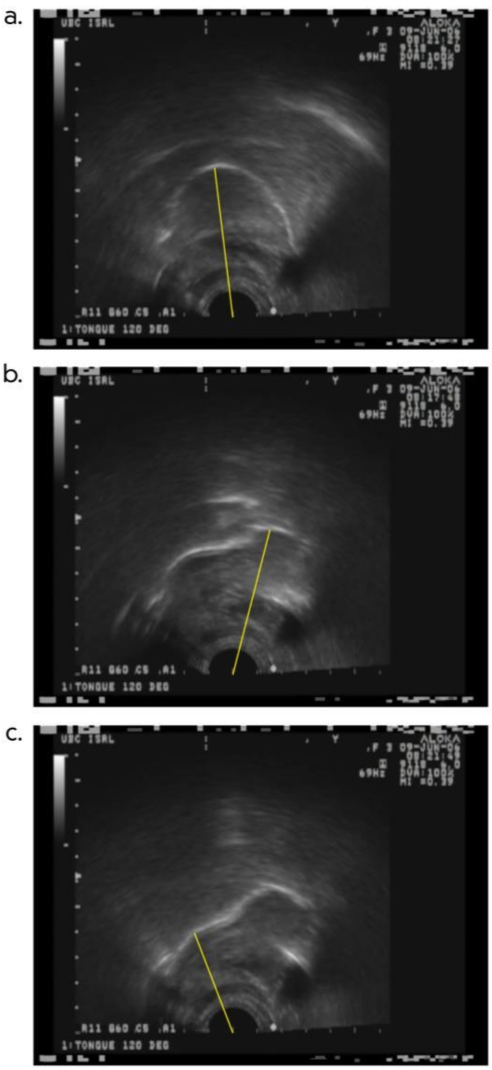


Figure 1: Tongue measurement points: (a) tongue dorsum for /wa/; (b) tongue tip/blade for /ɹa/; (c) tongue root for /ɹi/.

Analysis of the tongue

Tongue frames were extracted from the ultrasound video using Final Cut Pro. For each token, the extracted frame represented the point of most extreme constriction within the consonant prior to the transition into the vowel. For /wa/, this was the frame in which the tongue dorsum was highest relative to the middle of the transducer arc; for /ɹa/, this was the frame where the tongue blade was highest relative to the transducer arc; and for /ɹi/, where the visible portion of the tongue root was in its most posterior position relative to the same point on the transducer arc (see section 2.2). Analysis proceeded in ImageJ. Using the straight line tool, the distance from the transducer arc to the relevant point in each token was measured (see Figure 1). As with measurements for the lips, values were then scaled to centimetres.

3. Results

In order to investigate the validity of our hypotheses regarding the effects of Speech Production type, degree of Social Engagement and Target Syllable, three separate 2x2x3 repeated measures ANOVAs were conducted with normalized values (Student's t-statistic for each participant) for tongue height, lip protrusion and aperture as the dependent variables respectively. The statistical analyses were primarily conducted utilizing the GLM syntax in SPSS (http://www-01.ibm.com/software/analytics/spss/), with minor further investigations employing the affix package in R (http://www.r-project.org). Maulchy's test for Sphericity was employed and where sphericity was violated the Greenhouse-Geisser method was utilized to correct degrees of freedom. Additionally, simple main-effects analysis with a Bonferroni correction (significance at $p < 0.05$), was employed to further investigate any significant effects found in the repeated measures ANOVAs.

Tongue Height

Maulchy's test for sphericity regarding the 2x2x3 ANOVA for tongue height indicated a violation. A 2x2x3 repeated measures ANOVA yielded statistically significant differences between the means of Target Syllables, $F(1.12, 10.04) = 55.41$, $p = 0.0001$, $\eta^2_G = 0.84$, as well as significant interaction between the Target Syllables and the Speech Production method, $F(1.43, 12.91) = 7.51$, $p = 0.01$, $\eta^2_G = 0.03$. As illustrated in Figure 2, simple main effects post-hoc tests (Bonferroni corrected) on the estimated marginal means revealed significant mean differences ($p < 0.05$) in both vocalized ($p < 0.001$, < 0.001, M=1.919, 2.034, SE = 0.172, 0.164, 95% CIs [1.415, 2.423], [1.553, 2.516]) and mouthed ($p < 0.001$, < 0.001, M=1.757, 1.729, SE = 0.174, 0.121, 95% CIs [1.247, 2.267], [1.375, 2.083]) syllables of /ɹa/ and /wa/ compared to /ɹi/ respectively. Additionally, post-hoc tests indicated that the mean difference between vocalized and mouthed conditions only proved statistically significant for /wa/ ($p = 0.004$, M=0.159, SE = 0.042, 95% CI [0.064, 2.53]) as displayed in Figure 2 (error bars in the graphs correspond to the standard error of the mean in all figures). These results suggest that participants exhibited an attenuation in tongue height during mouthing versus vocalized conditions in /wa/ utterances. However, the current measurement of participant tongue height appeared to be statistically unaffected by the Social Engagement conditions, in line with the initial hypothesis. These results appear to indicate that tongue height attenuation during mouthed compared to vocalized speech is observed for certain syllables, and is unaffected for others.

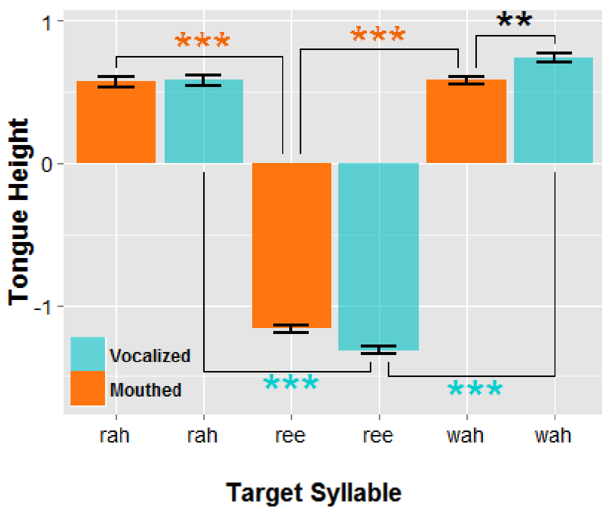


Figure 2: Post-hoc pairwise comparison regarding the interaction between Target Syllable and Speech Production method yielded significant mean differences in both vocalized ($p < 0.001$, < 0.001) and mouthed ($p < 0.001$, < 0.001) conditions. Note the significance values pertain to comparisons indicated by the brackets and are colour coded by Speech Production method. $p < 0.05$*, 0.01**, 0.001***.

Lip Protrusion

Similar to the results for Tongue Height, Maulchy's test for sphericity indicated that the Greenhouse-Geisser correction should be employed. As per the analysis of tongue height, a 2x2x3 repeated measures ANOVA regarding lip protrusion was conducted. Critically only the main effects of the method of Speech Production, $F(1, 9) = 10.85$, $p = 0.009$, $\eta^2_G = 0.10$, as well as Target Syllable, $F(1.27, 11.39) = 17.20$, $p = 0.0009$, $\eta^2_G = 0.19$, proved statistically significant. Bonferroni adjusted pair-wise post-hoc comparisons (see Figure 3) indicated an increase in lip protrusion for mouthed compared to vocalized utterances ($p = 0.009$, M=0.308, SE = 0.093, 95% CI [0.096, 0.519]), as well as for /wa/ compared against /ɹa/ and /ɹi/ ($p = 0.009$, 0.001, M=0.5, 0.456, SE = 0.125, 0.081, 95% CIs [0.133, 0.866], [0.219, 0.694]) respectively.

Participants appeared to exhibit more lip protrusion during mouthed compared to vocalized utterances. The differences in lip protrusion between the syllables appear to pattern in a related, but inverse manner to the tongue height data. Specifically, /wa/ exhibited an increased degree of lip protrusion comparative to /ɹa / and /ɹi/, as shown in Figure 4. However, lip protrusion measures in participants appear to be inert to the Social Engagement conditions, contra to our hypotheses.

While providing merits in isolation, measurements of lip protrusion only provide a single metric of assessing the external regions of the vocal tract, hence, the results of this data should be considered in correspondence with those of lip aperture.

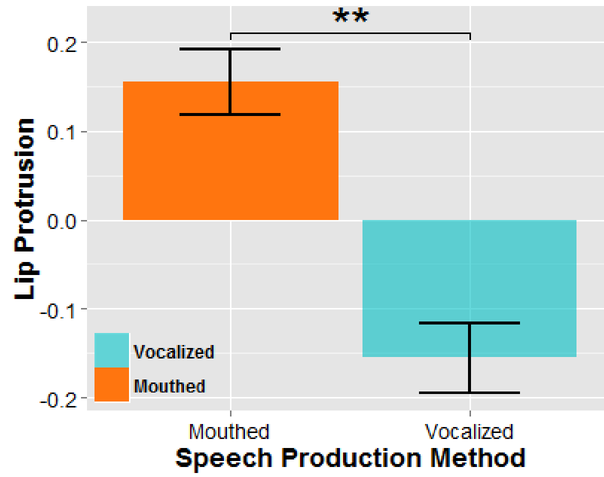


Figure 3: Post-hoc pairwise comparison regarding the main effect of Speech Production method. Lip protrusion increased significantly for mouthed compared to vocalized utterances ($p = 0.009$). p <0.05*, 0.01**, 0.001***

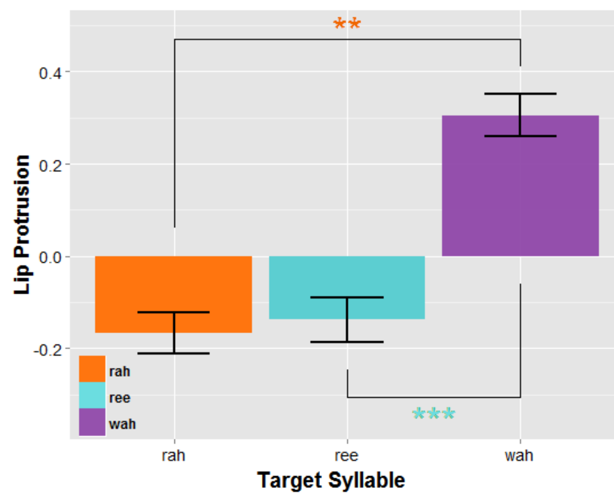


Figure 4: Post-hoc pairwise comparison regarding the main effect of Target Syllable. Lip protrusion was significantly different for /wa/ compared against /ɹa/ and /ɹi/ ($p = 0.009$, 0.001) respectively. Note the significance values pertain to comparisons indicated by the brackets and are colour coded to indicate the comparative difference in means regarding /wa/. $p < 0.05$*, 0.01**, 0.001***.

Lip Aperture

Results from the 2x2x3 repeated measures ANOVA regarding standardized measurements of lip aperture indicated statistically significant results for the main effect of Target Syllable, $F(1.65, 14.85) = 5.02$, $p = 0.03$, $\eta^2_G = 0.21$, as well as a significant interaction between whether participants were vocalizing or mouthing and the Social Engagement condition, $F(1, 9) = 6.62$, $p = 0.03$, $\eta^2_G = 0.01$. Bonferroni corrected post-hoc pairwise comparisons regarding the Target Syllables yielded non-significant results for all pairwise comparisons. Similar applications of the post-hoc procedure to the interaction yield a singular statistically significant mean difference between Social

Engagement conditions when participants were vocalizing. Specifically, participants exhibited smaller lip apertures during vocalization in the Not Present condition compared to when an interlocutor was Present and Gesturing (p = 0.025, M=0.187, SE = 0.069, 95% CI [0.030, 0.344]) as displayed in Figure 5. Interpretation of these results may benefit from disclosure that a visual inspection of this data indicated a greater degree of participant variability compared to the tongue height and lip protrusion metrics. For instance, the standard error regarding the difference between the means of participants mouthing in the Not Present condition and those obtained from participants when vocalizing in the Present and Gesturing condition are approximately three times greater than those of the statistically significant comparison despite visually similar disparities in magnitude (see Figure 5).

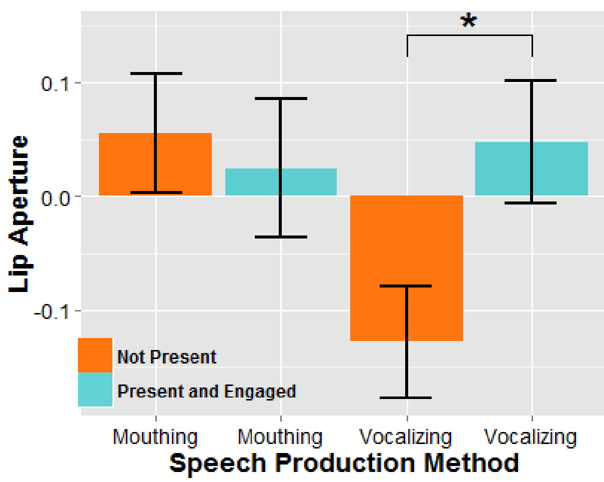


Figure 5: Post-hoc pairwise comparison regarding the interaction between Speech Production method and Social Engagement conditions. Participants exhibited smaller lip apertures during vocalization alone compared to when an interlocutor was present (p = 0.025). p < 0.05*, 0.01**, 0.001***.

4. Discussion

This study examined the effects of mouthing vs. vocalizing and interlocutor presence vs. absence on the movements of visible and non-visible articulators. Previous studies on speech in noise [6, 10] found increased movement in the visible articulators during speech in noisy environments. Ménard's [17] study on blind speech supports the notion that visible articulators are used by sighted speakers to convey speech information. In this context, our study was designed to shed more light on the possible differential uses of visible and non-visible articulators by sighted speakers in the absence of noise. We will discuss our findings in relation to our hypotheses provided in the introduction and will conclude with some elaborations that go beyond these hypotheses.

Firstly, we predicted that tongue movement would be unaffected by Speech Production method (mouthed/vocalized) and Social Engagement condition (presence/absence of an interlocutor). Considering /wa/, this was not the case with regard to Speech Production method. Mouthed speech showed significantly less articulatory movement as compared to vocalized speech. This finding may be explained by the fact that in the absence of an acoustic signal, it is not necessary for the tongue to hit an articulatory target. For the remaining two syllables, however, our hypothesis was confirmed: tongue height was unaffected by the changes in speech condition. Further, none of the Target Syllables were significantly affected by the Social Engagement conditions. Hence, we interpret these results as a partial validation of our initial hypothesis. The major differences in tongue height between the individual syllables /ɹa/, /wa/ and /ɹi/ can probably be ascribed to articulation differences due to the following vowel. One reason why /wa/ stands out as the only syllable showing a significant effect might be that the lips are perceptually more prominent during the articulation of /w/ versus /ɹ/. We can therefore not rule out that the tongue height findings are associated with the differences in lip movement. The finding that tongue height is statistically unaffected by the Social Engagement conditions does not come as a surprise since non-visible articulators are not expected to be affected by the presence of an interlocutor.

Secondly, we predicted that lip movements would increase in magnitude in mouthed conditions. In line with this prediction, results indicated that participants increased lip protrusion during mouthed utterances compared to vocalized utterances. The individual differences for the Target Syllables resemble the pattern that emerged for the tongue height data. Specifically, /wa/ exhibited a significantly increased degree of lip protrusion compared to /ɹa/ and /ɹi/. This implies a trade-off between tongue position and lip protrusion in /wa/. A similar trade-off has been previously observed between the tongue body and lip rounding for the vowel /u/ [19]. The measurements in lip aperture, however, did not produce any valuable insight for the distinction between mouthing and vocalizing.

Thirdly, we predicted that lip movements would increase in magnitude with the presence of an interlocutor. We therefore expected participants to produce articulations with greater protrusion and smaller aperture when an interlocutor was present. The findings for lip protrusion were not affected by Social Engagement condition. However, lip aperture showed a significant effect of Social Engagement, albeit in the direction opposite to what we predicted. During vocalized speech, participants produced smaller lip apertures when they were vocalizing alone, compared with when an interlocutor was Present and Gesturing. This was a surprising finding considering our prediction, but the relatively smaller aperture in the Not Present condition may be related to the lack of a communicative partner. Under this condition, because there is no communicative reason to make visual cues salient, participants may produce less dynamic articulations in general, maintaining a relatively more closed mouth across the entire utterance. In contrast, the presence of an interlocutor introduces a situation under which visual cues are useful and participants therefore respond more dynamically.

Though participants behaved in a way that contradicted our third prediction, the data can still be interpreted as demonstrating the sensitivity of visible articulators to the Social Engagement conditions in a way that supports a multimodal view of speech. Specifically, the observed interaction for lip aperture may only arise as the visual domain becomes relevant for communicative purposes. Lesser lip protrusion in blind participants compared to sighted [17] as well as the increase of lip protrusion under the effects of noise [5, 6, 10, 12] would appear to support these observations. However, under this interpretation it is unclear why no effect is observed in the mouthing condition when an interlocutor is present.

It is worth noting the limitations of our methodology. The measurement techniques we employed measured the maximal point of constriction of the Target Syllables. However, this measurement is static rather than dynamic, we were therefore unable to capture the amount of overall movement in each articulation. A more dynamic method of measurement which is able to capture movement could potentially be beneficial in obtaining data which more accurately depicts levels of movement/activation in speech gestures under these different speech conditions. Regarding the third hypothesis, a suggestion from an editor of this paper was that the perceived friendliness of the interlocutor could have influenced participant tendencies to display positive affect using the visible articulators (i.e. via smiling), and that this impacted lip aperture values. While we did look at naturalness and friendliness to ensure reliability and validity of our experimental conditions, our study was not designed to examine naturalness or friendliness as statistical factors. However, these would be interesting directions for future study.

Our findings suggest that speakers make use of both the auditory and visual speech signals and are aware of the information available to their interlocutor. To aid in communication, compensations are made when information from one of these signals is unavailable. Potential future research should investigate how the various visible and non-visible articulators respond dynamically under social engagement conditions.

Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author and Contributors

Authorship has been separated into two tiers, each ordered alphabetically (excluding the last author). Contributions within each tier were approximately equal.

Acknowledgements

The authors gratefully acknowledge funding provided by an NSERC Discovery Grant awarded to Bryan Gick, and by NIH Grant DC-02717 to Haskins Laboratories. We also thank Dr. Lawrence Ward and Grace Truong for consultation relating to analysis, Nicole Anger, Leighanne Chan, Lewis Haas and Taylor Poulin for their involvement in video frame extraction and measurement and Sarah Tarnowsky for assistance with editing the figures.

References

[1] J. B. Bavelas, J. Gerwing, C. Sutton, and D. Prevost. Gesturing on the telephone: Independent effects of dialogue and visibility. *J. Mem. Lang.* 58: 495-520, 2008.

[2] F. Campbell, B. Gick, I. Wilson, and E. Vatikiotis-Bateson. Spatial and temporal properties of gestures in North American English /r/. *Lang. and Speech* 53: 49-69, 2010.

[3] G. Calvert, C. Spence, B. E. Stein, and MIT CogNet. *The handbook of multisensory processes*, 2004. Cambridge: MIT Press.

[4] E. Cvejic, J. Kim, and C. Davis. Effects of seeing the interlocutor on the production of prosodic contrasts (L). *J. Acoust. Soc. Am.* 131(2): 1011-1014, 2012.

[5] C. Davis, J. Kim, K. Grauwinkel, and H. Mixdorff. Lombard speech: Auditory (A), Visual (V) and AV effects. *Speech Prosody*, Paper 252, 2006. Dresden, Germany.

[6] M. Fitzpatrick, J. Kim, and C. Davis. The effect of seeing the interlocutor on speech production in different noise types. *Interspeech* 12: 2829-2832, 2011. Florence, Italy.

[7] M. Garnier, L. Ménard, and G. Richard. Effect of being seen on the production of visible speech cues. A pilot study on Lombard speech. *InterSpeech* 13: 611-614, 2012.

[8] B. Gick. From Quantal Biomechanics to Whole Events: Toward a Multidimensional Model for Emergent Language. *Can. Acoust.* 40.3: 24-25, 2012.

[9] B. Gick. Articulatory correlates of ambisyllabicity in English glides and liquids. *Papers in Laboratory Phonology VI: Constraints on Phonetic Interpretation*, eds. J. Local, R. Ogden and R. Temple, 222-236, 2003. Cambridge: Cambridge University Press.

[10] V. Hazan, and J. Kim. Acoustic and visual adaptations in speech produced to counter adverse listening conditions. *Proceedings of Auditory-Visual Speech Processing*, 93-98, 2013. Inria: Rocquencourt, France.

[11] C. Herff, M. Janke, M. Wand, and T. Schultz. Impact of different feedback mechanisms in EMG-based speech recognition. *Interspeech* 12: 2213-2216, 2011. Florence, Italy.

[12] J. Kim, C. Davis, G. Vignali, and H. Hill. A visual concomitant of the Lombard reflex. In *Audio-Visual Speech Processing* 17-22, 2005. British Columbia, Canada.

[13] E. Lombard. Le signe de l'élévation de la voix. *Annales des maladies de l'oreille et du larynx*, 37: 101–119, 1911.

[14] D. W. Massaro, and M. M. Cohen. Perception of synthesized audible and visible speech. *Psychol. Sci.* 1: 55-63, 1990.

[15] Mayer, C., Gick, B., Weigel, T., & Whalen, D. H. Perceptual effects of visual evidence of the airstream. Proceedings of Acoustics Week in Canada. *Can. Acoust.* 41: 23-27, 2013.

[16] H. McGurk, and J. MacDonald. Hearing lips and seeing voices. *Nature* 264: 746-748, 1976.

[17] L. Ménard, A. Leclerc, A. Brisebois, J. Aubin, and A. Brasseur. Production and perception of French vowels in blind speakers and sighted speakers. International Seminar

on Speech Production (ISSP 2008), 197-200, 2008. Strasbourg, France.

[18] L. Mol, E. Krahmer, A. Maes, and M. Swerts. Seeing and being seen: the effects on gesture production. *J .Comp. Med. Comm.* 17(1):77-100, 2011.

[19] J. S. Perkell, M. L. Matthies, M. A. Svirsky and M. I. Jordan. Trading relations between tongue-body raising and lip rounding in production of the vowel /u/: A pilot "motor equivalence" study. *J. Acoust. Soc. Am.* 93(5):2948-2961, 1993.

[20] I. Stavness, B. Gick, D. Derrick, and S. S. Fels. Biomechanical modeling of English /r/ variants. *J. Acoust. Soc. Am. Express Letters* 131(5): 355-360, 2012.

[21] W. H. Sumby, and I. Pollack. Visual contribution to speech intelligibility in noise. *J. Acoust. Soc. Am.* 26(2): 212-215, 1954.

[22] A. Q. Summerfield. Use of visual information for phonetic processing. *Phonetica* 36: 314–331, 1979.

[23] W. V. Summers, D. B. Pisoni, R. H. Bernacki, R. I. Pedlow, and M. A. Stokes. Effects of noise on speech production: acoustic and perceptual analyses. *J. Acoust. Soc. Am.* 84(3): 917-28, 1988.

[24] L. A. Ross, D. Saint-Amour, V. M. Leavitt, D. C. Javitt, and J. J. Foxe. Do You See What I Am Saying? Exploring Visual Enhancement of Speech Comprehension in Noisy Environments. *Cereb. Cortex* 17: 1147-1153, 2007.

My Ears Are Alight

Per Hiselius*
3M Personal Safety Division, 3M Svenska AB, Box 2341, Malmstensgatan 19, SE-331 02 Värnamo, Sweden

Résumé

Les capacités du système auditif humain sont phénoménales. La plage dynamique qu'il supporte, la plage de fréquences qu'il couvre, et également, sa capacité à détecter et identifier la parole en présence de bruits parasites sont étonnantes. Dans la vie quotidienne, on utilise ces capacités de différentes façons: la communication orale, les alertes et les alarmes, l'analyse des appareils et des machines comme les ordinateurs et les voitures. Par exemple, "Est-ce que mon appareil est en marche ?", "Est-ce qu'il semble fonctionner normalement ou est-ce que quelque chose ne va pas?". De plus, nous utilisons aussi notre système auditif pour diverses formes de divertissement. Le revers de la médaille de ses capacités magnifiques est qu'elles posent des difficultés par exemple lors de la conception des bâtiments, des machines et d'appareils électroniques comme les téléphones mobiles, les ordinateurs, les écouteurs, les microphones, etc. Et bien que nous ayons cette capacité phénoménale à comprendre la parole dans les situations difficiles, on a souvent du mal à entendre ou du mal à comprendre. De plus, le système auditif humain s'abîme facilement. Ce document présente d'anciens et de nouveaux résultats de recherches liés aux capacités du système auditif et quelques-uns des challenges posés par ce dernier. Le contenu de cet article a été présenté lors de la Semaine canadienne de l'acoustique 2014 (Acoustics Week in Canada 2014) lors de l'une des trois présentations plénières invitées.

Mots clefs: système auditif, plage dynamique, plage de fréquences, parole dans le bruit, perte auditive

Abstract

The capability of the human auditory system is phenomenal. The dynamic range it can handle, the frequency range it covers, and, not the least, its ability to detect and identify speech in the presence of interfering sounds is astonishing. In daily life we use this capability in many ways. We use it for speech communication as well as for alerts and alarms. We use it for analysis of devices and machines, e.g. our computers and cars. Is it on? Does it sound normal, or is something wrong? We also use it for various forms of entertainment. However, there's a flip side to the great capability. From an engineering point of view it poses challenges when designing buildings, machines, and devices such as phones, computers, headphones, microphones, etc. And although we have a phenomenal ability to understand speech in challenging situations, we often mishear or misunderstand. Human hearing is also quite easily damaged. This paper presents old and new results related to the capability of our hearing, and some of the challenges related to the same. The content of this article was presented at the Acoustics Week in Canada 2014 as one of three invited keynote presentations.

Keywords: auditory system, dynamic range, frequency range, speech in noise, misheard lyrics, hearing loss

1 Our Hearing is Remarkable

The international space station orbits the earth at an altitude of about 400 km [1]. Let's assume that it sends out a 1 W signal from an omnidirectional antenna. By the time the signal reaches our planet the 1 W signal is spread out across a sphere having an area of two million square kilometers. Assuming no losses or reflections along the way the intensity would at that point be approximately 0.5×10^{-12} W/m^2. A sound wave of that intensity is audible for many people if presented as a pure tone around 3.5 kHz in a perfectly quiet room.

The shape of the human ear canal is quite complicated and varies significantly between individuals. But let's assume an ear canal having a diameter of 7 mm and a length of 26 mm. Let's also assume it has a perfectly cylindrical shape, rigid walls, and a rigid eardrum. An intensity of 10^{-12} W/m^2 equates to a sound pressure of 2×10^{-5} Pa which is defined as0 dB, and can be perceived under perfect circumstances. An insert type headphone with a speaker diaphragm covering the entire cross-section of the ear canal, would only have to move about 10 pm, i.e. 10^{-11} m, peak-to-peak, to generate this sound pressure, at which point the movement of the eardrum is in the order of 1 pm, or 10^{-12} m [2]. To produce a sound pressure level of 120 dB the diaphragm would still only have to move 0.01 mm. The required displacement of the diaphragm, and the movement of the eardrum, may be compared to the radii of atoms, ranging between 30 and 300 pm [3].

In short, the human ear is sensationally sensitive. At the same time even some of the more stringent safety regulations around the world, such as the Swedish Work Environment Act [4], allow workers to be exposed to levels up to 115 dB(A) - although the permitted daily noise exposure will be reached within half a minute.

* per.hiselius@mmm.com

A dynamic range of 115 dB equals a ratio of $0.56x10^6$, i.e. the sound pressure at 115 dB is almost one million times higher than that of 0 dB. Expressed in terms of intensity, a sound wave at 115 dB carries almost one trillion times more energy per second than one at 0 dB. The dynamic range covered by our hearing is truly amazing.

The frequency range covered by the human hearing spans over 3 decades, or 10 octaves. As a comparison, a microwave antenna advertised as an "ultra-wideband microwave antenna" may cover significantly less than one octave. Some motorcycle engines may rev up to 12,000 rpm, at which point each piston completes 200 cycles every second - propelled by 100 explosions every second - typically generating 10 kilowatts per cylinder, or more. An even higher rpm would mean even more frequent explosions, and thus more power. But the inertia of the pistons, valves, fuel mixture, and exhaust fumes, makes it an enormous challenge to increase the revs without losing efficiency. To perceive 20,000 Hz our eardrums need to complete 20,000 cycles every second, propelled only by the sound pressure, having intensities in the order of magnitude of nanowatts[i] per square meter. This must be considered a remarkable achievement.

Another remarkable achievement of our hearing ability is signal and speech recognition. In a situation where the signal-to-noise-ratio (SNR) is only 10 dB a person with normal hearing will still be able to understand most of what is said [5], regardless of the type of speech material being used. In a study [6] using military call signs it was shown that, in white noise, test subjects were able to correctly perceive 65,88% of the call signs at an SNR of -18 dB. To compare the RMS levels of two very different types of signals can be problematic. An SNR of -18 dB implies that the amplitude of the noise is 8 times higher than that of the speech. However, speech is an irregular signal with pauses, and will have bursts that are significantly louder than the average RMS level. Nonetheless, as can be seen in Figure 1, at an SNR of -18 dB the speech signal is completely masked by the noise. Even so, a trained person still has the capacity to correctly perceive almost two out of three call signs. This would not be possible if the speech material consisted of totally random words selected from an infinitely long list. Further, white noise is primarily a high frequency type of noise[ii], and the auditory masking will therefore be less severe than if the noise had been a low frequency type of noise, with a spectrum more similar to that of speech. The test participants in [5] were also well motivated, and situated in a lab environment without distractions. But the achievement is still astonishing.

In a recently developed test [7] aimed to investigate the impact hearing protectors have on the perception of speech in noise, it was shown that in a low frequency type of noise test normal hearing test participants were able to correctly identify more than 50% of the words presented at an SNR of -17 dB.

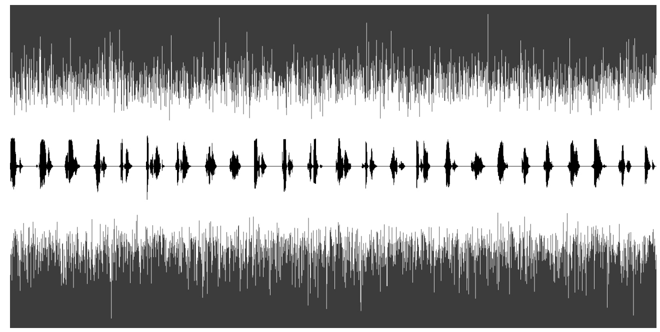


Figure 1: Time signals of words (black signal) and white noise (white signal) at an SNR of -18 dB.

This was again under perfect circumstances, but the result supports the Blue-Terry & Letowskistudy [6]. In fact, in the more recent study [7], which had a more challenging low frequency type of noise, test subjects quite frequently managed to correctly identify four consecutive words in an SNR of less than -20 dB. This could happen by chance, given the limited number of words used in the test, but it would (almost) literally be a one-in-a-million chance. It's safe to say that the capability of the human auditory system is remarkable.

2 Challenges and Risks

The great capability of our hearing is valuable in our daily life, but also poses challenges. Being exposed to undesirable sounds affects our quality of life, and even our health. The sensitivity of our hearing, and the fact that it never sleeps, complicates the planning of cities, roads, railroads, airports, industries, etc. For many people one of the biggest financial investments of their lives will be buying a house or a car. Because of our sensitive hearing, the design of houses have to be more complex due to the need for soundproofing and they thus become more expensive to build. In a modern car, where reducing weight is critical for reducing the fuel consumption, soundproofing may account for up to 25% of the total weight [8a, 8b]. Even if it's just half of that it will still add more weight to a normal car than does the engine and transmission. There's no doubt that acoustics has a major impact on our society, and on our lives.

The high dynamic range adds further complications. We use decibels, which is a logarithmic scale. But most people cannot intuitively interpret a scale where 80+90=90, or 92, depending on whether we are adding intensities or sound pressures. And because the sensitivity of our hearing is level- as well as frequency dependent- we need different weighting schemes, such as dB(A) and dB(C). In spite of great effort there are still no perfect measures neither to predict perceived loudness, nor to accurately predict the risk of acquiring a hearing damage. There are several measures available, but they all have shortcomings. The capability and complexity of our hearing is simply too great to allow it to be explained by simple metrics. Consequently, one can often see the wrong unit of measure being used, and the right one being misinterpreted.

[i] One nanowatt per square meter equals 30 dB.

[ii] A source producing white noise will, on average, produce the same power at all frequencies. However, per frequency band the power will increase by 3dB/octave which is why it's perceived as a quite sharp, high pitched, type of noise.

Music is an important part of most societies. It's a major industry, and plays a major role in many people's lives. When it comes to loudspeakers and headphones the hunt for perfect fidelity or for the perfect sound - which may not necessarily be the same as perfect fidelity - is still on. Manufacturers of microphones are still trying to match the frequency range as well as the dynamic range of our hearing. It's still is a major challenge to match the capability of our hearing.

While the lower end of the dynamic range is challenging from an engineering point of view, the opposite end of the range is problematic from a quite different point of view. It's fairly easy to produce high sound levels. All you need is a hammer and a hard surface to produce peak levels that are hazardous. But the short duration of the peaks make us underestimate the level [10]. Most modern movie theaters are capable of producing sound levels that are damaging, not to mention the levels produced at many music events. An intense light is unpleasant, and we will automatically look aside or close our eyes. Our hearing, on the other hand, can tolerate harmful levels without necessarily causing us any pain or discomfort; when listening to music, it may even provide great pleasure. The sound of roaring engines may also be perceived as immensely enjoyable, while inflicting permanent damage to the hearing of the listener. Unfortunately the annoyance (or perceived pleasure) generated by loud sounds, does not correlate with their potential to cause hearing damage. And even if we would like to, we can neither close our ears nor 'look away' from sound.

There was a time when reproducing music at high sound levels required some effort. Powerful amplifiers were heavy and expensive, and had to be combined with big, bulky, loudspeakers. Today we just have to buy an mp3 player and a pair of headphones to produce extreme levels. As previously mentioned, it's easy to produce high sound levels in a small enclosure such as an ear canal. This has been recognized in Europe, where there's a directive requiring compliance to a standard stating the maximum permissible output voltage of music players, as well as the maximum sensitivity of headphones [11]. The combination of the two ensures that the average level does not exceed 100 dB(A). However, for workers there's a European directive [12] stating an exposure limit equivalent to 87 dB(A) for eight hours, and many countries have enforced a more strict limit equivalent to 85 dB(A) for eight hours. With a music player producing 100 dB(A) a dose equivalent to 85 dB(A) for eight hours will be reached within 15 minutes. To reach the 87 dB(A) limit will take an additional 10 minutes.

For some reason we seem to accept damage to our hearing when listening to music, or attending motor shows and other venues with high sound levels. But it's not acceptable at our workplace, and we would most likely not accept damage to our eyes when watching a movie or when attending concerts and other events.

When our hearing is damaged it will often result in a shift of our hearing threshold, which can be measured. But again, our hearing cannot be described by simple metrics. Hearing damage may result in many other types of complications, such as tinnitus, reduced dynamic range, reduced frequency resolution, reduced temporal resolution, and hyperacusis (abnormal sensitivity and pain caused by even relatively quiet sounds). As a result, the performance and capability of our hearing may be greatly reduced also in ways that are more difficult to quantify, and for which a hearing aid cannot compensate. A common complaint among people with a sensorineural hearing loss is that they have difficulties following a conversation in the presence of an interfering noise - especially if that noise is made up from other people's voices, i.e. babble or cocktail noise. When our amazing ability to understand speech in noise is reduced it may greatly affect our professional, as well as social, life. Hearing damage may also affect our ability to appreciate music and sounds of nature.

Communication is a vital part of our life. Today, phones are used more than ever for various forms of communication. When it comes to speech communication a mobile phone, or cell-phone, is quite an advanced piece of equipment. Again, our excellent hearing makes it a challenge to design the device. When comparing a modern phone to an old land-line phone the most striking difference is perhaps in the shape of the device. A traditional land-line telephone is typically designed so that the mouthpiece, i.e. the microphone, can be positioned close to the mouth. Further, the earpiece is typically designed so that it can cover most of the outer ear, thus creating a baffle for the loudspeaker (earpiece) and also allow ambient noise to be reduced by at least partially blocking the outer ear. The long distance between the loudspeaker and the microphone will also reduce the risk for acoustics feedback and echoes. A traditional land-line phone is thus well suited for its purpose, unlike a modern mobile phone.

Not only do size constraints on modern phones require small components, but the microphone is often positioned far away from the mouth of the talker, and relatively close to the earpiece. As a result, the microphone gain needs to be high, and the sound from the earpiece is easily picked up by the microphone. This sound will not only transmit via the surrounding air on the exterior side of the phone, but also via the interior of the phone, and it may be air-borne as well as structure-born, or a combination of the two. In fact, at the microphone, the far end voice may be considerably louder than that of the person talking into the microphone. This calls for several actions. Without active echo cancelation in the near end phone, the far end talker would hear her or his own voice as a clear, distinct, and loud echo. To cancel out the echo without affecting the desired signal is difficult - especially when using miniature speaker components pushed to the limit, providing a fair amount of distortion. A great distance between the mouth and the microphone makes the signal to noise ratio at the microphone poor if the phone is used in a noisy environment. To lessen this problem, phones use multi-microphone solutions for noise suppression. Further noise suppression may be applied by the near end phone, by the network, as well as by the far end phone. To reduce noise is not difficult. The challenge is to do so without affecting the quality of the speech signal. To actually improve intelligibility is even more difficult because of our amazing ability to perceive speech in noise. When applying noise reduction, inevitably the speech signal will be affected to some extent, and this may instead have a negative effect on our ability to correctly perceive what is being said - even if the SNR is improved.

Our phones do not only reduce noise, they also intentionally add noise. To reduce the bandwidth required for a phone call every cell-phone has a voice detection system and will only transmit a signal when it detects a speech signal. At the receiving side, the far end, it may therefore become quiet when there's a pause in the speech at the near end. However, we constantly use our hearing as a tool to analyze what's going on around us, and we are likely to assume that a call has been terminated if it becomes perfectly quiet. On the receiving end the phone will therefore generate a noise similar to that of the background noise from the far end, and in every pause it will apply this artificial noise, called comfort noise. There is, of course, additional signal processing going on during a voice call. To further improve the perceived sound quality there's compression and equalization applied, not to mention all the coding, recoding, and decoding going on in the phones and networks. However, since our hearing is so well adapted for recognizing natural speech in noise it's again difficult to actually improve intelligibility. On the contrary, signal processing can easily reduce both the intelligibility and the perceived quality of a voice call.

Another, related, area is speech recognition and text-to-speech. Every smartphone has some form of text-to-speech engine installed or available for download. They can do an excellent job, and it's not always easy to tell the difference between a genuine human voice and an artificial one, at least not if there's a background noise adding some degree of masking. However, many words are spelled the same but pronounced differently, and have different meanings, i.e. heteronyms such as address, bow, row, wind, etc. These words will generally be used in some kind of context making it obvious to a human how to interpret, and pronounce, the words. This task is much more difficult for a phone or a computer. We use the very same ability when we interpret speech where homophones may be an issue, i.e. words pronounced the same way having different meanings.

If a speech signal contains homophones, is too soft to be clearly perceived, if there's an interfering sound masking a major part of the speech, or when a word is mispronounced, we use additional cues. The subject and context of the conversation, the situation and general circumstance, and, not the least, specific visual cues, may dramatically improve our ability to understand what's being said. This is why the speech recognition of our smartphones cannot compare to that of a real person. Our ability to recognize patterns, and to 'fill in the gaps' is quite remarkable. This is partly why we, under perfect circumstances, can correctly recognize words even when the signal to noise ratio is less than -20 dB. However, this ability may backfire. When we fill in the gaps we sometimes get it wrong. As a result we cannot trust our hearing. An obvious proof of this is all the internet sites posting examples of misheard lyrics[iii]. On a more serious note, the fact that we quite frequently mishear can also cause or worsen disputes and conflicts.

3 Conclusion

In conclusion, the capability of human hearing is truly phenomenal. It has a great impact on our lives and our society, and still poses challenges for engineers. Unfortunately it's also very susceptible to damage, and we can't trust our intuition when assessing the risk related to a noise exposure. We need to recognize this fact, and make sure we protect our hearing if we don't want to lose our ability to enjoy music and sounds of nature, or lose our amazing ability to understand speech also in challenging environments. And finally, as much as we would like to, we cannot always trust our hearing.

References

[1] ISSracker, August 2014, *http://www.isstracker.com/*

[2] Hallett, F. R., Speight, P. A., Stinson, R. H. 1977, Introductory Biophysics, New York: *John Wiley & Sons*.

[3] Wikipedia 2014: h*ttp://en.wikipedia.org/wiki/Atomic_radius*

[4] AFS 2005:16, Arbetsmiljöverkets föreskrifter om buller samt allmänna råd om tillämpningen av föreskrifterna, *ISBN 91-7930-455-9, ISSN 1650-3163*.

[5] Steeneken, H.J.M.1992. On measuring and predictingspeechintelligibility.Doctoratethesis*ISBN:90–6743–209–1*.

[6] Blue-Terry, M., Letowski, T. 2011. Effects of white noise on Callsign Acquisition Test and Modified Rhyme Test scores. *Ergonomics*, 54, 139-145.

[7] Hiselius, P., Edvall, N., Reimers, D. 2014, To measure the impact of hearing protectors on the perception of speech in noise. *Int J Audiol*. 2014 Dec 30:1-6(Epub ahead of print).

[8b] SEMCON 2014a: *http://www.semcon.com/en/Industry-solutions/Automotive-en/Technology-roadmap/Light/*

[8a] SEMCON 2014b: *http://www.semcon.com/Global/Docs/AUTOMOTIVE/Semcon_CFRP_Acoustics.pdf?epslanguage=en*

[9] Peus, S. 2004, Modern Acoustic and Electronic Design of Studio Condenser Microphones, *AES E-Library*, AES Convention:116 (May 2004)

[10] Brüel. P. V. 1976. Do We Measure Damaging Noise Correctly?

[11] *EN 60950-1:2006*: Information technology equipment - Safety -Part 1: General requirements.

[12] *Directive 2003/10/EC* of the European Parliament and of the Council, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise).

Editorial Note: ***This manuscript is published as an invited tutorial paper and meets peer-review criteria that are different than for regular research papers.***

[iii] Recommended phrases to use when searching for misheard lyrics: "me ears are alight", "misheard lyrics blinkbox music survey", and "commonly misheard lyrics".

ACOUSTICS WEEK IN CANADA 2016

September 21-23, 2016, Vancouver, British Columbia

Conference Co-chairs: Kathy Pichora-Fuller, University of Toronto
Clair Wakefield, Wakefield Acoustics, Victoria, BC

Welcome to Vancouver!

Vancouver looks forward to welcoming delegates to the 2016 Acoustics Week in Canada. Acoustics researchers, professionals, educators, and students from across the country are welcomed to Canada's scenic West Coast for three days of plenary lectures and technical sessions. The Canadian Acoustical Association Annual General Meeting will be held in conjunction with the conference, along with the Acoustical Standards Committee Meeting and an exhibition of acoustical equipment and services. There will be an opening reception on Wednesday September 21st, at the end of the first day of the conference, and the Awards Banquet will be held the next evening, on Thursday September 22nd. The World Congress of Audiology is an associated event that will be held only a few blocks away earlier in the same week from September 18th-21st.

The Canadian Acoustical Association conference will be held at the Sutton Place Hotel, a short walk from the Robson Street shopping area and Stanley Park with its over 1000 acres of land where you can visit the Vancouver Aquarium or enjoy walks in the forest, on the beach or along over 20 km of the Seawall. Vancouver is "spectacular by nature". It is a truly unique and world-class city. It has a mild climate, is safe, clean and friendly. You will find a blend of cosmopolitan amenities, natural splendor and cultural attractions. There are stadiums, dining, shops, art galleries, museums and entertainment within walking distance or easily accessible by a public transportation system of "Sky Trains" and buses. Or you could rent a bicycle and use the network of specialized bike lanes to get around the city like a local. It is a great city to see with your family.

There are lots of exciting options if you have time to extend your travels in conjunction with the conference. Vancouver is 1.5 hours from Whistler and 3 hours from Seattle. If you want to go further, then it is a 1.5-hour sail on BC Ferries through the Gulf Islands to visit Victoria on Vancouver Island. Or you could take a cruise to Alaska from Vancouver before the close of the season in early October.

Plenary Lectures

Each day of the conference will begin with a plenary lecture by a leading expert.

Wednesday September 21st: **Judy R. Dubno** from the Medical University of South Carolina will talk about age-related hearing loss and how interdisciplinary teams can advance research and practice in acoustics.

Thursday September 22nd: **Thais Morata** from the National Institute for Occupational Safety and Health (NIOSH) and the Center for Disease Control (CDC) will talk about hearing loss prevention in 2016 and modern ways to communicate to the public about hearing health and noise.

Friday September 23rd: **Bryan Gick and Sid Fels** from the University of British Columbia will talk about interdisciplinary approaches for advancing articulatory speech theory and synthesis by combining linguistics with electrical and computer engineering.

Technical Sessions

Technical sessions will cover all major areas of acoustic interest, including Hearing Loss Prevention, Acoustical Standards, Architectural Acoustics, Noise Control, Shock and Vibration, Hearing and Speech Sciences, Musical Acoustics, Underwater Acoustics, Marine Bioacoustics. If you would like to propose and/or organize a special session on a specific topic **please contact Co-Chair Kathy Pichora-Fuller as soon as possible** (conference@caa-aca.ca)**.**

Paper Submissions

The abstract deadline is June 15th, 2016.

Two-page summaries for publication in the proceedings of Canadian Acoustics are due by August 1st, 2016. Please see the conference website for further details.

Exhibition and Sponsorship

There will be an exhibition area for acoustical equipment, products, and services on September 22nd, 2016. If you or your company is interested in exhibiting, or if you would be interested in sponsoring a conference social event, technical session, coffee breaks, or student prizes, **please contact Co-Chair Clair Wakefield as soon as possible** (conference@caa-aca.ca). The conference offers an excellent opportunity to showcase your company and products or services.

Student Participation, Scholarships and Prizes

Students are enthusiastically encouraged to attend the conference and to submit papers. Students whose papers are accepted for presentation can apply for a student conference bursary that will cover one night of accommodation at the Sutton Place Hotel and free registration. Information about applying for a student conference bursary for the conference will be posted soon on the conference website. The deadline will be June 15th, 2016.

Student presenters are also eligible to win prizes for the best paper presentations (three prizes of $500). See the website of the Canadian Acoustical Association for more details about the presentation prizes and other awards for students. Note that the deadline to apply for other CAA student awards is April 30th, 2016.

Hotel Information

The Sutton Place Hotel is located in the heart of downtown Vancouver on Burrard Street near Robson Street. It features a signature restaurant and wine merchant, and an elegance that few hotels can rival, with European charm and exceptional service.
The basic room rate for the conference is $199/night (single or double) plus taxes, including the following:

- **Complimentary Internet:** wireless/high speed internet in guestrooms and wireless internet in function rooms.
- **Health Club and Pool:** Access to the fitness facility and swimming pool complimentary to all overnight guests.
- **The Sutton Shopper Program:** The Sutton Shopper Program, exclusive to the Sutton Place Hotel, will be offered to every guest with the group. This program enables guests to receive discounts between 10% - 30% at over fifty shops and services along the Robson Street shopping corridor.
- **Pre/Post Rates:** The guestroom rates will be extended to our group 3 days prior and 3 days following the inclusive dates of your meeting, subject to availability at the time of booking.

Direct reservations must be made prior to Friday, August 18, 2016. To make reservations, please state that you are coming for the "**Canadian Acoustical Association 2016 Conference**".
Telephone: **1-866-378-8866 (toll-free in Canada and Continental USA)**
Email: **res_vancouver@suttonplace.com**
On Line: **www.vancouver.suttonplace.com**
BOOKING GROUP CODE: VCSEP2016_CAA

Conference Registration

Details will be available shortly at the conference website.
CONFERENCE WEBSITE: http://awc.caa-aca.ca

Important Dates

Before Acoustics Week in Canada
April 30th: Deadline for student to apply for CAA awards to be presented at the Awards Banquet at the conference
June 15th: Deadline for submission of abstracts
June 15th: Deadline for student conference bursary applications
August 1st: Deadline for submission of two-page papers
August 18th: Cutoff date for group hotel reservations
September 18th-21st: World Congress of Audiology*
During Acoustics Week in Canada
September 21st: Plenary talk by Judy Dubno
September 21st: Opening reception
September 22nd: Plenary talk by Thais Morata
September 22nd: Exhibits
September 22nd: Annual General Meeting of CAA members
September 22nd: Awards Banquet
September 23rd: Plenary talk by Bryan Gick and Sid Fels
September 23rd: Announcement of Student Presentation Prizes at the closing lunch.

*World Congress of Audiology

For those who may be interested in attending two meetings while in Vancouver, the 33rd World Congress of Audiology (the meeting of the International Society of Audiology) will be held across the road at the Sheraton Wall Centre from September 18th to September 21st. Please see the WCA website for further information: **http://www.wca2016.ca**

Semaine canadienne d'acoustique 2016

21 au 23 septembre 2016, Vancouver, Colombie-Britannique

Coprésidents du congrès: Kathy Pichora-Fuller, University of Toronto
Clair Wakefield, Wakefield Acoustics, Victoria, BC

Bienvenue à Vancouver!

La ville de Vancouver est heureuse d'accueillir les délégués au congrès de la Semaine canadienne d'acoustique 2016. Les chercheurs et les professionnels en acoustique, de même que les éducateurs et les étudiants de partout au pays sont invités sur la côte pittoresque de l'Ouest canadien pour trois jours de séances plénières et scientifiques portant sur l'acoustique. L'assemblée générale annuelle de l'Association canadienne d'acoustique aura lieu pendant le congrès, ainsi que la rencontre du comité de normalisation en acoustique et une exposition d'équipements et de services. Il y aura une réception à l'ouverture du congrès dans la soirée du mercredi 21 septembre ainsi qu'un banquet de la remise des prix, en soirée du jeudi 22 septembre. Le Congrès mondial en audiologie prendra place dans la même semaine, soit du 18 au 21 septembre, et ce, seulement qu'à deux coins de rue du congrès de la Semaine canadienne d'acoustique

Le congrès de l' Association canadienne d'acoustique se tiendra à l'hôtel Sutton Place, situé à quelques pas des fameuses boutiques de la rue Robson, de même que du Parc Stanley où vous pouvez aussi visiter l'aquarium de Vancouver. Vous pourrez aussi aller faire de longues promenades en forêt, sur la plage ou encore sur le long des 20 km du Seawall et tout ça, à de très courtes distances de l'hôtel. En plus de sa nature mondialement reconnue, la ville de Vancouver jouit d'un climat bien tempéré. C'est une ville où l'on se sent en sécurité et entouré de gens sympathiques. Vancouver regorge d'attraits cosmopolites, tant sur le plan culturel que sur celui de ses richesses naturelles. On y trouve aussi un stade, des restaurants et cafés, des boutiques et galeries d'art, des musées de même que d'autres attraits et tous sont à des distances facilement faisables à la marche ou accessibles avec les transports publics, sans oublier le fameux «Sky Train». Il est aussi possible de louer un vélo et les multiples pistes cyclables de la ville vous permettront de vous promener en ville comme si vous étiez un résident permanent. Vancouver est aussi une ville merveilleuse à visiter en famille.

En plus des multiples attraits de Vancouver, il y aussi des endroits très intéressants à visiter à proximité de la ville. Par exemple, on peut se rendre à Whistler en 1 heure et demie, ou encore à Seattle (États-Unis) en trois heures. Il y a aussi les petites îles du golfe et même l'ile de Vancouver où l'on peut se rendre en traversier, et ce à moins d'une heure et demie de la ville, sans oublier les croisières en Alaska qui sont fonction jusqu'au début du mois d'octobre.

Séances plénières et scientifiques

Chaque jour du congrès débutera avec une séance plénière prononcée par un expert.

Mercredi 21 septembre: **Judy R. Dubno** de la *Medical University of South Carolina* viendra parler sur la perte d'audition associée au vieillissement et comment les équipes interdisciplinaires peuvent faire avancer la recherche et les pratiques en acoustique.

Jeudi 22 septembre: **Thais Morata** de la *National Institute for Occupational Safety and Health* and et du *Center for Disease Control* viendra parler de la prévention de la perte auditive en 2016 et des méthodes modernes de parler en publique de la santé auditive et du bruit.

Vendredi 23 septembre: **Bryan Gick et Sid Fels** de l'University *of British Columbia* vont venir parler des approches interdisciplinaires pour l'avancement des théories articulatoires de la parole et de leur synthèse, en combinant les modèles linguistiques, électriques et de génie informatique.

Séances techniques

Il y aura des séances techniques portant sur l'ensemble des sujets en acoustique, soit la prévention de la perte auditive, les normes d'acoustiques, l'acoustique architecturale, le contrôle de bruit, les chocs et les vibrations, les sciences de l'audition et de la parole, l'acoustique en musique, l'acoustique sous-marine et la bioacoustique marine.

Si vous êtes intéressés à organiser ou à suggérer une séance spéciale sur un sujet précis, s'il-vous-plaît communiquez le plus rapidement possible avec la coprésidente du congrès, **Kathy Pichora-Fuller à l'adresse suivante** conference@caa-aca.ca**.**

Soumissions des propositions de communication

La date limite pour la soumission d'un résumé de présentation est le 15 juin 2016.

La date limite pour la soumission des articles résumés de 2 pages qui seront publiés dans les actes de congrès est le 1er août 2016. Pour plus de détails, prière de consulter le site internet du congrès.

Exposition et commandites

Il y aura un espace d'exposition pour les équipements, les produits et les services en acoustique le 22 septembre 2016. Si vous, ou votre entreprise, êtes intéressés à exposer ou commanditer un évènement social du congrès, une séance technique, une pause-café ou des prix d'étudiants, **prières de communiquer avec le coprésident du congrès Clair Wakefield le plus rapidement possible** au conference@caa-aca.ca. Le congrès offre une excellente occasion de présenter votre entreprise, vous produits ou vos services.

Participation des étudiants, bourses et prix

C'est avec enthousiasme que les étudiants sont invités à participer au congrès et d'y présenter leurs travaux de recherche. Les étudiants dont la proposition de présentation sera acceptée pourront faire une demande de bourse qui couvrira les frais pour une nuitée à l'hôtel Sutton Place, de même que les frais d'inscription au congrès. Les informations au sujet de la demande de cette bourse étudiante seront bientôt affichées sur le site internet du congrès. La date limite pour soumettre une demande de bourse est le 15 juin 2016.

Les étudiants qui présenteront leurs travaux sont aussi éligibles aux prix des meilleures présentations (trois prix de $500). Pour plus de détails au sujet des prix pour les présentations et autres reconnaissances pour les étudiants, prières de consulter le site internet de l'Association. Il est à noter que la date limite pour soumettre sa candidature au Prix étudiant de l'Association canadienne d'acoustique est 30 avril 2016.

Information sur l'hôtel du congrès

L'hôtel Sutton Place est située au centre-ville de Vancouver sur la rue Burrard, tout près de la rue Robson. En plus d'un restaurant signature et d'un marchand de vin, cet hôtel au charme européen et d'une élégance inégalée offre un service exceptionnel.

Le tarif de base pour une chambre pendant le congrès est de $199/nuit (simple ou double) et les taxes sont en sus. Ce tarif inclut les services suivants:

- **Service internet gratuit:** l'internet sans fil et à haute vitesse est disponible dans toutes les chambres et les salles de réunion.
- **Centre de conditionnement et piscine:** les invités de l'hôtel bénéficient d'un accès gratuit aux équipements du centre de conditionnement de même qu'à la piscine.
- **Le programme "Sutton Shopper Program":** Ce programme, exclusif à l'hôtel, est offert à tous les délégués qui hébergent à l'hôtel et donne droit à des rabais de 10% à 30% dans plus de 50 boutiques et services offerts de la rue Robson.
- **Tarifs réduits avant et après le congrès:** Tous les délégués qui hébergent à l'hôtel pendant le congrès pourront profiter du tarif réduit trois jours avant le congrès ainsi que trois jours après, selon la disponibilité des chambres au moment de la réservation.

Pour profiter des tarifs réduits, vous pouvez directement réserver une chambre en indiquant que vous êtes un délégués au congrès de la "**L'Association canadienne d'acoustique**".

Téléphone: **1-866-378-8866 (sans frais au Canada et États-Unis)**

Adresse courriel: **res_vancouver@suttonplace.com**

En ligne: **www.vancouver.suttonplace.com**

Code de réservation pour le groupe: VCSEP2016_CAA

Inscription au congrès

Les détails seront bientôt affichés sur le site internet du congrès: **http://awc.caa-aca.ca**

Dates importantes

Avant la Semaine canadienne d'acoustique

30 avril: date limite pour soumettre une demande pour le Prix étudiant de l'Association de l'acoustique canadienne, qui sera remis lors du banquet.

15 juin: date limite pour la soumission des résumés de présentation

15 juin: date limite pour soumettre une demande de bourse étudiante

1er août: date limite pour soumettre l'article résumé de deux pages à paraître dans les actes de congrès.

18 août: dernier jour pour profiter du tarif réduit pour le séjour à l'hôtel du congrès

18 au 21 septembre: Congrès mondial en audiologie*

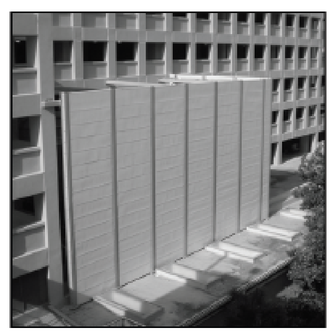
Pendant la Semaine canadienne d'acoustique
21 septembre: Séance plénière de Judy Dubno
21 septembre: Cérémonie d'ouverture
22 septembre: Séance plénière de Thais Morata
22 septembre: Exposition
22 septembre: Assemblée générale annuelle pour les membres de l'Association de l'acoustique canadienne
22 septembre: Banquet de la remise des prix
23 septembre: Séance plénière de Bryan Gick et Sid Fels
23 septembre: Annonce du prix pour la meilleure présentation des étudiants au déjeuner de fermeture.

*Congrès mondial en audiologie

Pour ceux qui souhaitent participer à deux congrès pendant leur séjour en Vancouver, sachez qu'il sera possible de le faire puisque le 33e Congrès mondial en audiologie (organisé par la Société internationale d'audiologie) aura lieu juste de l'autre côté de la rue au *Sheraton Wall Centre* du 18 au 21 septembre. Pour plus de détails, consulter le site internet du congrès: **http://www.wca2016.ca**


www.pcbpiezotronics.ca/acoustics(en-CA)
When You Need to Take a
Sound Measurement
Larson Davis
PCB
PCB
PCB
PCB
Total Customer Satisfaction
PCB PIEZOTRONICS
PCB's Broad Range of Acoustic Products
High Quality ▪ Unbeatable Prices ▪ Fast Delivery ▪ Best Warranty
To Learn More Visit: www.pcbpiezotronics.ca/acoustics(en-CA)
Toll Free 888-424-0033 ▪ E-mail info@dalimar.ca
PCB PIEZOTRONICS INC.
Dalimar instruments
A PCB GROUP COMPANY
LARSON DAVIS
A PCB PIEZOTRONICS DIV.
Your acoustic measurement experts providing a full line of quality
microphones, meters, and noise monitoring solutions

Central Energy Plant Louvers



Cooling Tower Barrier Wall System

CANADIAN ACOUSTICS TELEGRAM ANNOUNCEMENTS - ANNONCES TÉLÉGRAPHIQUES DE L'ACOUSTIQUE CANADIENNE

Tri-Agency Open Access Policy on Publications

The good news? Publication and copyright policies of Canadian Acoustics journal are fully compliant with these new rules! That's another good reason for reseachers to publish in Canadian Acoustics!

The Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Social Sciences and Humanities Research Council of Canada (SSHRC) are federal granting agencies that promote and support research, research training and innovation within Canada. As publicly funded organizations, the Agencies have a fundamental interest in promoting the availability of findings that result from the research they fund, including research publications and data, to the widest possible audience, and at the earliest possible opportunity. Societal advancement is made possible through widespread and barrier-free access to cutting-edge research and knowledge, enabling researchers, scholars, clinicians, policymakers, private sector and not-for-profit organizations and the public to use and build on this knowledge.According to a new policy, all grant recipients that were funded in whole or in part by NSERC or SSHRC for grants awarded May 1, 2015 and onwar (Januray 1, 2008 for CIHR) are required to ensure that any peer-reviewed journal publications arising from Agency-supported research are freely accessible within 12 months of publication.

May 28th 2015

Looking for a job in Acoustics?

There are many job offers listed on the website of the Canadian Acoustical Association!

You can see them online, under http://www.caa-aca.ca/jobs/

August 5th 2015

CAA is now social!

Canadian Acoustical Association is moving to the social media!

Find us on social media:Twitter: @CanAcousticalFacebook: facebook.com/canadianacousticalassociation

December 14th 2015

ICA Early Career Award

Congratulations to Frank Russo for receiving the ICA Early Career Award!

The winner of the 2016 ICA Early Career award is Frank Russo. Professor Russo works in the Department of Psychology at Ryerson University in Toronto, Canada, and is the current President of the Canadian Acoustical Association.

February 8th 2016

InterNOISE 2016

Internoise 2016 will be held in Hamburg, Germany, 21-24 August 2016.

Abstracts in any area of noise and vibration control are welcome. The abstract deadline is 10 March 2016, and final papers are due 17 May 2016. Abstracts can be submitted online at www.internoise2016.org.

February 16th 2016

The Canadian Acoustical Association - L'Association canadienne d'acoustique

MEMBERSHIP DIRECTORY 2015 - ANNUAIRE DES MEMBRES 2015

Adel A. Abdou
King Fahd Univeristy of Petroleum and Minerals, (KFUPM)
Architectural Engineering Dept. P.O. Box 1917
Dharan 31261
SA
adel@kfupm.edu.sa
+966 13 8602762

Dr. Sharon Mildred Abel
299 Roehampton Avenue, Apt. 239,, Toronto, ON , M4P 1S2
CA
sabel@rogers.com

Jennifer Abel
University of British Columbia
2613 West Mall, Vancouver, BC V6T 1Z4,
jennifer.abel@alumni.ubc.ca

Forall Subscription Agency
Av. Protasio Alves 1121 Loja 14, Porto Alegre
RS 90410-001
BR
4ALL@FORALLBRASIL.COM.BR

Dr. Steve James Aiken
Dalhousie University
1256 Barrington St, PO Box 15000, Halifax, NS, CANADA, B3J 4R2,
CA
steve.aiken@dal.ca
902-494-1057

Jean-Luc Allard
2271 Fernand-Lafontaine Blvd., Longueuil, QC, J4G 2R7
CA
jeanluc.allard@snclavalin.com
514-393-1000

Paolo Ammirante
paolo.ammirante@ryerson.ca

Brooke Anderson
Kinetics Noise Control Inc.
1670 Bishop Street North, Cambridge, Ontario, N1R 7J3
CA
banderson@kineticsnoise.com
905-670-4922

Nadim Arafa
University of Ontario Institute of Technology
2000 Simcoe Street , L1H 7K4, Oshawa, ON, Canada
CA
nadim.arafa@uoit.ca
905 721 8668 ex: 3949

Jessica Arsenault
Rotman Research Institute, University of Toronto
Baycrest Hospital, 3560 Bathurst St, Toronto, ON, M6A 2E1,
CA
jess.arsenault@mail.utoronto.ca

Marc Asselineau
10 B rue des Messageries Paris, F75010
FR
m.asselineau@peutz.fr
33-1-45230500

Mr. Frank Babic
AMEC
160 Traders Blvd. E., Suite 110 Mississauga, ON L4Z 3K7
CA
frank.babic@amec.com
905.568.2929

Walid Baccari
Québec-Océan, Pavillon Alexandre-Vachon1045, Avenue de la Médecine, local 2064, Université Laval, Québec (Québec), G1V 0A6, Canada, ,
CA
walid.baccari.1@ulaval.ca
418 931-8303

Mr. Cédrik Bacon
1 Infinite Loop, MS26-AE, Cupertino, CA, 95014,
US
cedrik.bacon@gmail.com

Mr. Alberto Behar
Ryerson University
307 - 355 St Clair W, Toronto, M5P 1T5
CA
albehar31@gmail.com
(416) 265-1816

Dr. Umberto Berardi
Ryerson University
350 Victoria Street, Toronto, Ontario, Canada M5B 2K3
CA
uberardi@ryerson.ca
416 979 5000 (3263)

Mr. Elliott H. Berger
3M Personal Safety Division
7911 Zionsville Rd 46268
US
elliott.berger@mmm.com

Lucie Beriault
Centre de documentation, 1255, rue Beauregard, Longueuil, J4K 2M3
CA
lucie.beriault.agence16@ssss.gouv.qc.ca

Dylan Bernhard
University of Alberta
CA
dbernhar@ualberta.ca

Chris Bibby
4208 7th ave SW, Calgary, T3C0E4,
CA
chrisbibby@gmail.com

Tanor Bonin
University of Waterloo
tanorbonin@gmail.com

Fabien Bonnet
École de Technologie Supérieure
1175-7 Boulevard de Maisonneuve Est,
Montréal H2L 1Z8,
CA
fabien.bonnet.1@ens.etsmtl.ca
5144047900

Ian Bonsma
HGC Engineering
2000 Argentina Road, Plaza 1, Suite 203, L5N
1P7
CA
ibonsma@hgcengineering.com

British Library
British Library
Acquisitions Unit (DSC-AO), Boston Spa,
Wetherby, LS23 7BQ
GB
indirectint1@caa-aca.ca

David W. Brown
Brown Strachan Assoc., Two Yaletown Sq.,
1290 Homer St., Vancouver, BC, V6B 2Y5
CA
bsa@brownstrachan.com

Claudio Bulfone
531 - 55A St. Delta, BC V4M 3M2
CA
cbulfone@gmail.com

Brian Bulnes
AECOM
CA
brian.bulnes@aecom.com
905-712-7057

Mr. Todd Anthony Busch
Todd Busch Consulting
Todd Busch Consulting, #803 - 615 Belmont St,
New Westminster, B.C. V3M6A1,
CA
toddbusch@hotmail.com
6045224567

Dr. Blake Edward Butler
University of Western Ontario
Department of Physiology and Pharmacology,
Medical Sciences Building Room 216,
University of Western Ontario, London,
Ontario, N6A 5C1,
CA
bbutler9@uwo.ca

Wil Byrick
1370 Don Mills Rd, Unit 300, Toronto, ON,
M3B 3N7
CA
wbyrick@pliteq.com
416-449-0049

Scott Carr
32 Troop Ave, Dartmouth, NS, B3B 1Z1
CA
scott@jasco.com
902-405-3336

Mandy Chan
HGC Engineering, 2000 Argentia Road, Plaza
1, Suite 203, Mississauga, ON, L5N 1P7 ,
CA
machan@hgcengineering.com

Brian Chapnik
HGC Engineering Ltd., 2000 Argentia Rd.,
Plaza One, Suite 203, Mississauga, ON, L5N
1P7
CA
bchapnik@hgcengineering.com

M. Cheesman
University of Western Ontario Dept.
Communication Sciences & Disorders
Faculty of Health Sciences, Elborn College
London, ON N6G 1H1
CA
cheesman@uwo.ca

Mark Cheng
Vancouver Airport Authority, PO Box 23750,
Airport Postal Outlet, Richmond, BC, V7B 1Y7
CA
mark_cheng@yvr.ca

Chinese Academy of Sciences Library
PO Box 830470, Birmingham, AL, 35283
US
indirectUSA1@caa-aca.ca

Cheng-Hao Chiu
Totem Field Studio, 2613 West Mall,
Vancouver, BC
CA
chenhao@alumni.ubc.ca

Ms Ina Chomyshyn
True Grit Consulting Ltd
1263 Innovation Drive, Thunder Bay, Ontario,
P7B 0A2,
CA
ina@tgcl.ca
807-626-5640

Wladyslaw Cichocki
University of New Brunswick
University of New Brunswick, Dept of French,
Fredericton, NB E3B 5A3,
CA
cicho@unb.ca
506-447-3236

Greg Clunis
907 Admiral Ave., Ottawa, ON, K1Z 6L6
CA
greg@integraldxengineering.ca
613-761-1565

Benjamin Coulson
RWDI , Consulting Engineers & Scientists
650 Woodlawn Road West, Guelph ON N1K
1B8,
CA
ben.coulson@rwdi.com
519-823-1311 x2333

Ann Cox
ARCADIS SENES Canada Inc.
121 Granton Drive, Unit 12 Richmond Hill,
ON L4B 3N4
CA
acox@senes.ca

Dr Briony Elizabeth Croft
SLR Consulting (Canada)
Suite 200 - 1620 West 8th Avenue, Vancouver,
BC, V6J 1V4, Canada,
bcroft@slrconsulting.com
6047904202

CSIC - Biblioteca
Ctro Tecnol Fisicas L Torres Quevedo, Serrano
144, 28006 MADRID
ES
indirectint2@caa-aca.ca

Dr Gilles Daigle
National Research Council, Building U66,
Ottawa, ON K1A 0R6
CA
gilles.daigle@nrc.gc.ca
819-561-7857

Tom Dakin
Ocean Networks Canada
2098 Skylark Lane Sydney, BC V8L 1Y4
CA
TDakin@UVic.ca
250-853-3541

Steve Davidson
Davidson & Associés Inc.
12 Lafleur St. N , St-Sauveur, QC , J0R 1R0
CA
sdavidson@davidson-assoc.com

Jack Davis
6331 Travois Cres NW, Calgary, AB, T2K 3S8,
CA
davisjd@telus.net
403-275-6868

Henk de Haan
dBA Noise Consultants
dBA Noise Consultants RR1, Site 14, Box 55
Okotoks, AB T1S 1A1
CA
dBAnoiseconsultants@gmail.com
403 836 8806

Mr. Terry J. Deveau
Jasco Applied Sciences
3 Shore Road Herring Cove, NS B3V 1G6
CA
deveau@chebucto.ns.ca
902-479-3398

Ric Doedens
K R Moeller Associates Ltd.
3-1050 Pachino Court, Burlington, Ontario,
L7L 6B9
CA
rdoedens@logison.com
905-332-1730

Stan Dosso
University of Victoria
University of Victoria, School of Earth and
Ocean Sciences, P.O. Box 3055, Victoria, BC,
V8W 3P6
CA
sdosso@uvic.ca

Olivier Doutres
École de technologie supérieure (ÉTS)
École de technologie supérieure, 1100 Rue
Notre-Dame Ouest, Montréal, QC H3C 1K3,
CA
olivier.doutres@etsmtl.ca

Alex Dundon
AECOM
5600 Cancross Court, Suite A, Mississauga,
Ontario L5R 3E9
CA
alex.dundon@aecom.com

David Egan
Egan Acoustics
P.O. Box 365, Anderson, SC, 29622-0365,
US
eegan@g.clemson.edu
864-226-3832

Nicolas Ellaham
University of Ottawa
607-30 Eleanor drive, Nepean, ON, K2E7E5,
CA
nellaham@uottawa.ca

Dale D. Ellis
18 Hugh Allen Drive, Dartmouth, NS B2W
2K8
CA
daledellis@gmail.com
902-464-9616

Prof. John H Esling
University of Victoria
Department of Linguistics, University of
Victoria, Victoria, BC V8W 3P4,
CA
esling@uvic.ca
2504772270

Pascal Everton
SLR Consulting (Canada) Ltd.
#1185, 10201 Southport Road S.W. Calgary, AB
T2W 4X9
CA
peverton@slrconsulting.com

James Farquharson
FDI Acoustics, Suite 250, 600 Crowfoot
Crescent NW, Calgary, AB, T3G 0B4
CA
jamesf@fdiacoustics.com

Andrew Faszer
Golder Associates Ltd., 102, 2535 - 3rd Avenue
S.E., Calgary, Alberta, Canada T2A 7W5
CA
andrew.faszer@ualberta.net
403-698-4554

Clifford Faszer
FFA Consultants in Acoustics & Noise
Control Suite 210 3015 - 5th Avenue N.E.
Calgary, AB T2A 6T8
CA
cfaszer@ffaacoustics.com

Clifford Faszer
Suite 210N, 3015-5th Ave NE Calgary, AB T2A
6T8 T2A 6T8
CA
info@ffaacoustics.com
403.508.4996

Sr. Tiago Simão Ferreira
Instituto Federal de Minas Gerais, Federal
Institute of Minas Gerais (Brazil)
tiago.simao@ifmg.edu.br
5503192155550

Shaye Folk-Blagbrough
#416, 3600 Windcrest Drive, North Vancouver,
BC, V7G 2S5
CA
Shaye_Folk-Blagbrough@yvr.ca

Harold Forester
1434 Franklin, Laval, QC H7W 1K6
CA
hforester@outlook.com
450-681-2333

Claude R. Fortier
State of the Art Acoustik Inc, Suite 43, 1010
Polytek St., Ottawa, ON, K1J 9J3
CA
cfortier@sota.ca
613-745-2003

Roger Foulds
9 Doble St., PO Box 388, Sunderland, ON, L0C
1H0
CA
roger@soundtrap.ca
705-357-1067

Leslie D Frank
SLR Consulting (Canada) Ltd.
SLR Consulting (Canada) Ltd.. 1185, 10201
Southport Rd. SW Calgary, AB T2W 4X9
CA
LFrank@SLRconsulting.com
403-385-1306

Ron Galloway
70 Frid Street, Suite 1 Hamilton, ON L8P 4M4
CA
ron.galloway@armtec.com
289-975-4404

Bill Gastmeier
HGC Engineering
12 Roslin Ave S., Waterloo, ON, N2L 2G5
CA
gastmeier@rogers.com

Behrou Ghazizadeh
364 Lawrence Ave. W., Toronto, ON, M5M 1B7
CA
behrou@vendatech.com
416-787-8797

Mr. Hazem Gidamy
M.Eng. P.Eng.
SS Wilson Associates Acoustical Consulting Engineers 15 Wertheim Court, Suite 211 Richmond Hill, ON L4B 3H7
CA
info@sswilsonassociates.com
905-707-5800

Prof. Christian Giguère
University of Ottawa
Audiology/SLP Program, 451 Smyth Road, Ottawa, Ontario, K1H8M5,
CA
cgiguere@uottawa.ca
(613) 562-5800 x4649

Ms. Dalila Giusti
Jade Acoustics Inc.
411 Confederation Parkway Unit 19 Concord Ontario L4K 0A8
CA
dalila@jadeacoustics.com
905-660-2444

Huiwen Goy
University of Toronto
University of Toronto Mississauga, Dept. of Psychology, DV2037, 3359 Mississauga Road North Mississauga, ON L5L 1C6,
CA
huiwen.goy@utoronto.ca
905-569-4634

Catherine Grant
Gradient Microclimate Engineering Inc., 127 Walgreen Road , Ottawa, ON K0A 1L0
Gradient Microclimate Engineering Inc., 127 Walgreen Road, Ottawa, ON, K0A 1L0
CA
kate@gradientwind.com

Dr. Anant Grewal
National Research Council
National Research Council, 1200 Montreal Road, Ottawa, Ontario, K1A-0R6,
CA
anant.grewal@nrc-cnrc.gc.ca
(613) 991-5465

Mr. Manfred Grote
ARCOS Acoustical Consulting Ltd.
2828 Toronto Cres. N.W. Calgary, AB T2N 3W2
CA
arcosacoustic@shaw.ca
403-283-1191

Peter Hanes
National Research Council Bldg M-36 Ottawa, ON K1A 0R6
CA
ph3238@yahoo.ca

Harriet Irving Library
University of New Brunswick, PO Box 7500, Fredericton, NB, E3B 5H5
CA
indirectcan3@caa-aca.ca

Gillian Hatcher
Stantec Consulting Ltd
40 Highfield Park Drive,, Dartmouth, NS, B3A 0A3,
CA
gillian.hatcher@stantec.com
902-468-7777

Matt Hildebrand
Wenger Corporation
Wenger Corporation 555 Park Drive PO Box 448 Owatonna, MN 55060
US
matt.hildebrand@wengercorp.com
507-774-8716

Per Hiselius
Examensvagen 2, SE-22467, Lund, Sweden,
SE
per_hiselius@hotmail.com

Joe Hood
Akoostix Inc.
Akoostix Inc. Suite 12, 10 Akerley Blvd Dartmouth, NS B3B 1J4
CA
jhood@akoostix.com
(902) 404-7464

Mr. Brian Howe
HGC Engineering Ltd., Plaza One, Suite 203, 2000 Argentia Rd., Mississauga, ON, L5N 1P7 ,
CA
bhowe@hgcengineering.com

IET-The Institution of Engineering and Technology
Michael Faraday House, Six Hills Way, STEVENAGE, SG1 2AY
GB
indirectint4@caa-aca.ca

Dr. Amir Iravani
Dillon Consulting Limited
53 Banstock Drive Toronto ON M2K 2H7
CA
airavani@dillon.ca

John Hopkins University
Serials / Acquisitions - 001ACF5829EI, Milton S. Eisenhower LibraryBaltimore, MD, 21218
US
indirectusa2@caa-aca.ca

Prof. Jeffery A. Jones
Wilfrid Laurier University
CA
jjones@wlu.ca

Grant Kaminski
CAN-CELL Industries
14735 124 Ave NW, Edmonton (AB), T5L 3B2
CA
grant.kaminski@can-cell.com
780-699-2283

Dr Stephen E. Keith
Health Canada
Radiation Protection Bureau, Health Acoustics, Non-ionizing Radiation Section Rm 228, 775 Brookfield Rd., 6301B Ottawa, ON K1A 1C1
CA
stephen_keith@hc-sc.gc.ca
+1 613 941-8942

Tim Kelsall
Hatch
2800 Speakman Dr. , Mississauga, ON, L5K 2R7
CA
tkelsall@hatch.ca
905-403-3932

Douglas S. Kennedy
BKL Consultants Ltd., #308-1200 Lynn Valley Rd, North Vancouver, BC, V7J 2A2
CA
kennedy@bkl.ca

Ms. Kathryn Joanne Kennedy Katsiroumpas
None
17 Linnsmore Crescent, Toronto, Ontario, M4J 4J8,
CA
kkatsiroumpas@hotmail.com
4164660625

Andrew Khoury
6600 Trans Highway, Suite 511, Pointe-Claire, QC, H9R 4S2
CA
andrew.khoury@bksv.com
514-695-8225

Michael Kiefte
School of Human Communication Disorders,
1256 Barrington St., Halifax, NS, B3J 1Y6 CA
CA
mkiefte@dal.ca

Mr. Ivan Koval
Reliable Connections Inc.
CA
soundproofing.expert@gmail.com
416-471-2130

André L'Espérance
1040, avenue Belvédère, suite 215, Sillery, QC,
G1S 3G3
CA
info@softdb.com
418-686-0993

Josée Lagacé
University of Ottawa
451 Smyth Rd Room 3053, Roger Guindon Hall
Univeristy of Ottawa Ottawa, ON K1H 8M5
CA
josee.lagace@uottawa.ca
613-562-5800

Sylvain Lalonde
Acoustifab Inc., 677 de la Sabliere,
Bois-des-Filion, QC, J6Z 4T8
CA
info@acoustifab.com

Jean Laporte
ACOUSTIKALAB INC.
CP 52523, 324 rue Castelneau,, Montréal,
Qébec,, H2R 3C5,
CA
jlaporte@acoustikalab.com
514-692-1147

Dr. Chantal Laroche
Programme d'audiologie et d'orthophonie,
École des Sciences de la réadaptation, Faculté
des Sciences de la santé, Université d'Ottawa,
451 Chemin Smyth Ottawa, ON, K1H 8M5
CA
claroche@uottawa.ca

Daniel Larose
193 Joseph Carrier, Vaudreuil-Dorion, QC, J7V
5V5
CA
daniel@dalimar.ca
514-424-0033

Frédéric Laville
Ecole de technologie supérieure, Université du
Québec, 1100 Notre-Dame Ouest, Montréal,
QC, H3C 1K3
CA
frederic.laville@etsmtl.ca

Cécile Le Cocq
École de technologie supérieure
CA
copyeditor@caa-aca.ca

Learning Res. Center
A T Still Univ Hlth SCI, 5850 E Still Circ, Mesa,
AZ, 85206-3618
US
indirectusa3@caa-aca.ca

Buddy Ledger
5248 Cedar Springs Road, Burlington, Ontario
L7P 0B9,
CA
buddyledger@gmail.com

Marcus Li
177 Westfield Trail, Oakville, ON, L6H 6H7,
CA
Li.MarcusTW@gmail.com

Zhao Li
Harbin Engineering University, University of
Victoria
4210 Tyndall Ave. Victoria, BC
CA
lizhao0517@gmail.com

Al Lightstone
30 Wertheim Court, Unit 25, Richmond Hill,
ON, L4B 1B9
CA
solutions@valcoustics.com
905-764-5223

Chang Liu
Editorial Development Dept., Thomson
Reuters
chang.liu@thomsonreuters.com

Banda Logawa
University of British Columbia
706-575 Delestre Ave, Coquitlam BC V3K0A6
CA
logawa_b@yahoo.com

Alexander P. Lorimer
HGC Engineering Ltd., Plaza One, Suite 203,
2000 Argentia Rd., Mississauga, ON, L5N 1P7 ,
CA
alorimer@hgcengineering.com

Parnia Lotfi Moghaddam
MMM Group Limited
100 Commerce Valley Drive West Thornhill,
ON L3T 0A1
CA
lotfimoghaddamp@mmm.ca
905-882-4211 ext. 6577

Roderick Mackenzie
SoftdB
1240 Beaumont Avenue, Suite 206, Montreal,
QC, H3P 3E5
CA
r.mackenzie@softdb.com

Ewan Andrew Macpherson
Western University
Western University, 1201 Western Rd, Elborn
College Room 2262, London, ON N6G 1H1,
CA
ewan.macpherson@nca.uwo.ca
519-661-2111 x88072

Dr. Gary S. Madaras
Rockfon
4849 S. Austin Ave., Chicago, IL 60638
US
gary.madaras@rockfon.com
708.563.4548

Denise Mallette
I.R.S.S.T. - Informathèque 11e étage 505 boul
de Maisonneuve O Montréal, QC H3A 3C2
CA
mallette.denise@irsst.qc.ca
514-288-1551

Mr Paul E Marks
BKL Consultants Ltd
BKL Consultants Ltd, #308 - 1200 Lynn Valley
Road, North Vancouver, BC, Canada, V7J 2A2
CA
marks@bkl.ca
604-988-2508

Emma Marotte
Dalhousie University
2498 Robie Street, Halifax, NS, B3K4N1,
CA
emma.marotte@gmail.com

Steve Marshall
Scantek, Inc.
Scantek, Inc., 6430 Dobbin Road, Suite C,
Columbia, MD 21045,
US
S.Marshall@scantekinc.com
1-410-290-7726

Christian Martel
Octave Acoustique Inc., 963, chemin Royal,
Saint-Laurent-de-l'Ile-d'Orleans, QC, G0A 3Z0
CA
octave@videotron.ca

Alexis Martin
Ecole de Technologie Supérieure
alexis.martin.1@ens.etsmtl.ca

John Martyn
Right to Quiet Society, 359 - 1985 Wallace
Street, Vancouver, BC, V6R 4H4
CA
info@quiet.org

Eric Matheson-Jones
9628 Austin O'Brien Road NW Edmonton, AB
T6B 2C2
CA
mathesonjones@gmail.com

Mr Nigel Maybee
SLR Consulting (Canada) Ltd.
SLR Consulting (Canada) Ltd., #1185-10201
Southport Road SW, Calgary, AB, T2W 4X9
CA
nmaybee@slrconsulting.com
403-385-1308

Nick McCabe
HGC Engineering, 2000 Argentia Road Plaza 1
Suite 2003, Mississuaga, ON, L5N 1P7
CA
nmccabe@hgcengineering.com

Stephen McCann
Cambium Inc.
597 Homewood Avenue, Peterborough,
Ontario K9H2N4
CA
stephen.mccann@cambium-inc.com

MDDEP
Dir politique de la qualité de l'atmosphère,
675 Rene-Levesque Est 5E-B30, Québec, QC,
G1R 5V7
CA
indirectcan4@caa-aca.ca

Mr. T. Medwedyk
Group One Acoustics Inc., 1538 Sherway Dr.,
Mississauga, ON, L4X 1C4
CA
goainc@bellnet.ca

Garfield Mellema
Defence Research & Development Canada -
Atlantic
Defence Research Establishment Atlantic P.O.
Box 1012 Dartmouth, NS B2Y 3Z7
CA
garfield.mellema@drdc-rddc.gc.ca

Steve Meszaros
4567 Valley Road, North Vancouver, BC, V7K
2M1,
CA
steve_meszaros@hotmail.com

J.G. Migneron
Acoustec Inc.
90, rue H.-Poirier, , Lévis, QC , G7A 2W1
CA
courrier@acoustec.qc.ca
418-496-6600

M. Jean-Philippe Migneron
Université Laval
1393-204, rue de Jupiter, Lévis, QC G6W 8J3
CA
jean-philippe.migneron.1@ulaval.ca
418-906-0333

Peter Milne
McGill University
182C Sherway Dr, Nepean, ON, K2J 2G8,
CA
pmiln099@gmail.com

Rachel Min
Vancouver Airport Authority
rachel_min@yvr.ca

Ministère des transports
Centre Documentation, 35 Port-Royal Est, 4e
étage, Montréal, QC, H3L 3T1
CA
indirectcan5@caa-aca.ca

Takashi Mitsuya
University of Western Ontario
National Centre for
AudiologyCommunication Sciences and
DisordersElborn College, Room 1207,
University of Western
OntarioLondon, Ontario, Canada N6G 1H1
CA
tmitsuya@uwo.ca

Joaquin E. Moran
Hatch Ltd., 4342 Queen St,, Suite 500, Niagara
Falls, ON, L2E 7J7
CA
jmoran@hatch.ca

Michel Morin
6555 Cote des Neiges, Suite 440 Montréal, QC
H3S 2A6
CA
mmorin@mjm.qc.ca
514-737-9811

Dr Geoffrey Stewart Morrison
University of Alberta, University of New
South Wales
803-4438 West 10th Avenue, Vancouver BC
V6R 4R8
CA
geoff-morrison@forensic-evaluation.net
604 637 0896

Rasoul Morteza Pouraghdam
MASc in Mechanical Engineering,
Specialization Acoustics, Concordia
University, Montreal
CA
r_morte@encs.concordia.ca

Yoichi Mukai
University of Alberta
Department of Linguistics, 3-26 Assiniboia
Hall, University of Alberta, Edmonton AB
Canada T6G
mukai@ualberta.ca
(780) 710-7516

M. Vincent Nadon
Gent University, École de technologie supérieure
316 Major Lavallée,, Deux-Montagnes, Qc,, Canada, J7R 6M8,
vincent.nadon@etsmtl.ca

Flora Nassrallah
University of Ottawa
6072 Red Willow Drive, Ottawa, Ontario, K1C7J5
CA
fnass039@uottawa.ca

Hugues Nelisse
IRSST
IRSST 505 Boul de Maissonneuve Ouest
Montréal, QC H3A 3C2
CA
nelisse.hugues@irsst.qc.ca

Gabe Nespoli
Ryerson University
gabe@psych.ryerson.ca

David J Nicholson
920 Hamel Road, PO Box 253 Hamel, MN 55340
US
dave@maxxon.com
763-478-9626

Zahra Nili Ahmadabadi
425, rue de la Montagne, apartment no. 4152, Montreal, Quebec , Canada. Postal code: H3C 0J9
CA
ak09890@ens.etsmtl.ca

NOAA National Marine Mammal Lab
Library Bldg 4 Rm 2030 , 7600 Sand Point Way NE, Seattle, WA, 98115-6349
US
wjordan@wtcox.com

Masaki Noguchi
University of British Columbia
4449 West 14th Avenue, Vancouver, B.C. Canada, V6R2Y2
CA
msk_ngch@yahoo.com

Northern Illinois University
Periodicals Dept., University Libraries, 1425 West Lincoln Highway, DeKalb, IL, 60115-2868
US
service@harrassowitz.de
+49-611-530 396

Dr. Colin Novak
Akoustik Engineering Limited
515 Riverside Dr. West, Unit 1103, Windsor, ON, N9A 7C3
CA
akoustik@akoustik.ca
(519)903-7193

Tomasz Nowak
8542 83rd Ave, Edmonton, T6C 1B1,
CA
now.tomek@gmail.com

Mr. John O'Keefe
O'Keefe Acoustics
10 Ridley Gardens, Toronto, Canada. , M6R 2T8
CA
john@okeefeacoustics.com
416-532-9673

Caitlin O'Neill
University of Victoria
304-1000 McKenzie Ave. , Victoria, BC, V8X 4C8
CA
caitlin.v.oneill@gmail.com
2508573214

Donald Olynyk
Acoustical Consultant
9224-90 Street Edmonton, AB T6C 3M1
CA
don.olynyk@shaw.ca
7804654125

Dr. John C. Osler
Defence Research and Development Canada
Atlantic Research Center, PO Box 1012
Dartmouth, Dartmouth, NS , B2Y 3Z7
CA
John.Osler@drdc-rddc.gc.ca
902-426-3100 ext 119

Mr. Kevin Packer
FFA Consultants in Acoustics & Noise Control Ltd.
121 Sandpiper Lane, Chestermere, AB, T1X 1B1,
CA
kpacker@ffaacoustics.com
403-922-0577

Michel Parent
FDI Acoustics, Suite 250, 600 Crowfoot Crescent NW, Calgary, AB, T3G 0B4
CA
mitchp@fdiacoustics.com

Richard Patching
Patching Associates Acoustical Eng. 9, 4825 Westwinds Dr. NE Calgary, AB T3J 4L4
CA
richard@patchingassociates.com

Richard Joseph Peppin
Engineers for Change, Inc.
5012 Macon Rd, Rockville, MD 20852,
US
peppinR@asme.org
301-984-3375

Aaron Peterson
Brown Strachan Associates
Two Yaletown Square, 1290 Homer Street, Vancouver, BC, V6B 2Y5
CA
bsadrafts@hotmail.com
(604) 689-0514

Prof. Kathleen Pichora Fuller
University of Toronto
Dept. of Psychology University of Toronto
3359 Mississauga Rd. N. Mississauga, ON L5L 1C6
CA
k.pichora.fuller@utoronto.ca
(905) 828-3865

Howard Podolsky
Pyrok Inc.
121 Sunset Rd. Mamaroneck, NY, 10543
US
mrpyrok@aol.com
914-777-7770

Linda Polka
McGill University
McGill University Sch of Communication Sciences & Disorders 1266 Pine Ave. West Montréal, QC H3G 1A8
CA
linda.polka@mcgill.ca
514-398-7235

Daniel P. Prusinowski
Aurora Acoustical Consultants Inc., 745 Warren Drive, East Aurora, NY 14052, USA
Daniel P. Prusinowski, 745 Warren Drive, East Aurora, NY 14052, USA,
US
dprusinowski@verizon.net
1-716-655-2200

Dr. John David Quirt
Consultant
1949 Mulberry Crescent, Ottawa, ON, K1J 8J8,
CA
jdq.acoustics@bell.net
613-745-2793

Roberto Racca
JASCO Applied Sciences
JASCO Applied Sciences Ltd., 2305 - 4464
Markham Street , Victoria, BC, V8Z 7X8
CA
roberto.racca@jasco.com

Prof. Ramani Ramakrishnan
Ryerson University
27 Ashmount Crescent, Toronto, ON, pcode,
M9R 1C8
CA
rramakri@ryerson.ca

Allan Raun
Swallow Acoustic Consultants Ltd
Swallow Acoustic Consultants, 23 - 366 Revus
Ave. Mississuaga,, ON, L5G 4S5,
CA
araun@swallowacoustic.ca
905-271-7888

Zohreh Razavi
STC Acoustical Consulting LTD
3164 Canfield Cres. North Vancouver, BC,
V7R 2V8.
CA
zoe@stcacoustical.com
604-307-2006

Erwin Rebke
Alberta Infrastructure, 3rd Floor 6950-113
Street NW, Edmonton, AB, T6H 5V7
CA
erwin.rebke@gov.ab.ca

Dr. Eric Rehm
Takuvik / Université Laval
eric.rehm@takuvik.ulaval.ca
418-254-7234

Rebecca Reich
rebecca.reich@gmail.com

Mary Richard
West Caldwell Calibration Labs
5 Marley Court , Markham ON, L3S 3M7
CA
wcclca@gmail.com
905-554-8005

Werner Richarz
Echologics Engineering 6295 Northam Drive,
Unit 1 Mississauga, ON L4V 1W8
CA
wricharz@echologics.com

Robertson Library
University of PEI, 550 University Ave,
Charlottetown, PE, C1A 4P3
CA
indirectcan6@caa-aca.ca

Prof. Joana Rocha
Carleton University
Department of Mechanical and Aerospace
Engineering,, Carleton University,, 1125
Colonel By Drive,, Ottawa, ON, K1S 5B6
Canada, ,
CA
joana.rocha@carleton.ca

Mr Alfredo Rodrigues
AMEC Environment & Infrastructure
160 Traders Blvd. E., Suite 110 Mississauga,
ON, L4Z 3K7
CA
al.rodrigues76@gmail.com
(905) 568-2929 x 4317

Jessie Roy
RWDI Air Inc.
1000, 736-8th Avenue S.W., Calgary, AB, T2P
1H4
CA
jessie.roy@rwdi.com
403-232-6771 6248

Prof. Frank A. Russo
Ryerson University
Department of Psychology, Ryerson
University, 350 Victoria Street, Toronto,
Ontario, M5B 2K3
CA
russo@ryerson.ca

Ryerson University Library
LIB-551, 350 Victoria Street, Toronto, ON, M5B
2K3
CA
indirectcan7@caa-aca.ca

Juliana Saga
PTI
PTI, Rua Peixoto Gomide 209, 01409901 Sao
Paulo SP, BRAZIL
BR
import@pti.com.br

Mehrzad Salkhordeh
dB Noise Reduction Inc.
240-J Holiday Inn Drive Cambridge, ON N3C
3X4
CA
mehrzad@dbnoisereduction.com
519-651-3330 x 220

M. Claude Sauvageau
Centre de recherche industrielle du Québec
1201 boul. Crémazie est Bureau 1.210
Montréal, QC H2M OA6
CA
claude.sauvageau@criq.qc.ca
514-383-1550

Katrina Scherebnyj
14920 25A Avenue, Surrey, BC, V4P 1N7,
Canada,
kscherebnyj@gmail.com

Stefan Schoenwald
Swiss Federal Laboratories for Materials
Science and Technology
Überlandstrasse 129 , CH-8600 Dübendorf,
Switzerland
CA
stefan.schoenwald@empa.ch
41 58 765 6579

Dr. Mark Andrew Scott
Memorial University, Kobe Shoin University
shark_scott@hotmail.com

Mahmoud Shaaban
University of Ontario Institute of Technology
691 Simcoe St. N. L1G4V6 Oshawa, ON,
Canada
CA
mahmoud.shaaban@uoit.ca

Cameron W. Sherry
1128 route 203, Howick, QC, J0S 1G0
CA
cameronsherry4@gmail.com

Caroline Sigouin
Université du Québec à Chicoutimi
caroline.sigouin@uqac.ca

Davor Sikic
Jade Acoustics Inc. 411 Confederation Parkway, Unit 19 Concord, ON L4K 0A8
CA
davor@jadeacoustics.com
905-660-2444

Duncan Spence
2323 Royal Windsor Dr., Mississauga, ON, L5J 1K5
CA
amsales@blachford.ca
905-823-3200

Robert D. Stevens
HGC Engineering Ltd., Plaza One, Suite 203, 2000 Argentia Rd., Mississauga, ON, L5N 1P7
CA
rstevens@hgcengineering.com

Dr. Michael R. Stinson
National Research Council, Building U-66, Room 230, Ottawa, ON K1A 0R6
CA
mike.stinson@nrc-cnrc.gc.ca

Clarence Stuart
City of Edmonton, Engineering Services Section, 11004 - 190 Street NW, Edmonton, AB, T5S 0G9
CA
clarence.stuart@edmonton.ca

Dr. Aimee Surprenant
Memorial University of Newfoundland
Memorial University of Newfoundland Psychology Dept., Science Building St. John's, NL A1B 3X9
CA
asurpren@mun.ca
709-896-4786

John C Swallow
President, Swallow Acoustic Consultants Ltd
Swallow Acoustical Consultants 366 Revus Ave., Unit 23 Mississauga, ON L5G 4S5
CA
jswallow@swallowacoustic.ca
9052717888

John Swallow
Swallow Acoustic Consultants Ltd.
366 Revus Ave., Unit 23 Mississauga, ON L5G 4S5
CA
info@swallowacoustic.ca

Nicholas Sylvestre-Williams
Aercoustics Engineering Ltd.
50 Ronson Drive, Suite 165 Toronto, ON M9W 1B3
CA
NicholasS@aercoustics.com
(416) 249-3361

Prof. Jahan Tavakkoli
Ryerson University
Dept of Physics, Ryerson University, 350 Victoria Street, Toronto, ON M5B 2K3
CA
jtavakkoli@ryerson.ca
(416) 979-5000

TIB u. Universitaetsbibliothek
4.2 Team Zeitschrften, Welfengarten 1 B, D-30167 Hannover
DE
indirectint5@caa-aca.ca

Jessica Tinianov
HGC Engineering
34 Superior Ave, Toronto ON, M8V 2M6,
CA
jtinianov@hgcengineering.com

Cristina Tollefsen
Defence Research and Development Canada
P. O. Box 1012, Dartmouth, NS B2Y 3Z7,
CA
cristina.tollefsen@gmail.com

Mihkel Toome
77 Woodside Ave., Toronto, ON, M6P 1L9,
CA
mtoome@gmail.com

Karen Turner
Protec Hearing
Protec Hearing, Unit E, 77 Redwood Avenue, Winnipeg, Manitoba, R2W5J5
CA
protec1@mymts.net

Dr Helen Ule
Akoustik Engineering Limited
1258 Aubin Road, Windsor, ON N8Y 4E5
CA
helen@akoustik.ca
(519) 903-7193

Jim Ulicki
Xscala Sound & Vibration
234 - 5149 Country Hills Blvd., Suite 516
Calgary, AB T3A 5K8
CA
caa@xscala.com
403-274-7577

Université de Montréal
Bibliothèque Acquisitions Périodiques, CP 6128, Succ. Centre-Ville, Montréal, QC, H3C 3J7
CA
indirectcan8@caa-aca.ca

Svein Vagle
Ocean Science Division
Institute of Ocean Sciences PO Box 6000 9860 West Saanich Road Sidney, BC V8L 4B2
CA
Svein.Vagle@dfo-mpo.gc.ca
250 363 6339

Olivier Valentin
719 6eme avenue, VERDUN, QC, H4G 3A3
CA
m.olivier.valentin@gmail.com
514-885-5515

Kenric Van Wyk
124 Fulton St E, 2nd Floor, Grand Rapids MI, US
kvanwyk@acousticsbydesign.com
6162415810

Mr. Peter VanDelden
650 Woodlawn Road West Guelph, ON N1K 1B8
CA
peter.vandelden@rwdi.com
519-823-1311

Guilhem Viallet
Ecole de technologie supérieure, département génie mécanique, 1100 rue Notre-Dame Ouest, Montreal, Québec, H3C 1K3
guilhem.viallet.1@ens.etsmtl.ca

Prof. Jérémie Voix
ÉTS, Université du Québec
1100 Notre-Dame Ouest Montréal (QC) H3C 1K3
CA
voix@caa-aca.ca
+1 514 396-8437

Mr. Clair W. Wakefield
Wakefield Acoustics Ltd.
301-2250 Oak Bay Ave, VICTORIA, British Columbia, V8R 1G5
CA
clair@wakefieldacoustics.com
250-370-9302

Thomas Walton
15 Allison Avenue, Morrisburg Ontario , K0C 1X0
CA
twalton@eckel.ca

Lina Wang
Stantec, 200 - 325 25th Street SE Calgary AB T2A 7H8, , ,
CA
lina.wang@stantec.com

Graham Warner
2396 Forbes St, Victoria, BC V8R 4B6 CA
CA
grahamawarner@gmail.com

Graham Warner
2396 Forbes St, Victoria BC V8R 4B6,
CA
gwarner@uvic.ca

Mr. Larry Alan Westlake
High-Impact Health & Safety Support Services
High-Impact Health & Safety Support Services, 126 Essex Court, Thunder Bay, ON P7A 7P1
CA
ohslaw@highimpacths.com
807-345-6691

Mr. Ronald G. White
Decoustics
7 Amberglen Court, Holland Landing, ON L9N 1J6
CA
Ron.White@saint-gobain.com
905-652-5257

Tim C Wiens
Conestoga-Rovers & Associates
651 Colby Drive Waterloo, ON N2V 1C2
CA
twiens@craworld.com
519-884-0510 xx2352

Hugh Williamson
Hugh Williamson Associates Inc., PO Box 74056, RPO Beechwood, Ottawa, ON, K1M 2H9
Hugh Williamson Assoc. Inc., PO Box 74056 RPO Beechwood, Ottawa, ON K1M 2H9,
CA
hugh@hwacoustics.ca
613 747 0983

Dr Douglas James Wilson
Imagenex Technology Corp.
3621 Evergreen Street Port Coquitlam, BC V3B 4X2
CA
dougww3@aol.com
604 468 9406

Mr. Chris N. Wolfe
Vibra-Sonic Control, 4004 Gravely Street Burnaby, BC V5C 3T6
CA
chris@vibra-sonic.com
604-294-9495

Ms. Wing Yiu Stephanie Wong
University of Toronto
44 Old English Lane, Thornhill, ON., L3T2T9, Canada
CA
wystephanie.wong@utoronto.ca

Mr. Richard G Wright
SLR Consulting (Canada) Ltd.
SLR Consulting (Canada) Ltd. #1185-10201 Southport Road SW, Calgary, AB T2W 4X9
CA
rwright@slrconsulting.com
403-385-1309

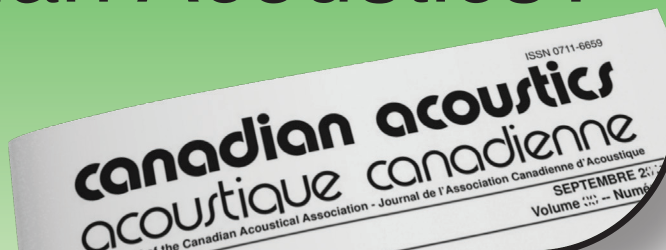
Jakub Wrobel
O2E Inc., Environmental Consultants, 399 South Edgeware Road, Unit 5, St. Thomas, ON, N5P 4B8,
CA
j.wrobel@o2e.ca

Mr. Victor William Young
Golder Associates Ltd.
Golder Associates Ltd., 102, 2535 3rd Ave SE, Calgary, AB T2A 7W5,
CA
victor_young@golder.com
587-434-4984

Michel Zielinski
51427 Range Road 270, Spruce Grove, AB, T7Y 1E9
CA
sales@fabra-wall.com
780-987-4444

Dejan Zivkovic
2286 Glastonbury Rd., Burlington, ON, L7P 4C8
CA
dejan.zivkovic@ontario.ca

Why publish in Canadian Acoustics?



Because, it is...

- A respected scientific journal with a 40-year history uniquely dedicated to acoustics in Canada
- A quarterly publication in both electronic and hard-copy format, reaching a large community of experts worldwide
- An Open Access journal, with content freely available to all, 12 months from time of publication
- A better solution for fast and professional review providing authors with an efficient, fair, and constructive peer review process.

Pourquoi publier dans Acoustique canadienne ?

Parce que, c'est...

- Une revue respectée, forte de 40 années de publications uniquement dédiée à l'acoustique au Canada
- Une publication trimestrielle en format papier et électronique, rejoignant une large communauté d'experts à travers le monde
- Une publication "accès libre" dont le contenu est disponible à tous, 12 mois après publication
- Une alternative intéressante pour une évaluation par les pairs, fournissant aux auteurs des commentaires pertinents, objectifs et constructifs

Application for Membership

CAA membership is open to all individuals who have an interest in acoustics. Annual dues total $100.00 for individual members and $50.00 for student members. This includes a subscription to ***Canadian Acoustics***, the journal of the Association, which is published 4 times/year, and voting privileges at the Annual General Meeting.

Subscriptions to *Canadian Acoustics* *or* Sustaining Subscriptions

Subscriptions to ***Canadian Acoustics*** are available to companies and institutions at a cost of $100.00 per year. Many organizations choose to become benefactors of the CAA by contributing as Sustaining Subscribers, paying $475.00 per year (no voting privileges at AGM). The list of Sustaining Subscribers is published in each issue of ***Canadian Acoustics*** and on the CAA website.

Please note that online payments will be accepted at http://jcaa.caa-aca.ca

Address for subscription / membership correspondence:

Name / Organization ______________________________

Address ______________________________

City/Province ________________ Postal Code __________ Country ________________

Phone ________________ Fax ________________ E-mail ________________

Address for mailing Canadian Acoustics, if different from above:

Name / Organization ______________________________

Address ______________________________

City/Province ________________ Postal Code __________ Country ________________

Areas of Interest: (Please mark 3 maximum)

1. Architectural Acoustics
2. Engineering Acoustics / Noise Control
3. Physical Acoustics / Ultrasound
4. Musical Acoustics / Electro-acoustics
5. Psychological / Physiological Acoustic
6. Shock and Vibration
7. Hearing Sciences
8. Speech Sciences
9. Underwater Acoustics
10. Signal Processing / Numerical Methods
11. Other

For student membership, please also provide:

________ ________ ________ ________

(University) *(Faculty Member)* *(Signature of Faculty Member)* *(Date)*

I have enclosed the indicated payment for:
[ ] CAA Membership $ 100.00
[ ] CAA Student Membership $ 50.00

Corporate Subscriptions (4 issues/yr)
[ ] $100 including mailing in Canada
[ ] $108 including mailing to USA,
[ ] $115 including International mailing

[ ] Sustaining Subscription $475.00
(4 issues/yr)

Please note that the preferred method of payment is by credit card, online at http://jcaa.caa-aca.ca

For individuals or organizations wishing to pay by check, please register online at *http://jcaa.caa-aca.ca* and then mail your check to:

Executive Secretary, The Canadian Acoustical Association, PO Box 74068, Ottawa, Ontario, K1M 2H9, Canada

Formulaire d'adhésion

L'adhésion à l'ACA est ouverte à tous ceux qui s'intéressent à l'acoustique. La cotisation annuelle est de 100.00$ pour les membres individuels, et de 50.00$ pour les étudiants. Tous les membres reçoivent ***l'Acoustique Canadienne***, la revue de l'association. Les nouveaux abonnements reçus avant le 31 août s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de ***l'Acoustique Canadienne*** de cette année. Les nouveaux abonnements reçus après le 31 août s'appliquent à l'année suivante.

Abonnement pour la revue *Acoustique Canadienne* et abonnement de soutien

Les abonnements pour la revue ***Acoustique Canadienne*** sont disponibles pour les compagnies et autres établissements au coût annuel de 100.00$. Des compagnies et établissements préfèrent souvent la cotisation de membre bienfaiteur, de 475.00$ par année, pour assister financièrement l'ACA. La liste des membres bienfaiteurs est publiée dans chaque issue de la revue ***Acoustique Canadienne***. Les nouveaux abonnements reçus avant le 31 août s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de ***l'Acoustique Canadienne*** de cette année. Les nouveaux abonnements reçus après le 31 août s'appliquent à l'année suivante.

Notez que tous les paiements électroniques sont acceptés en ligne http://jcaa.caa-aca.ca

Pour correspondance administrative et financière:

Nom / Organisation ____________________

Adresse ____________________

Ville/Province ____________ Code postal ________ Pays ____________

Téléphone ____________ Téléc. ____________ Courriel ____________

Adresse postale pour la revue Acoustique Canadienne

Nom / Organisation ____________________

Adresse ____________________

Ville/Province ____________ Code postal ________ Pays ____________

Cocher vos champs d'intérêt: (maximum 3)

1. Acoustique architecturale
2. Génie acoustique / Contrôle du bruit
3. Acoustique physique / Ultrasons
4. Acoustique musicale / Électro-acoustique
5. Physio / Psycho-acoustique
6. Chocs et vibrations
7. Audition
8. Parole
9. Acoustique sous-marine
10. Traitement des signaux /Méthodes numériques
11. Autre

Prière de remplir pour les étudiants et étudiantes:

________ ________ ________ ________

(Université) (Nom d'un membre du corps professoral) (Signature du membre du corps professoral) (Date)

Cocher la case appropriée:
[ ] Membre individuel 100.00 $
[ ] Membre étudiant(e) 50.00 $

Abonnement institutionnel
[ ] 100 $ à l'intérieur du Canada
[ ] 108 $ vers les États-Unis
[ ] 115 $ tout autre envoi international

[ ] Abonnement de soutien 475.00 $ (comprend l'abonnement à *L'acoustique Canadienne*)

Merci de noter que le moyen de paiement privilégie est le paiement par carte crédit en ligne à *http://jcaa.caa-aca.ca*

Pour les individus ou les organisations qui préféreraient payer par chèque, l'inscription se fait en ligne à ***http://jcaa.caa-aca.ca*** **puis le chèque peut être envoyé à :**

Secrétaire exécutif, Association canadienne d'acoustique, BP 74068, Ottawa, Ontario, K1M 2H9, Canada

SUSTAINING SUBSCRIBERS - ABONNÉS DE SOUTIEN

The Canadian Acoustical Association gratefully acknowledges the financial assistance of the Sustaining Subscribers listed below. Their annual donations (of $475.00 or more) enable the journal to be distributed to all at a reasonable cost.
L'Association Canadienne d'Acoustique tient à témoigner sa reconnaissance à l'égard de ses Abonnés de Soutien en publiant ci-dessous leur nom et leur adresse. En amortissants les coûts de publication et de distribution, les dons annuels (de 475.00$ et plus) rendent le journal accessible à tous les membres.

Acoustec Inc.
J.G. Migneron - 418-496-6600
courrier@acoustec.qc.ca
acoustec.qc.ca

ACOUSTIKALAB Inc.
Jean Laporte - 514-692-1147
jlaporte@acoustikalab.com
ACOUSTIKALAB.com

Aercoustics Engineering Ltd.
Nicholas Sylvestre-Williams - (416) 249-3361
NicholasS@aercoustics.com
aercoustics.com

AMEC
Mr. Frank Babic - 905.568.2929
frank.babic@amec.com
amec.com

Bruel & Kjaer North America Inc.
Andrew Khoury - 514-695-8225
andrew.khoury@bksv.com
bksv.com

Dalimar Instruments Inc
Monsieur Daniel Larose - 450-424-0033
daniel@dalimar.ca
www.dalimar.ca

dB Noise Reduction
Mehrzad Salkhordeh - 519-651-3330 x 220
mehrzad@dbnoisereduction.com
dbnoisereduction.com

FFA Consultants in Acoustics and Noise Control
Clifford Faszer - 403.508.4996
info@ffaacoustics.com
ffaacoustics.com

GHD
Tim C Wiens - 519-884-0510 x2352
tim.wiens@ghd.com
ghd.com

H.L. Blachford Ltd.
Duncan Spence - 905-823-3200
amsales@blachford.ca
blachford.ca

Hatch Associates Ltd.
Tim Kelsall - 905-403-3932
tkelsall@hatch.ca
hatch.ca

HGC Engineering Ltd.
Bill Gastmeier -
gastmeier@rogers.com
hgcengineering.com

Integral DX Engineering Ltd.
Greg Clunis - 613-761-1565
greg@integraldxengineering.ca
integraldxengineering.ca

Jade Acoustics Inc.
Ms. Dalila Giusti - 905-660-2444
dalila@jadeacoustics.com
jadeacoustics.com

JASCO Applied Sciences (Canada) Ltd.
Roberto Racca -
roberto.racca@jasco.com
jasco.com

MJM Conseillers en Acoustique Inc.
Michel Morin - 514-737-9811
mmorin@mjm.qc.ca
mjm.qc.ca

Peutz & Associés
Marc Asselineau - 33-1-45230500
m.asselineau@peutz.fr
peutz.fr

Pliteq Inc.
Wil Byrick - 416-449-0049
wbyrick@pliteq.com
pliteq.com

Pyrok Inc.
Howard Podolsky - 914-777-7770
mrpyrok@aol.com
pyrok.com

ROCKFON
Dr. Gary S. Madaras - 708.563.4548
gary.madaras@rockfon.com
rockfon.com

ROXUL
Meghan Billingsley - 9053387600
amanda@birchallpr.com
roxul.com

RWDI AIR Inc.
Mr. Peter VanDelden - 519-823-1311
peter.vandelden@rwdi.com
rwdi.com

Scantek Inc.
Steve Marshall - 1-410-290-7726
S.Marshall@scantekinc.com
scantekinc.com

Soft dB Inc.
André L'Espérance - 418-686-0993
info@softdb.com
softdb.com

Swallow Acoustic Consultants
John Swallow -
info@swallowacoustic.ca
swallowacoustic.ca

True Grit Consulting Ltd.
Ms Ina Chomyshyn - 807-626-5640
ina@tgcl.ca
tgcl.ca

Valcoustics Canada Ltd.
Al Lightstone - 905-764-5223
solutions@valcoustics.com
valcoustics.com

Vibra-Sonic Control
Mr. Chris N. Wolfe - 604-294-9495
chris@vibra-sonic.com
vibra-sonic.com

Wakefield Acoustics Ltd.
Mr. Clair W. Wakefield - 250-370-9302
clair@wakefieldacoustics.com
wakefieldacoustics.com

West Caldwell Calibration Labs
Mary Richard - 905-554-8005
wcclca@gmail.com
wccl.com