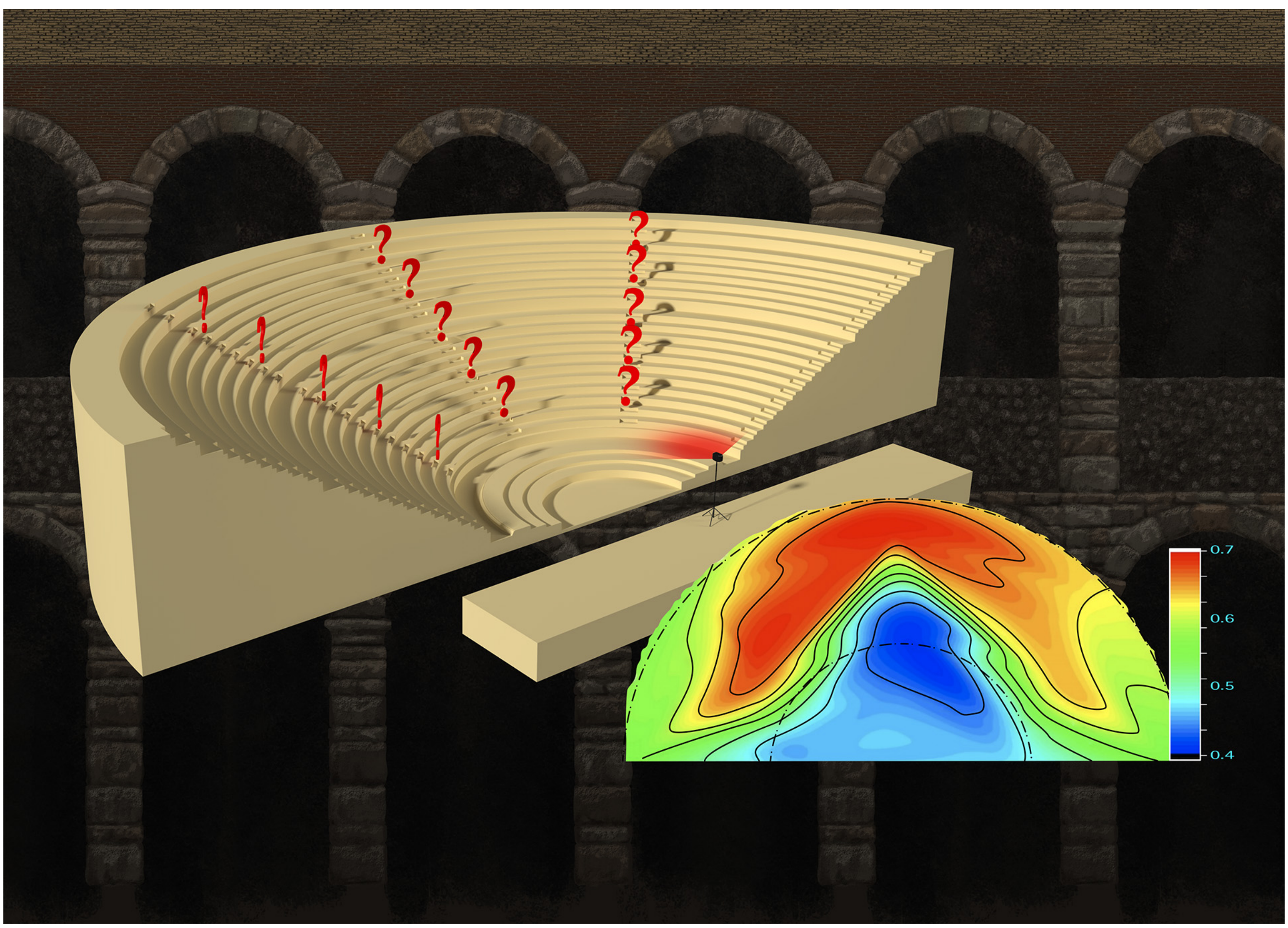
ISSN 0711-6659

canadian acoustics
acoustique canadienne

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

MARCH 2021 MARS 2021
Volume 49 - - Number 1 Volume 49 - - 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 Membership form and send it to the Executive Secretary of the Association (see address above). - Canadian Acoustical Association/Association Canadienne d'Acoustique c/o JASCO Applied Sciences 2305–4464 Markham Street Victoria, BC V8Z 7X8 - - - 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 de remplir le formulaire d'inscription et de l'envoyer au secrétaire exécutif de l'association (voir adresse ci-dessus). - Canadian Acoustical Association/Association Canadienne d'Acoustique c/o JASCO Applied Sciences 2305–4464 Markham Street Victoria, BC V8Z 7X8 - - - secretary@caa-aca.ca - Dr. Roberto Racca

Contents - Table des matières

Editor’s note: The role of Sound towards a post-pandemic resilient society
Éditorial : Le rôle de Son dans une société résiliente post-pandémique

The role of Sound towards a post-pandemic resilient society

Dear reader, it is with a bit of hope that I write you this editorial at the beginning of the first issue of the new year.

We now have vaccines, and although the pandemic is still struggling our world, we can start hoping that there will be some light in front of us. We can start to make plans and dreams post-pandemic scenarios.

Over the last year, we have learned new meanings of the word “globalization”; we understood we are connected and should be aware of the interconnected challenges of our society. We all know the impacts that the social dis-tancing is causing, but it is now time for recovery and resiliency.

Many researchers over the last 12 months have been able to keep doing a bit of researches, while many busines-ses have been forced to close. My desire is now that re-searchers will be dedicated more than ever to support com-panies. A radical transformation of our society is needed not only for the post-pandemic era but also for the multiple unresolved crises we still have (starting from *climate change*). We live together in an interconnected world, and we will need to communicate more and help each other, overcoming the separations that have been unfortunately challenged us in the past. We will restart traveling, meeting people, discovering places, and pursuing sustainable development.

Now, let me present this issue. This is a real inter-national issue, with overseas making most of the issue. In an era when we cannot travel and performance spaces can be visited only virtually, we have two papers about Roman Theatres that will allow our Canadian readers to travel both geographically and historically. Moreover, we have a high-ly interesting paper on the history of hearing loss and much other content.

I wish you a pleasant reading of this issue.
Umberto Berardi
Editor in Chief.

Le rôle du Son dans une société résiliente post-pandémique

Cher lecteur, c'est avec un peu d'espoir que je vous écris cet éditorial au début du premier numéro de la nouvelle année.

Avec l’arrivée des vaccins, et bien que nous luttons encore contre cette pandémie à travers le monde, nous pou-vons commencer à espérer un peu de lumière dans le futur. Nous pouvons commencer à faire des plans et à rêver à des scénarios post-pandémiques.

Au cours de l’année dernière, nous avons appris de nouvelles significations du mot «mondialisation»; nous avons compris que nous sommes connectés et que nous devons être conscients des défis d’interconnection de notre société. Nous connaissons tous les impacts que la distan-ciation sociale entraîne, mais il est maintenant le temps de la reprise et la de résilience.

Au cours des 12 derniers mois, de nombreux cher-cheurs ont pu continuer à faire quelques recherches, tandis que de nombreuses entreprises ont été contraintes de fer-mer. Mon souhait est maintenant que les chercheurs se consacrent plus que jamais à soutenir les entreprises. Une transformation radicale de notre société est nécessaire non seulement pour l’ère post-pandémie, mais aussi pour les multiples crises non résolues que nous connaissons encore (à commencer par le changement climatique). Nous vivons ensemble dans un monde interconnecté, et nous devrons, plus que jamais, communiquer et nous entraider, surmonter les séparations qui nous ont malheureusement été con-testées dans le passé. Nous recommencerons à voyager, à rencontrer des gens, à découvrir des lieux et à poursuivre le développement durable.

Maintenant, permettez-moi de présenter ce numéro. Il s'agit d'un véritable numéro international, avec, pour l’es-sentiel, des auteurs d’outre-mer. À une époque où nous ne pouvons pas voyager, où les espaces de spectacle ne peu-vent être visités que virtuellement, nous avons deux articles sur les théâtres romains qui permettront à nos lecteurs can-adiens de voyager à la fois géographiquement et histo-riquement. De plus, nous avons un article très intéressant sur l'histoire de la perte auditive et bien d'autres contenus.

En vous souhaitant une agréable lecture.
Umberto Berardi
Rédacteur en chef

Measurements of Acoustical Parameters in the Roman Theatre of Verona

Lamberto Tronchin*1, Francesca Merli†1, Antonella Bevilacqua‡2, Marco Dolci♦3 et Umberto Berardi♯4
[1]Department of Architecture, University of Bologna, Italy
[2]CIDEA, University of Parma, Italy
[3]Gruppo CSA spa Via Torrente 22, Rimini, Italy
[4]Faculty of Engineering and Architectural Science, Ryerson University, Toronto, Canada

Résumé

L'attention des érudits concernant l'acoustique des anciens théâtres en plein air s'est considérablement accrue au cours des siècles et parmi les bâtiments historiques qui ont survécu jusqu'à nos jours, l'acoustique du théâtre romain de Vérone n'a pas encore été approfondie. Dans cet article, les résultats de l'étude acoustique ont été comparés aux valeurs mesurées par des chercheurs dans les théâtres romains de Bénévent et de Séville. Cependant, les données de post-traitement obtenues à l'intérieur du théâtre de Vérone ont été analysées de deux manières différentes : par une méthodologie classique représentant les graphiques des paramètres acoustiques, et par la création d'une vidéo montrant une réponse impulsionnelle (IR) en temps réel et les réflexions relatives survenues aux limites de la construction. La technique la plus récente a été réalisée en utilisant un réseau de microphones sphériques multicanaux, qui rappelle l'approche MIMO, capable d'avoir un contrôle spatial complet de la propagation du son dans l'espace. Les auteurs de cet article illustrent une brève histoire du théâtre, y compris la description des éléments de construction, ainsi que deux procédures distinctes en montrant les résultats qui renforcent la nécessité d'utiliser l'approche MIMO à côté des graphiques traditionnels capables de détecter la directivité des réflexions sonores et d'estimer l'intensité de la diffusion.

Traduit avec www.DeepL.com/Translator (version gratuite)
Mots clefs: Théâtre antique en plein air; paramètres acoustiques; échantillonnage PCM spatial, réseau de microphones sphériques, mesures MIMO.

Abstract

The attention of the scholars to the acoustics of ancient open-air theatres has increased considerably through the centuries. Among the historical buildings survived to nowadays the acoustics of the Roman theatre of Verona has not been deeply investigated, yet. In this paper, the outcomes of the acoustic survey have been compared with the values measured by researchers in the Roman theatres of Benevento and Seville. However, the post-processing data obtained inside the theatre of Verona have been analysed in two different ways: by a standard methodology representing the graphs of the acoustic parameters, and by the creation of a video showing a real-time impulse response (IR) and relative reflections occurred at the boundaries of the construction. The latest technique has been realised by using a multichannel spherical microphone array, which calls back the MIMO approach that is capable to have complete spatial control of the sound propagation through space. The authors of this paper illustrate a brief history of the theatre, including the description of the construction elements, and also two distinct procedures in showing the results that strengthen the necessity of using the MIMO approach beside the traditional graphs capable to detect the directionality of sound reflections and to estimate the intensity of scattering.

Keywords: Open-air ancient theatre; acoustical parameters; spatial PCM sampling, spherical microphone array, MIMO measurements.

1 Introduction

Recently, the European Union has financed several research projects in order to increment the knowledge related to the architectural and acoustical characteristics of ancient open-air theatres [1-4]. The necessity of further investigations is driven by the intention to adopt the acoustics of classical open-air theatres, historically used for comedies and tragedies, to contemporary uses, including musical entertainments and summer festivals [5-7]. In fact, the introduction of modern sound systems electronically amplified could cause a risk of damaging these cultural heritages, corrupting their preservation to the new generations. This paper focuses on the acoustic study of the Roman theatre of Verona, a city located in northern Italy, in comparison with the acoustics existing in the Roman theatre of Benevento and Seville.

Today the Roman theatre of Verona is back to be one of the city points flourishing of cultural activities during the summer seasons.

* lamberto.tronchin@unibo.it
† francesca.merli8@unibo.it
‡ antonella.bevilacqua@unipr.it
♦ mdolci@csaricerche.com
♯ uberardi@ryerson.ca

2 The Roman Theatre of Verona

2.1 Historical Background

When Romans planned the first expansion behind the river Adige, Verona was a small village developed along two main roads, called *Via Postumia* and *Via Claudia Augusta*. Under the influence of Julius Caesar, Verona was proclaimed a *municipium* in 49 BC, to be governed by local magistrates. As such, a great transformation began: the main doors of the city walls became monumental and the civic spaces saw the construction of different public buildings.

The idea of building a theatre out of the core of the village was primarily due to taking advantage of the natural slope of Saint Peter's hill in order to save as much construction materials as possible to support the steps of the *cavea* [8]. The theatre was surrounded by a temple honoured to god *Jupiter*, built on top of the hill and connected to it through a few terraces (Figure 1).

The roman age was for Verona the first flourishing period, with a singular richness of architectural monuments and bridges. During the 3rd century AC, the theatre of Verona started to fall in disuse. The great cause was the development of Christianism, which considered immoral all kinds of shows [9]. Another reason was a fire occurred in the second half of the 3rd century, which destroyed the core of the theatre, causing the fusion of the lead pipelines that were used for collecting rainwater. After that, the theatre was transformed into a necropolis, while the temple was converted to a Christian church [10].

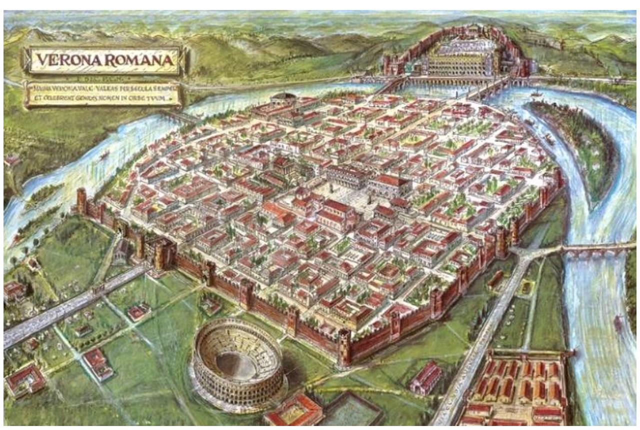


Figure 1: Ideal reconstruction of Verona during the 1st century AC, by G. Ainardi.

During the Middle Ages, an entire district was built on the same site, with private residences standing directly above the Roman theatre, covering completely the historical building. During the 19th century, the invasion of the Austrian soldiers transformed the site into a military base. Different campaigns of archaeological excavations were promoted by Andrea Monga, a well-off merchant. His effort brought to the purchase of the whole area where the theatre was located just underneath the various constructions built wildly on the hill [11].

A French architect, named Edmond-Jean-Baptiste Guillame (1826-1894), described the conditions of the theatre and produced lots of drawings, showing to be deeply keen in studying all the details noted on his booklet (i.e. Memoire).

The sketch represented in Figure 2 gives an idea of how the theatre should be erected, based on the hypothesis of Guillame. The wooden sticks, supported by shelves at the level of the third order, should be a trace of the presence of a *velarium* that coronated the ambulatory [12].

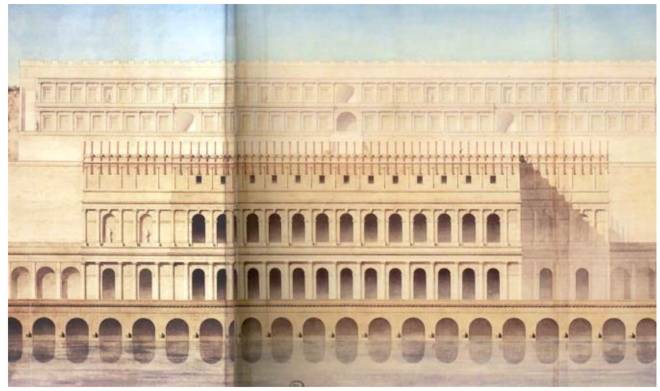


Figure 2: Elevation of the Roman theatre. Reconstruction designed by E. Guillame, 1860 [12].

2.2 Constructive characteristics

The structural elements of the Roman theatre of Verona were realized by using a light grey tuff, which corresponds to the stone composing S. Peter's hill [8]. Despite its good resistance, the tuff deteriorates quickly if subject to meteorological conditions when installed outdoors. Another type of stone (i.e. limestone from Valpolicella), in white and pink colours, was used for architectural decorations, frames and arch keys.

The architectural orders of the columns were tuscan for the lowest level, ionic for the second and corinthium for the upper level [8].

Because the theatre was built on the slope of the hill, the heavy rains during adverse conditions could provoke landslides. In order to comply with this problem, a cut of 18×2 cm (L×W) was created into the stone blocks between the steps of the audience area, where the rainwater falling from the hill could be collected and convolved to the river through a canalization system below the *cavea* [10].

What is visibly disrupting the continuity of the hemicircular seats is the construction of a medieval church dedicated to S. Siro and Libera (Figure 3).

The original capacity of the theatre of Verona could be approximately 3000 seats, although today it is reduced to 2000. The main parts are the following:

- The orchestra is placed at the centre of the theatre in a semi-circular space. The diameter of the orchestra is 29.60 meters;
- The *proscaenium* is in front of the scenic building and it is 1.4 meters above the level of the orchestra;
- The entries (called *vomitoria*) are usually at the sides of the *parascaenia* and facilitate the public access to the seats;

Figure 3: View of the Roman Theatre in Verona and of a post-construction on the left representing the church of S. Siro and Libera.

- The scenic building is composed of tuff blocks and covered by marble sheets. It was 27 meters high, 72 meters long and 6 meters wide;
- The *cavea* is the space dedicated to the audience. Horizontal corridor (*praecinctio*) subdivided the *cavea* into two main sectors, called *ima* (lower) and *summa* (upper) *cavea*;
- The *ambulacrum* (ambulatory) is an arched gallery crowning the upper *cavea*, having dimensions of 2.3 meters height and 2.95 meters width.

2.3 Brief *excursus* of other Roman theatres

Theatres of similar characteristics were built also in other parts of the Roman territory. In particular, to cite a few of them, the theatre of Benevento, located nearby Naples, and Seville, in Spain, represent the evidence of the flourishing construction activity undertaken by Romans other than their love for the shows. The theatre of Benevento and Seville are herein chosen in order to show a few samples of how the Romans were able to construct different volume sizes of such types of buildings.

The theatre of Benevento was built during the 2^{nd} century AC and was made of up to 25 arcades divided into three levels. The diameter of the *cavea* is approximately 80m while the diameter of the orchestra is 20m [13]. The *cavea* is composed of 19 and 8 steps, respectively related to the *ima* and *summa cavea,* against the 25 and 12 steps found in Verona. The large dimensions of the theatre allowed it to have a capacity of over 10000 seats [14]. The scenic building was 44.2m long and 3.5m wide, but nowadays only disconnecting parts of the *scenae fronts* are erected, the rest has been lost throughout the centuries, as shown in Figure 4.

Another important Roman theatre is that one located in Seville, Spain, so called the Italic theatre because it was built in one of the Roman provinces. In particular, the diameter of the *cavea* is about 71m, similar to what is found in Verona (i.e. 76m), having a capacity of 3000 seats. The diameter of the orchestra is 15m while the dimensions of the scenic building are 42m in length and 5.6m in width [15]. From Figure 5 it is possible to see that the *ima cavea* and the scenic building have been preserved almost intact.

The presence of the scenic building is very important under acoustic point of view, because it promotes to build-up of the reflections, acting as a reflector that directs the sound towards the audience area.

Figure 4: Aerial view of the Roman theatre of Benevento

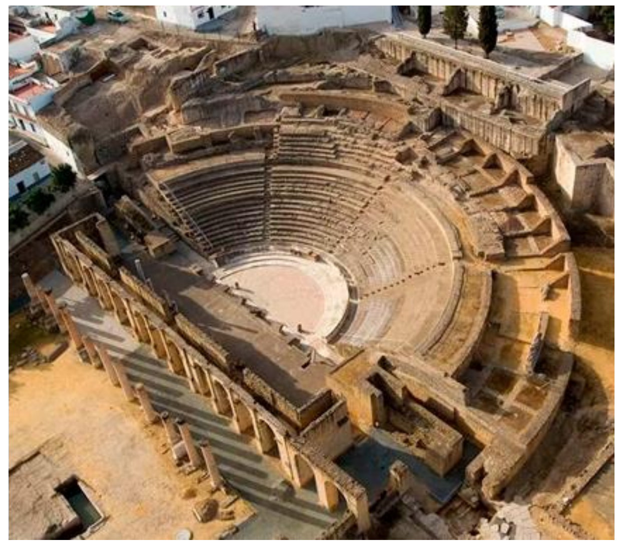


Figure 5: Italic theatre of Santiponce, Seville.

Table 1 summarises the architectural features of the three theatres, as discussed.

Table 1: Architectural characteristics of the theatres of Benevento, Verona and Seville.

Description	Benevento	Verona	Seville
Orchestra diameter (m)	20	29.6	15
Cavea diameter (m)	80	76	71
Actual Capacity (seats)	8000	2000	3000
Scenic Blg [L×W] (m)	44.2×3.5	72×6	42×5.6

3 Acoustical measurements in Verona

In order to analyse the acoustic characteristics of the theatre of Verona, an acoustic survey was carried out with the following equipment:

- Equalised omnidirectional loudspeaker (Look Line);
- Microphones:
  - Binaural dummy head (Neumann KU-100);
  - B-Format (Sennheiser Ambeo);
  - Omnidirectional microphone (Bruel&Kjaer)

- 32-channel (MhAcoustics em32 Eigenmike®);
- 360° Camera;
- Personal Computer connected to the loudspeaker and all the receivers.

The measurements were executed by using a dodecahedral sound source emitting an excitation signal (a 20s long Exponential Sine Sweep (ESS)) having a uniform sound pressure level for the range between 40 Hz and 20 kHz, while the microphones were employed to record signals necessary to obtain the impulse responses (IRs).

The sound source was placed at 1.5m from the finished floor, precisely in the proscenium area where the actors were used to stand on, and the microphones were positioned on the radial axes of the *cavea*, with the probes at the height of 1.1m above their reference floor. All the microphones were moved for 11 positions across the *cavea* to represent as much as possible the audience area (Figure 6). The 360° camera was installed in the same positions as the em32 microphone locations. The acoustics measurements were carried out without any audience and any scenery installed.

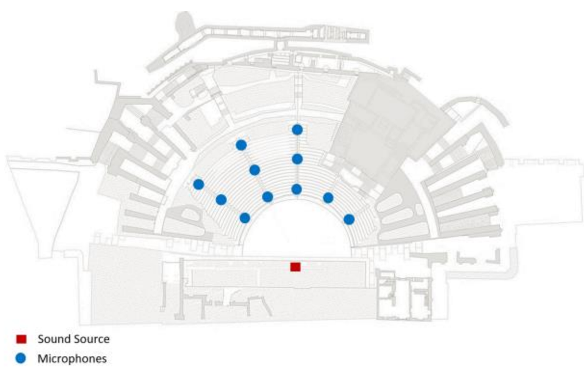


Figure 6: Measurement setup: red point indicates the sound source position and the blue points indicate the receiver positions.

The reason why different microphones were used is to highlight the difference of result representation between the traditional setup and the innovative system. The multichannel em32 Eigenmike® microphone (manufactured by MhAcoustics), equipped with 32 capsules mounted on a spherical surface, has the capability to extract any arbitrary directivity of virtual microphones from real microphones arrays by using a Spatial PCM Sampling (SPS) beamformer, which has a better resolution for high directivity patterns when used as an 8th order cardioid, by representing 122 directions uniformly covering the whole solid angle [16].

4 Results

4.1 Traditional acoustic parameters

Figure 7 shows the IR measured with the dodecahedral sound source. The recorded ESS signals have been processed by using the plugin Aurora suitable for Audition.

Several acoustic parameters defined in the international standards ISO 3382-1 [17], such as the early decay time (EDT), reverberation time (T_{30}), clarity (C_{80}) and definition (D_{50}) have been analysed [18]. Figures 8 to 11 show the comparison between the values found in Verona and measured by the authors and those related to the other two open-air theatres, as provided by the literature [14, 15].

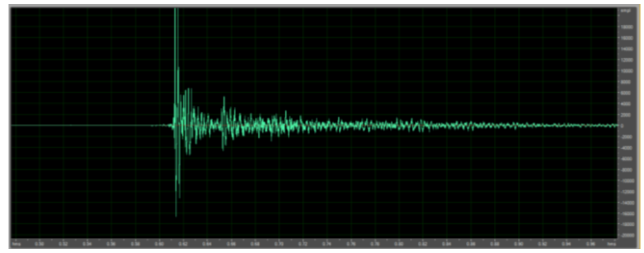


Figure 7: Measured IR in the Roman theatre of Verona having the sound source placed in the *proscaenium* and the receiver (omnidirectional microphone) placed in the central sector of the *summa cavea*.

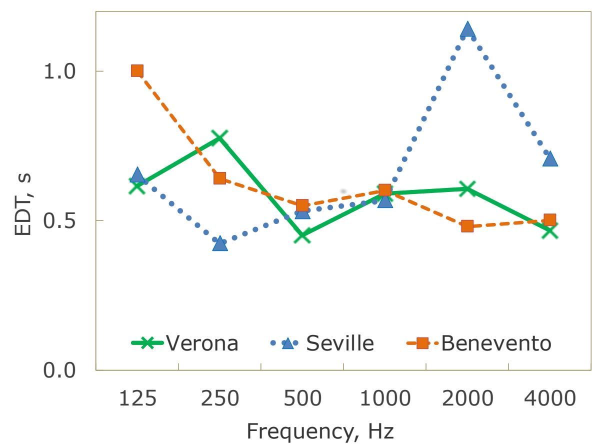


Figure 8: Measured results of Early Decay Time (EDT).

The values of the acoustic parameters are shown in the octave bands between 125 Hz and 4 kHz, considered as the average results of all the measurement positions.

Figure 8 shows that the EDT is approximately 0.6s in Verona, having the values over the frequency range similar to Benevento. What is most in evidence from the graph above is the peak at 2 kHz related to Seville, probably due to the presence of the entire stage walls, reflecting strongly the high frequencies sound rays. However, the overall value of EDT is good for both speech and music in all the theatres.

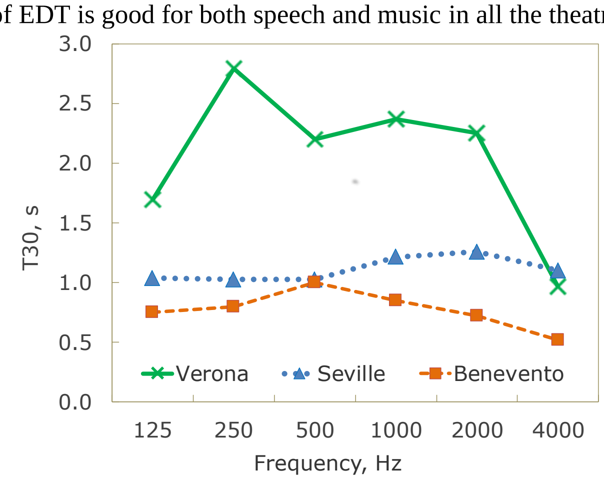


Figure 9: Measured results of Reverberation Time (T_{30}).

Figure 9 shows that T_{30} is higher in Verona than the other two theatres. This effect is due mainly to the reflections on the buildings surrounding the *cavea*, like the presence of the archaeological museum on one of the extremities of the scenic building, the church of S. Siro and Libera, the convent of S. Jerome parallel to the scenic building and behind the *summa cavea* and other residential properties crowning other sides and built on the slope of S. Peter's hill. The buildings' facades reflect the sound and therefore this geometrical circumstance is favourable to cause a longer reverberant tail.

In Benevento and Seville, despite the partial presence of the scenic building, no significant reflections are given by other contributions because of the absence of surrounding buildings and, thus, the values of T_{30} are contained around 1s. Probably the difference between Benevento and Seville regarding the integrity of the scenic building's wall justifies that slight variance in values, which is null at 500 Hz.

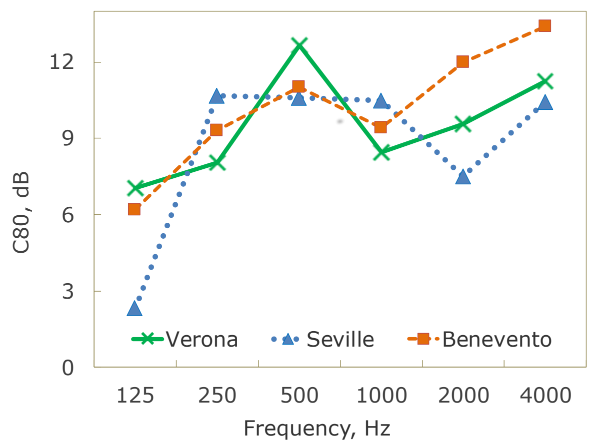


Figure 10: Measured results of Clarity Index (C80).

Figure 10 shows the averaged values of C_{80} of all the receivers as a function of frequency. The results indicate that clarity is similar among the three theatres. If the average value is approximated to 11dB across all the frequency bands, it can be considered good for music perception. High peaks were found at 500 Hz in Verona and at 4 kHz in Benevento, which could be due to the materials (i.e. stone in Verona and bricks in Benevento) currently installed on the seats of the *cavea* as a result of recent restoration works [14]. These hard surface materials reflect the sound at different frequency bands and help to achieve a good listening. In Seville probably the roughness of the original stone of the seats attenuated this effect, resulting in more uniform on the mid frequencies, with very good clarity at 125 Hz.

For all the three cases, although the field is not completely diffuse as the open-air theatres are, the definition (D_{50}) is 85% across all frequencies, as shown in Figure 11, which is considered a good value for good listening and speech comprehension based on the parameters of Greek and Roman theatres. The values over all the frequency bands are more than 0.5, except for 125 Hz of Seville, which is slightly low compared to the other ones but still considered an acceptable value.

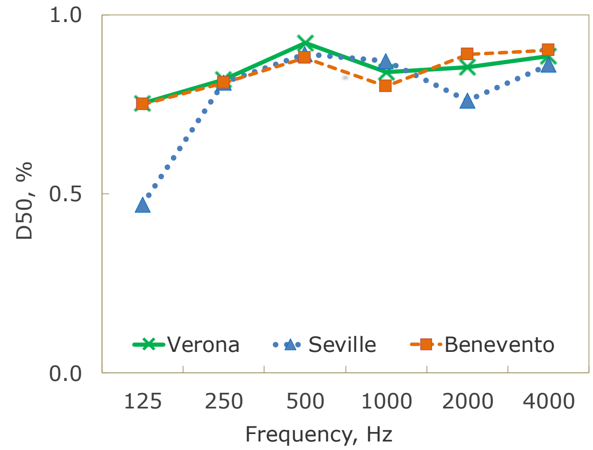


Figure 11: Measured results of Definition (D_{50}).

The analysis then considered the sound strength (G), which is a more suitable parameter to characterize the acoustic of an open-air space than the reverberation time [19]. It is analysed in relation to the Roman theatre of Verona, only.

In Figure 12, all the values of the strength are positive, with significant robustness which can be considered a good result for sound amplification in open air theatre. It is due to the buildings surrounding the *cavea*.

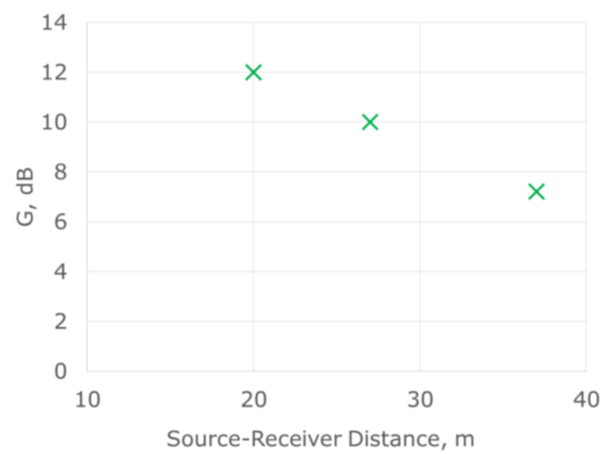


Figure 12: Measured results of StrenGth (G) at 1k Hz.

4.2 Analysis of the distribution of sound reflections

By taking advantage of the em32 Eigenmike® microphone's capabilities, panoramic sound maps were obtained for each source-receiver combination. Such maps are useful to understand the specific role of architectural elements interacting with sound, showing the direction of arrival of the sound reflections and their relative intensity.

The new elaboration technique involves the analysis of data obtained by a combination of an omnidirectional sound source, a multichannel microphone (i.e. em32 Eigenmike®) and a panoramic view (i.e. a 360° image represented in an equirectangular view), where the 32 microphone signals, recorded from each of the 32 capsules, have been processed by extracting 122 high directivity virtual microphones (with

8th order cardioid setup) spreading the directions uniformly distributed in the space (i.e. Spatial PCM Sampling (SPS) encoding) [16]. The beamformed multichannel IR has been divided into short frames, analysed singularly. For each frame, the amount of energy associated with each virtual microphone has been computed and then represented as a colour map overlay. The overall result is a video showing the sound waves arriving at the receiver from all the possible spherical directions.

The video has been realized by processing 2048 samples at 48 kHz sampling rate. Each virtual microphone required to sum the results obtained from the convolution of the 32 input channels with the 32 FIR filters. In order to elaborate a matrix given by the 32 virtual microphone outputs, combined with the FIR filters and having 2048 samples, a VST plugin (i.e. X-volver) was employed to facilitate the massive operation. A 32×32 filter matrix has been used for converting the signal coming from the 32 transducers of the microphone into the 32 SPS signals [20].

In order to have a right read of the following image, some guidance is briefly given. The sound pressure level having different ray energy is faithfully represented by the contour levels. The colour scale indicates that the sound waves having more energy are represented with red and warm colours, while the blue-violet and cold colours indicate a poor energy sound wave.

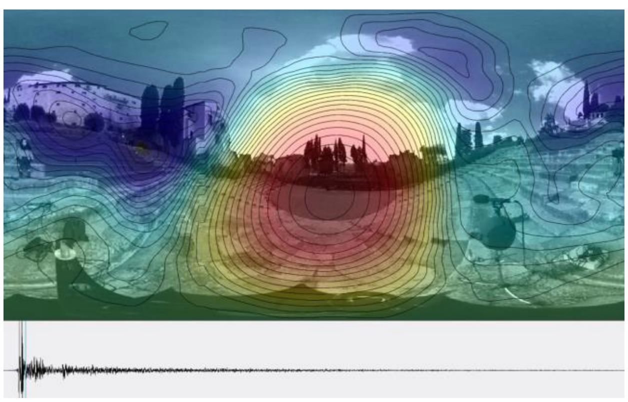


Figure 13: Acoustical map showing the arrival of a direct sound.

An example of the usefulness of such maps is given in Figure 13, which shows the sound coming from the source placed in the *proscaenium* and arriving at the receiver placed in the *cavea*.

The stone of the steps composing the *cavea*, being a reflecting material, contributes to rising upward the reflections of the soundwaves, as the contour levels show laterally in Figure 14.

Other than the early reflections, Figure 14 shows also the late reflections coming from the floor of the orchestra, being as well in hard material (i.e. marble).

The acoustical maps, as shown above, demonstrate to be useful not only for understanding the direction of arrival of the sound rays but also to see how the sound wave is scattered based on the width of the coloured circles shown in the maps. As such, the wider is the circle, the more scattered is the sound wave. The sharper circles (e.g. related to the floor reflections) indicate a more directive sound wave.

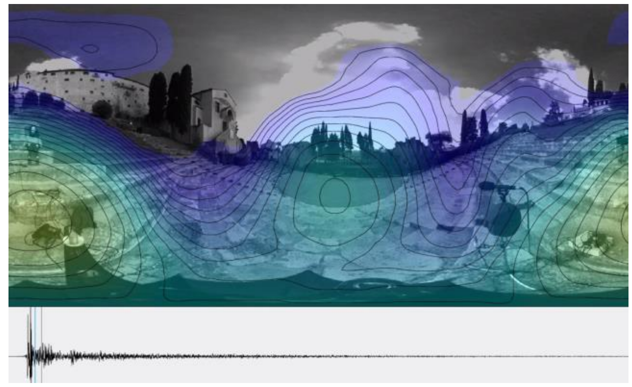


Figure 14: Acoustical map showing the reflections scattered onto the steps.

5 Conclusion

This work presents two types of analysis results about the acoustic survey undertaken in the ancient open-air Roman theatre of Verona. Measurements based on ISO 3382-1 were conducted in situ in unoccupied conditions using omnidirectional sound source and four types of microphones.

The first methodology indicates the results based on the standard configuration, which is composed of the graphs' representation. In particular, the theatre of Verona has been compared with the other two Roman theatres, that are in Benevento and Seville.

Following this approach, results obtained from the measurement campaign showed that the buildings surrounding the theatre of Verona exert their influence on the reverberant tail of the energy decay by undergoing many scattered reflections, which is more attenuated in Benevento and Seville. The energy parameters show an excess of clarity for music and high definition of the word, similar to what has been found in Benevento and Seville.

Regarding the strength of the theatre of Verona, historical studies [21] assume that the circular corridor (*praecinctio*) dividing *ima* and *summa cavea* interrupts the trend of a straight-line tangent to the edges of the steps, in order to follow the natural inclination of the hill. This footfall in terms of sound propagation means a shortened sound-receiver distance for the last row of seats and hence more energy at these receiver positions [22].

This study has been extended to analyse the specific path of sound reflections and relative directionality. By taking advantage of the abilities of the new microphone (i.e. em32 Eigenmike®), 3D sound maps are obtained for each source-receiver combination. Such maps indicate the direction of arrival of the sound reflections and their relative intensity, contributing to understanding the specific role of architectural elements interacting with the soundwave other than the magnitude of scattering based on the size of the contour levels.

Unfortunately, the role of the occupancy inside the theatre of Verona remains unexplored, because not measured. However, by literature [13] if it is assumed that the hypothetical roof of an open-air theatre could be considered as a surface area having a unitary absorption, the additional sound absorption of the audience is not crucial in determining significant variations on the acoustic parameters, since the scattering effect is not substantial as in enclosed volumes.

In addition, further conjectures could be made upon the virtual reconstruction of the theatre of Verona at its initial shape, but this discussion shall be considered in future articles.

Acknowledgments

This work was carried on within the project n.201594LT3F, funded by PRIN (Programmi di Ricerca Scientifica di Rilevante Interesse Nazionale) of the Italian Ministry of Education, University and Research and the project "SIPARIO-Il Suono: arte Intangibile delle Performing Arts–Ricerca su teatri italiani per l'Opera POR-FESR 2014-20", n. PG/2018/632038, funded by the Regione Emilia Romagna under EU Commission. The Authors thank Edoardo Piana for his precious help during the test measurements.

References

[1] J.H. Rindel, ERATO; Final Report; Technical University of Denmark: Copenaghen, Denmark, 2006.

[2] J.H. Rindel, Roman theatres and revival of their acoustics in the ERATO project. *Acta Acust. United Acust*. 99, 21–29, 2013.

[3] C. Hak, N. Hoekstra, B. Nicolai, W. Wenmaekers, Project ancient acoustics part 1 of 4: A method for accurate impulse response measurements in large open-air theatres. In *Proceedings of the 23rd International Congress of Sound Vibrations (ICSV23),* Athens, Greece, 2016.

[4] R.H. Wenmaerkers, B. Nicolai, N. Hoekstra, C.C. Hak, Project ancient acoustics part 4 of 4: Stage acoustics measured in the Odeon of Herodes Atticus and in the theatre of Argos. In *Proceedings of the 23rd International Congress on Sound Vibrations (ICSV23)*, Athens, Greece, 10–14 July 2016.

[5] E. Bo, A. Astolfi, A. Pellegrino, D. Pelegrin-Garcia, G.E. Puglisi, L. Shtrepi, M. Ryctarikova, The modern use of ancient theatres related to acoustic and lighting requirements: Stage design guidelines for the Greek theatre of Syracuse. *Energy Build*. 95, 106–115, 2014.

[6] E. Bo, M. Bergoglio, A. Astolfi, A. Pellegrino, Between the archaeological site and the contemporary stage: An example of acoustic and lighting retrofit with multifunctional purpose in the ancient theatre of Syracuse. *Energy Procedia* 78, 913–918, 2015.

[7] U. Berardi, G. Iannace, The acoustic of Roman theatres in Southern Italy and some reflections for their modern uses. *Appl. Acoust.* 170, 107530, 2020.

[8] L. Franzoni, G. Lampronti, The Roman Theater: history and shows (*Il Teatro Romano: la storia e gli spettacoli)* Verona, Editore Comune di Verona, 1988.

[9] F. Dal Forno, The Roman theatre of Verona (*Il teatro romano di Verona*) Vita veronese, 1961.

[10] M. Bolla, The Roman theatre of Verona and its sculptures (*Il teatro romano di Verona e le sue sculture*) Ed. Grafiche Aurora, Verona, 2010.

[11] P. Brugnoli, In beautiful Verona (*Nella bella Verona*) Ed. Cappelli, 81-104, 1972.

[12] M. Bolla, The Roman theatre of Verona, in Italy antiqua. Envois by French architects (1811-1950) (*Il teatro romano di Verona, in Italia antiqua. Envois degli architetti francesi (1811-1950)*). Italy and Mediterranean area, exhibition catalog (Paris-Rome, 2002), 26-40, 2002.

[13] G. Iannace, U. Berardi, L. Maffei, Virtual reconstruction of the historical acoustics of the theatrum tectum of Pompeii *Journal of Cultural Heritage,* 19, 6, 555-566, 2016.

[14] G. Iannace, A. Trematerra, The discovery of Benevento Roman Theatre Acoustics, *Journal of Cultural Heritage*, 15, 698-703, 2014.

[15] S. Giron Borrero, A. Alvarez Corbacho, Patrimonio sonoro de los treatros romanos, *IV Foro Internacional de teatros romanos*, 2018.

[16] A. Farina, A. Amendola, L. Chiesi, A. Capra, S. Campanini, "Spatial PCM Sampling: A new method for sound recording and playback". *AES 52nd International Conference*, Guildford, UK, 2013.

[17] ISO 3382-1 Acoustics-Measurement of Room Acoustic Parameters - Part 1: Performance Spaces, ISO: Geneva, Switzerland, 2009.

[18] P. Ciancio Rossetto, G.P. Sartorio, Teatri Greci e Romani: alle origini del linguaggio rappresentato censimento analitico, Turin, 1994.

[19] Mo, J. Wang, The conventional RT is not applicable for testing the acoustical quality of unroofed theatres, *Build. Acoust*, 20, 1, 81–86, 2013.

[20] A. Farina, L. Tronchin, 3D sound characterisation in theatres employing microphone arrays *Acta acustica united with Acustica,* 99, 1, 118-125, 2013.

[21] Vita Veronese, monthly journal, year XVI, May - June. Ed. Ghidini & Fiorini, 178-187, 1963.

[22] A. Farneatani, N. Prodi, R. Pompoli, On the acoustics of ancient Greek and Roman theatres, *Journal of Acoustics Society of America*, 124 (3), 2008.

ACOustics begins with ACO™
SLARMSuccesses™
Red Rocks & ATTPAC, Dallas
ODM Family
NetSLARM™
NORMAL
ALERT
ALARM
CONNECT
PS9200KIT
1/2 Inch
1 Inch
1/4 Inch
Systems
<2Hz >120kHz
<0dBA >170 dBSPL
7052PH
PHANTOM POWER
A-TECH INSTRUMENTS LTD.
MEASUREMENT & CONTROL FOR RESEARCH & INDUSTRY
TEL: (416) 754.7008 | FAX: (416) 754.2351
EMAIL: SALES@A-TECH.CA | WWW.A-TECH.CA
P.O. BOX 252 | SCARBOROUGH | ONTARIO M1E 4R5
Exclusive Canadian Agent
ACO Pacific, Inc.
www.acopacific.com sales@acopacific.com

The Acoustics of the Cassino Roman Theatre

Silvana Sukaj [*1], Gino Iannace [†2], Umberto Berardi [‡3]; Giueppe Ciaburro [♦2] et Amelia Trematerra [♯2]
[1] European University of Tirana (UET), Tirana, Albania
[2] Università degli Studi della Campania, Aversa (Ce), Italy
[3] Department of Architectural Science, Ryerson University, Toronto, Ontario, Canada.

Résumé

Dans cet article, les caractéristiques acoustiques du théâtre romain de Cassino sont discutées. Le théâtre a été construit à l'époque impériale,puis, après les invasions barbares, il fut abandonné et détruit. Il a été reconstruit ces dernières années. Une source sonore placée sur la scène et dans l'orchestre a été utilisée et les caractéristiques acoustiques conformes à la norme ISO 3382 ont été mesurées. Le théâtre a un temps de révérence court égal à 0,6 seconde car le mur de la scène n'a pas été reconstruit. Cependant, en saison estivale, le théâtre est utilisé pour des spectacles musicaux utilisant des systèmes d'amplification électro-acoustiques pour avoir une bonne acoustique

Mots clefs: théâtres antiques, temps de réverbération, scène, orchestre, cave, acoustique des salles.

Abstract

In this paper, the acoustic characteristics of the ancient Roman theatre of Cassino are discussed. The theatre was built during the Imperial Age and was abandoned and destroyed after the Barbaric invasions. The theatre has been rebuilt in recent years and it is currently used for summer events ad performance. To measure the acoustic characteristics of this ancient theatre, the authors used a spherical omnidirectional sound source placed on the stage and in the orchestra. The results show that nowadays the theatre has a short reverberation time equal to 0.6 seconds due to the lack of the stage wall, which has not been rebuilt. The weak sound strength justifies the use of electro-acoustic amplification systems which during the summer season, are adopted to improve the acoustic experience in this ancient theatre.

Keywords: ancient theatres, reverberation time, archeoacoustics, scena, orchestra, cavea, room acoustics.

1 Introduction

In ancient times, theatrical buildings were built to provide performances with a better vision and listening conditions [1-3]. The theatres built in Greece were resting on the slope of a hill with a concentric stepped structure. This configuration improved the visual experience and allowed a better distribution of the sound. Vitruvius, in the ancient book "*De Architectura*", provides some rudimental principles of architectural acoustics, which support many of the features found in ancient theatres [4-6]. To improve the acoustics, Vitruvius suggested to place vases (*echeia*) under the steps; this fascinating hypothesis, today finds applications with acoustic resonators used for correcting the acoustics of modern theatres. The acoustics of the ancient theatres was mainly due to the regular arrangement of the aligned semi-circular steps and to the regular geometries which acted as diffusing surfaces. The diffused sound field in ancient theatres guaranteed good acoustic conditions, as repetitively reported in recent studies [7, 8].

During the imperial period, more than a thousand theatres were built [9]. Theatres were not only buildings for performances as they were places for political and religious meetings. In fact, all the cities of the Roman Empire had a theatre, and the richest citizens contributed financially to its construction. Theatrical performances were offered by rich men to gain the people's consent and political power.

Several measures were used to improve the acoustics of the theatres, such as covering the orchestra with square marble slabs, so to obtain a better diffusion of incident sound. The scena became a building with columns, stuccos, and plasters. The rows of columns, arranged on several levels, created diffusing surfaces that improved the propagation of sound. While the scena building was covered with a canopy to increase early reflections of sound towards the *cavea*. The presence of the scena building allowed a better distribution of the sound in the cavea. In fact, the voice of the actor was reflected by the scena building and then returned to the audience sitting in the cavea. The theatres were used during the summer season and to protect the spectators from the summer heat, the cavea was covered with awnings (*velaria*) [10]. The size of the scena building covered the maximum height of the cavea in order to enclose the scena and the cavea in a single body. Furthermore the size of the scena of Roman theatres was doubled compared to that of Greek theatres. Figure 1 shows a reconstruction of the scena, orchestra, and cavea of the ancient Roman theatre. In this paper the acoustic characteristics of Roman Theatre of Cassino are discussed.

The city of Cassino in Italy was very important during the Imperial Empire, because it was located along the most important communication routes with Rome. This explains

* silvana.sukaj@uet.edu.al
† gino.iannace@unicampania.it
‡ uberardi@ryerson.ca
♦ giuseppe.ciaburro@unicampania.it
♯ amelia.trematerra@unicampania.it

the construction of important buildings such a large theatre and the amphitheatre inside the walls of the ancient city. Figure 2 shows the aerial view with evidence of the theatre and amphitheatre of Cassino by Google maps.

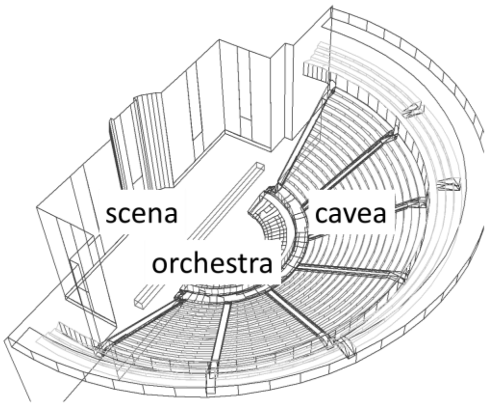


Figure 1: Main elements of the Roman theatre: the scena, the orchestra and the cavea.

Figure 2: Aerial view with the position of the theatre (left) and amphitheatre (right) in the current state by Google maps.

The Roman theatre of Cassino was built in the first century BC, during the Augustan period. The cavea stands on the slope of a hill and is oriented to the South - East. The ground plan and the orchestra are semi-circular. Subsequent historical events led it to being abandoned and demolished.

Figure 3 shows the ground plan of the theatre in current state, with the main dimension and the principal elements (scena, orchestra, and cavea).

While Figure 4 shows the ground plan of the theatre before the restoration (1900) in this period only few elements of the structures had been preserved; and after the restoration (2007) [11].

Figure 5 shows the theatre during the restoration works. The restoration involved only a few parts of the cavea and was completed in 2000. In its current state, the theatre has a semi -circular orchestra with a diameter of 10 m; the cavea with an external diameter of 56 m; and the scena of 5.0 m x 27.4 m. Only nineteen steps have been rebuilt, compared to the origin, in stone and mortar, with height of 0.40 m and depth of 0.70 m, so the cavea has a slope of 30°. The current capacity is about 1,000 spectators.

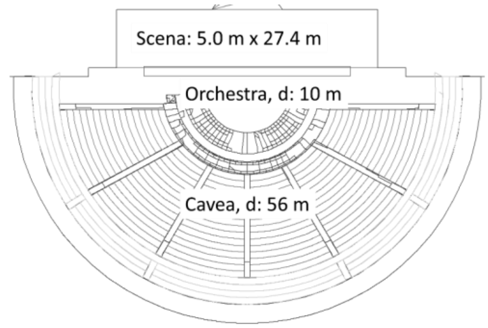


Figure 3: Ground plan of the theatre in the current state, with the main dimension and the principal elements (scena, orchestra, cavea).

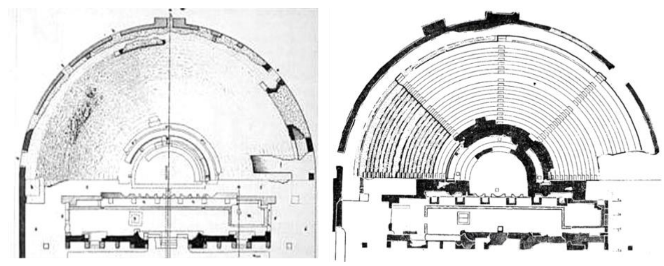


Figure 4: Ground plan of the theatre before the restoration work (left) in 1900, and after the restoration (right) in 2007 [11].

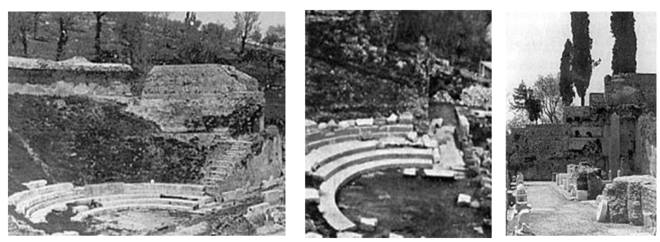


Figure 5: The theatre during the restoration work [11].

Figures 6 and 7 show the side and front view of the theatre in its current state respectively [12].

Figure 6: Front view of the theatre in the current state.

2 Acoustic measurements

To evaluate the acoustic characteristics of the theatre, acoustic measurements were carried out in accordance with literature practice [13] and the standard ISO 3382 [14]. A spherical omnidirectional sound source was placed on the scena at a height of 1.5 m from the floor, in the actor position.

Figure 7: Side view of the theatre in the current state.

The sound source was fed with a MLS signal, by impulse response technique. The acoustic procedure and the post processing methodology were similar to those used to study other theatres [15-20]. The impulse response was detected with an omnidirectional microphone (GRAS 40 AR endowed with the preamplifier 01 dB PRE 12 H) placed at a height of 1.2 m. The receiving points were placed on the I, V, IX, XV and XIX steps, in order to obtain information from varying distances from the sound source, along the three radial directions in the cavea. Figure 8 shows the position of the sound source on the scena, and the receiver points in the cavea set out along three radial directions. The distances of the receiver points from the sound source on the scena were: I step 13 m; V step 17 m; IX step 19 m; XV step 23 m and XIX step 27 m.

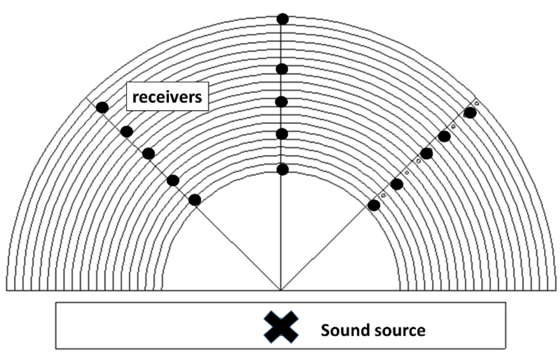


Figure 8: Position of the sound source (**x**) on the scena and the five receivers (•) in the cavea.

During the acoustic measurements, the theatre was empty; the measured noise level was equal 35 dBA. Figures 9 shows the sound source on the scena during the acoustic measurements. The impulse responses were analysed with the software Dirac 4.0. The acoustic parameters defined in the standard ISO 3382 that were analyzed are the reverberation time (T_{30}), early decay time (EDT), sound strength (G), clarity (C_{80}), definition (D_{50}), and sound transmission index (STI).

While Figure 10 shows the sound source on the scena and measurement microphones in the cavea for the measurement of G (strength, dB), for a total of ten receivers.

Figure 9:Sound source on the scena during the measurements.

The typical suggested values of the different monaural acoustic parameters for both speech comprehension and music listening are discussed in [21]:

- T_{30} should assume values below 1.0 second for a clear perception of speech, while it could assume values around 2.0 seconds for music listening preference;
- C_{80} should have a higher value if the goal is to separate initial sounds from diffuse ones, making discrete sounds stand apart from each other. In a sound field which is not completely diffuse, C_{80} is uncorrelated to reverberation time. For the purposes of good listening conditions of music, it is generally reported that C_{80} should be in a range between -2 dB and 2 dB, while it is expected to be above 2 dB if speech perception is a priority;
- D50 may assume values from 0 to 1.0, but for a good speech comprehension, it should have values above 0.5;
- STI represents the degree of the amplitude modulation in a speech signal, with them both referring to the distortion in speech signals caused by reverberation, echoes, and background noise. Values of STI greater than 0.5 represent favorable speech intelligibility conditions.

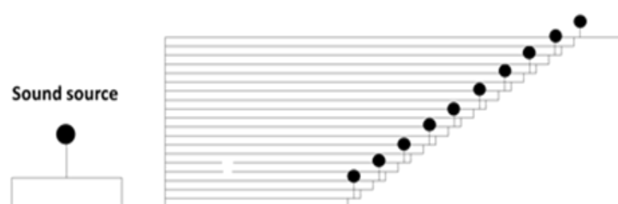


Figure 10: Sound source on the scena and measurement microphones in the cavea for the measurement of G, for a total of ten receivers.

Table 1 shows a synthesis of the optimal acoustic values for different listening conditions.

Table 1: Optimal acoustic parameter values for different listening conditions.

Parameters	EDT, s	T30, s	C80, dB	D50
Values for musical performances	1.8 < EDT < 2.6	1.6 < T30 < 2.2	-2 < C80 < 2	< 0.5
Values for speech performances	1.0	0.8 < T30 < 1.2	> 2	> 0.5

3 Acoustic results

For the fifteen receivers, with the sound source on the scena: Figure 11 shows the average measured values of T30 with the standard deviation; Figure 12 shows the average measured values of EDT, with the standard deviation; Figure 13 shows the average measured values of C80, with the standard deviation; Figure 14 shows the average measured values of D50, with the standard deviation. The measured values confirm that the lack of a roof and backstage wall led to a few sound reflections with short reverberation time, as highlighted in values below 0.5 second of T30. The average value of C80 is equal to 13 dB, while the average value D50 is equal to 0.9. The STI is equal to 0.85 [22-26]. Acoustic measurements show that the theatre, in the actual configuration, cannot be used for opera or symphonic music, since the scena, with no rear wall, prevents any sound reflections, and the listeners only perceive the direct sound. To improve acoustics of the theatre, some screens should be installed at rear of the scena, so as to allow for sound reflection. Figure 15 shows the impulse response on step VII with the effects of the multiple reflections due to the diffraction on the sound on the steps. The multi-reflections of the sound generate a diffusion of the incident sound in all directions, distributing the sound field evenly. Each edge of the steps emit a sound like a secondary sound source. The seats are regular surfaces so are an acoustic filter that passes sound coming from the scena at the expense of surrounding noise.

In open-air theatres, the parameter G (strength, dB) assumes a special significance for the assessment of acoustics. G represents the subjective level of sound and it is defined as the gain from sound pressure level, which is produced by the same spherical omnidirectional sound source, with the same power level (Lw), in a free field at a distance of 10 m from the sound source. To measure the acoustic parameter G, the spherical omnidirectional sound source was calibrated and the sound power level Lw (dB) was measured through the "substitution method" with an reference sound source. The procedure consists of a comparison of the sound pressure level in octave band of a noise source under test with those of the calibrated reference sound source. The reference sound source consists of a centrifugal fan driven by a powerful asynchronous motor type B&K 4204 [27, 28].

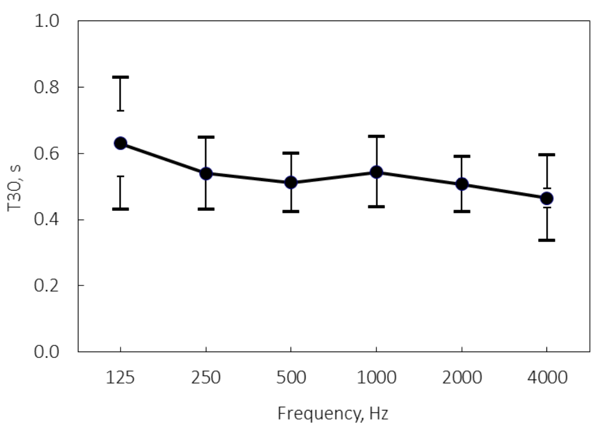


Figure 11: Average values and relative standard deviations of T30.

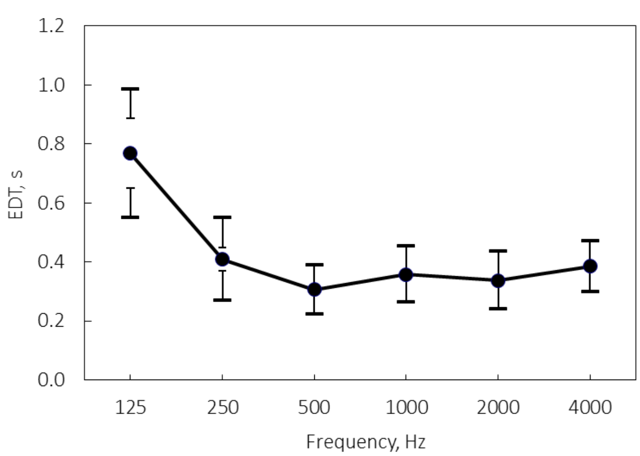


Figure 12 :Average values and relative standard deviations of EDT.

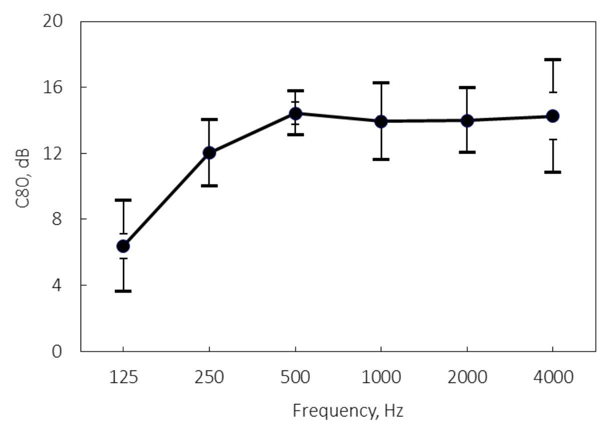


Figure 13: Average values and relative standard deviations of C80.

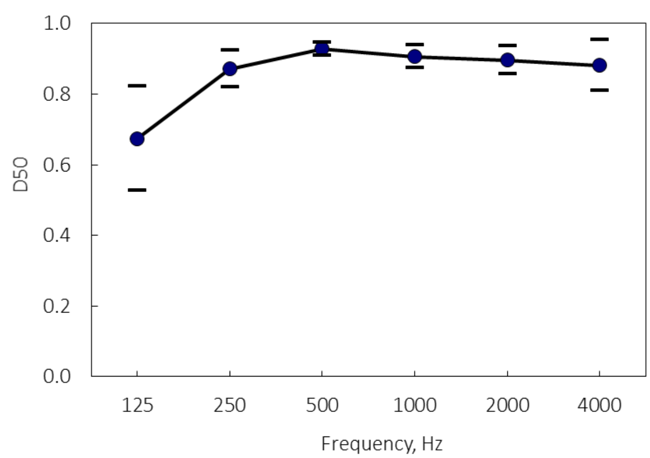


Figure 14: Average values and relative standard deviations of D50.

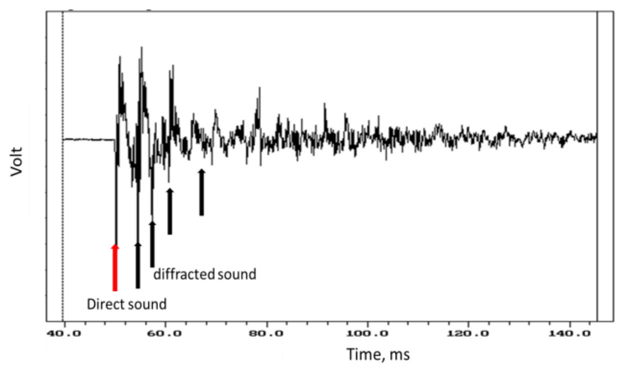


Figure 15: Impulse response on step VII, multi reflections are due to the diffraction on the sound on the steps.

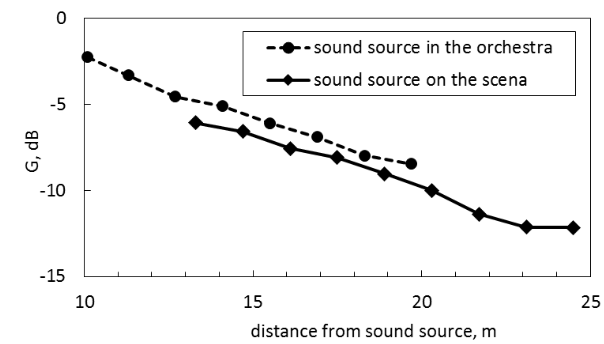


Figure 16: Average value of G along the cavea, with the sound source on the scena and in the orchestra.

The calibration procedures were carried out in a closed large room, and than the set-up was preserved. With the same Lw "calibration" set-up, the sound source was feed during the measurements in the theatre. The acoustic parameter G (strength, dB) was calculated with the following formula:

$$G = Lp - Lw + 31 \text{ (dB)}$$

where Lp (dB) is the sound pressure level detected in the cavea along on the ten steps (Figure 10). Lw (dB) is the sound power level of the spherical sound source. Figure 16 shows the average values of the G, measured along the three directions in the cavea, when the spherical sound source is placed on the scena and in the orchestra.

Based on the sampled results, the spatial distributions of the acoustic parameters were obtained in the cavea. Figure 17 shows the map of T30 at the frequency of 1000 Hz. The reverberation is very low and does not exceed 1.0 second due to the absence of reflective surfaces, while slightly increase only in the upper part of the cavea. Then Figure 17 shows the map of C80 at the frequency of 1000 Hz. Finally, Figure 17 shows the map of D50 at the frequency of 1000 Hz, in the theatre, approaches the unit value. However, with modest variations, the average spatial distribution suggests that the theatre has excellent behaviour for speech understanding [29].

The spatial distribution of the acoustic characteristics is not uniform. In the reconstruction of the theatre some walls are taller than others and this effect generates non-symmetrical sound reflections, resulting in an uneven spatial distribution.

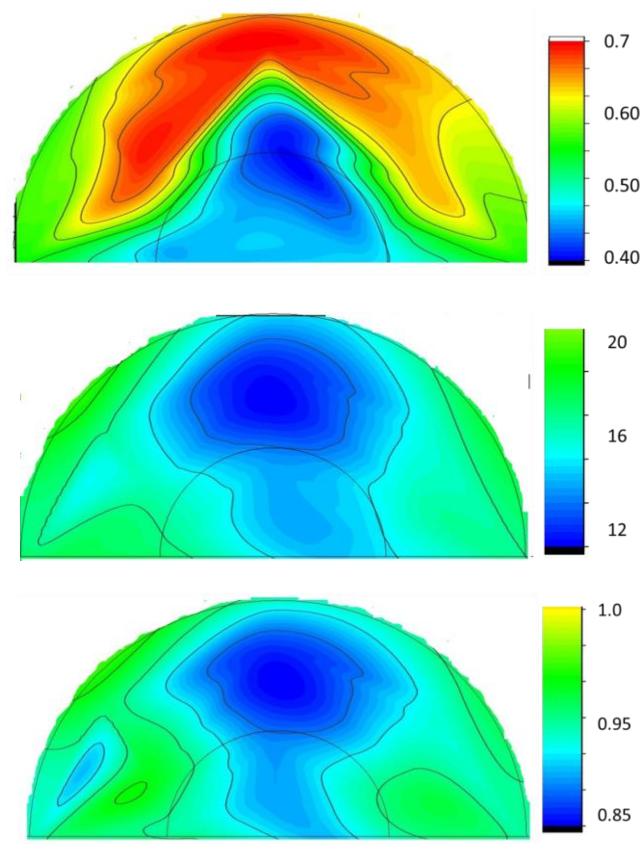


Figure 17: Maps (top to down) of T30 (s), C80 (dB), and D50 at the frequency of 1000 Hz.

4. Discussion

In order to assess the acoustic characteristics of the theatre of Cassino in the actual configuration, a comparison was conducted with the acoustic parameters measured in empty conditions into the open-air theatres of Pompeii (large theatre and Odeon), Benevento, Posillipo, Taormina, Segesta and Siracusa [30-35]. The average values of the monaural parameters at the mid-frequency bands of 500 Hz and 1.0 kHz are reported in Table 2.

Table 2. Acoustic parameters averaged at mid-frequency bands of 500 Hz and 1.0 kHz measured in some ancient theatres in empty conditions.

Theatres	T_{30} [s]	C_{80} [dB]	D_{50} [-]	Cavea diameter [m]
Benevento	0.9	8.0	0.78	93
Cassino	0.6	19.0	0.91	53
Pompeii (large theatre)	0.9	6.0	0.70	60
Pompeii (Odeon)	1.0	9.5	0.8	30
Posillipo	1.1	3.0	0.70	47
Taormina	1.9	1.17	0.53	110
Segesta	0.5	16.0	0.90	63
Siracusa	1.2	13.0	0.90	140

From the comparison with the other reconstructed open type theatres, the Cassino theatre has the shortest reverberation time, due to the geometric characteristics. The cavea has not been completely rebuilt, so even the scena building walls have not been rebuilt. The absence of reflective surfaces does not generate a reverberant field. The theatre has few sound reflections, for its current use, all the events involving the use of sound amplification with loudspeakers. A possible solution to improve the acoustics of the theatre would be the installation of temporary structures of high-density PVC sheets with reflective characteristics, so that the sound incident on the sheets can be sent back into the cavea.

5. Conclusions

The paper reports the acoustic measurements in the Roman theatre of Cassino. The theatre has been partially rebuilt and it is nowadays used for theatrical performances. The acoustic measurements show that the absence of reflective surfaces, such as the walls of the scena building, makes the acoustics insufficient. In fact, the values of the reverberation time do not exceed 1.0 second, and also it is measured a low sound strength value (G, dB). Nowadays during modern performances, sound amplification systems with loudspeakers are used. Not surprisingly, the historical atmosphere and the suggestion of these places make the listener forget the acoustic limits of these theatres or the diffuse use of loudspeakers. However, there is no doubt about the fascination of performance in these theatres that attract a large number of spectators inside the cavea of the ancient theatre. So, the recovery of the ancient theatres allows these buildings to be the cultural centre of the shows in the summer season.

References

[1] G. C. Izenour, *Theatre Design*, McGraw-Hill, New York, 1977.

[2] P. Arnott, *An introduction to the Greek theatre*, Springer, 1991.

[3] P. Wilson, *The Greek theatre and festivals: documentary studies*, Oxford University Press on Demand, 2007.

[4] W.C. Sabine, *Collected Papers On Acoustics*, Cambridge Harvard University Press, 1923.

[5] M.P. Vitruvio, *De Architectura*.

[6] P. Zanker, *La città romana*, Laterza, 2013.

[7] N. F Declercq; C. S. A Dekeyser. Acoustic diffraction effects at the Hellenistic amphitheater of Epidaurus: seat rows responsible for the marvelous acoustics, *J. of the Acoustical Society of America* 121(4), 2011-2022 (2007).

[8] T. Lokki; A. Southern; S. Siltanen; L. Savioja, Acoustics of Epidaurus – Studies With Room Acoustics Modelling Methods, *Acta Acustica* 99, 40 – 47 (2013).

[9] F. Sear, *Roman Theatres: An Architectural Study*, OUP Oxford, 2006.

[10] F.R.d Alfano; G. Iannace; C. Ianniello; E. Ianniello, "Velaria" in ancient Roman theatres: Can they have an acoustic role? Energy Build. 95, 98–105, (2015). https://doi.org/10.1016/j.enbuild.2015.03.010

[11] G.F. Carettoni, Il teatro romano di Cassino, *in Notizie degli scavi di antichità* 1939, 99-141.

[12] C. Pisani Sartorio, P. Rossetto Ciancio, *Teatri greci e romani. Alle origini del linguaggio rappresentato. Censimento analitico*. Seat Torino, 1994.

[13] F. Canac, *L'acoustique des theatres antiques. Ses enseignements*. Editions du centre national de la recherche scientifique, Paris, 1967.

[14] ISO 3382-1:2009: *Acoustics - Measurement of room acoustic parameters*.

[15] G. Iannace; A.Trematerra, The rediscovery of Benevento Roman Theatre Acoustics, *Journal of Cultural Heritage* 15(6), 698, (2014).

[16] U. Berardi; G. Iannace; L. Maffei, Virtual reconstruction of the historical acoustics of the Odeon of Pompeii, *Journal of Cultural Heritage* 19, 555-566 (2016).

[17] A. Trematerra; S. Paternuostro; I. Lombardi, Virtual reconstruction and sound field simulation of the Odeon of Posillipo. *16th Conf. Applied Mathematics*, APLIMAT 2017; Bratislava; Slovakia; 2017.

[18] U. Berardi. A double synthetic index to evaluate the acoustics of churches, Archives of Acoustics, 37, 4 (2012).

[19] U. Berardi; E. Cirillo; F. Martellotta.A comparative analysis of energy models in churches, Journal Acoustical Society of America, 126, 4 (2009).

[20] R. S. Shankland, Acoustics of Greek theatres, *Physics Today* 26, 30–35 (1973).

[21] M. Barron, *Auditorium Acoustics and Architectural Design*, E&FN SPON London, 1993.

[22] J. H. Rindel, Roman Theaters and the Revival of Their Acoustics in the ERATO Project, *Acta Acustica* 99, 21-29 (2013).

[21] S. L. Vassilantonopoulos; J. N. Mourjopoulos, A study of ancient Greek and Roman theater acoustics. *Acta Acustica united with Acustica* 89(1), 123-136 (2003).

[23] K. Chourmouziadou; J. Kang, Acoustic evolution of ancient Greek and Roman theatres. *Applied Acoustics* 69, 514-529 (2008).

[24] A. C. Gade; M. Lisa; C. Lynge; J.H. Rindel, Roman Theatre Acoustics; Comparison of acoustic measurement and simulation results from the Aspendos Theatre, Turkey. *In Proc. ICA 2004*.

[25] G. Iannace, U. Berardi, F. De Rossi, S. Mazza, A. Trematerra and G. Ciaburro. Acoustic Enhancement of a Modern Church. *Buildings* 9, 83, (2019).

[26] U. Berardi, G. Iannace and A. Trematerra. Acoustic treatments aiming to achieve the Italian minimum environmental criteria (CAM) standards in large reverberant classrooms. *Canadian Acoustics / Acoustique canadienne* 47(1), 73-80 (2019).

[27] https://www.bksv.com/en/products/transducers/ acoustic/sound-sources/reference-4204

[28] ISO 3747:2011: *Determination of sound power levels of noise sources using sound pressure Comparison method for use in situ*.

[29] U. Berardi; G. Iannace, The acoustic of Roman theatres in Southern Italy and some reflections for their modern uses. *Applied Acoustics* 170, 107530 (2020).

[30] G. Iannace; A. Trematerra, The acoustic effects of the audience in the modern use the of ancient theatres. Jurnal Teknologi 80(4), 147-155 (2018).

[31] A. Farnetani; N. Prodi; R. Pompoli, On the acoustics of ancient Greek and Roman theaters. *J. of the Acoustical Society of America* 124(3), 1557-1567 (2008).

[32] E. Bo; A. Astolfi; A. Pellegrino; D. Pelegrin-Garcia; G.E. Puglisi; L. Shtrepi; M. Rychtarikova, The modern use of ancient theatres related to acoustic and lighting requirements: Stage design guidelines for the Greek theatre of Syracuse. *Energy and Buildings* 95, 106-115 (2015).

[33] L. Tronchin; F. Merli; M. Manfren, On the acoustics of the Teatro 1763 in Bologna. *Applied Acoustics* 172, 107598 (2021).

[31] L. Tronchin; F. Merli; M. Manfren; B. Nastasi, The sound diffusion in Italian Opera Houses: Some examples. *Building Acoustics* 27(4), 333–355 (2020).

[34] G. Ciaburro; G. Iannace; I. Lombardi; A. Trematerra. Acoustic Design of Ancient Buildings: The Odea of Pompeii and Posillipo. Buildings 10, 224 (2020). https://doi.org/10.3390/buildings10120224

[35] G. Iannace; A. Trematerra, The audience effect on the acoustics of ancient theatres in modern use. In Proc. of 142nd *Audio Engineering Society International Convention* 2017, AES 2017.


CONTROL
NOISE
LOWER PROJECT COSTS
IMPROVE SPEECH PRIVACY
BOOST COMFORT
& WELLNESS
QUICK ROI
INCREASE PRODUCTIVITY
FACILITY
FLEXIBILITY
ENHANCE WORKPLACE CULTURE
SUPPORT FOCUS
LogiSon ACOUSTIC NETWORK
SOUND. THAT WORKS.™
Sound masking is more than a product. It's a service provided by professional technicians who know the effect isn't achieved from the moment they power the system, but by tuning the sound to an independently-proven curve. Designed right, tuned right—that's our motto. And the result is more consistent, comfortable and effective sound masking.
www.logison.com
© 2021 KR MOELLER ASSOCIATES LTD. LOGISON IS A REGISTERED TRADEMARK OF 777388 ONTARIO LIMITED. PHOTO BY VINCENT LIONS.

CHANGES IN THE PREVALENCE AND CHARACTERISTICS OF HEARING LOSS IN A NOISE-EXPOSED POPULATION BETWEEN 1980 AND 2015

Sasha Brown*[1,2], Lorienne M. Jenstad†[1,3], Angela Ryall‡[1] and Ellen Stephenson♦[4]
[1]School of Audiology & Speech Sciences, the University of British Columbia, Vancouver, Canada
[2]WorkSafeBC, Vancouver, Canada
[3]Wavefront Centre for Communication Accessibility, Vancouver, Canada
[4]Department of Community and Family Medicine, the University of Toronto, Toronto, Canada

Résumé

La mise à jour des réglementations, l'amélioration de la réduction du bruit et l'utilisation accrue des dispositifs de protection auditive (PA) peuvent permettre aux travailleurs exposés au bruit de mieux entendre. Dans une étude de cohorte rétrospective (1980-2015), nous avons effectué une analyse secondaire d'une base de données de tests auditifs annuels effectués sur des travailleurs exposés au bruit âgés de 20 à 55 ans. La taille de l'échantillon par cohorte variait de n=1386 à n=5165. Aucune différence de cohorte cliniquement significative dans les seuils de 5 dB ou plus n'a été trouvée pour les 20 ou 30 ans. Pour les 45 et 55 ans, les cohortes nées plus tard avaient de meilleurs seuils que les cohortes nées plus tôt. La prévalence de la perte auditive a diminué pour les cohortes nées plus tard pour les 30, 45 et 55 ans. Les jeunes de 20 ans dans les cohortes ultérieures étaient plus susceptibles d'utiliser des PA que ceux des cohortes antérieures. La prévalence plus faible de la perte auditive et les seuils plus élevés chez ces travailleurs exposés au bruit peuvent être dus à l'utilisation accrue des appareils de protection auditive, aux changements de la réglementation sur le lieu de travail, à l'amélioration du contrôle du bruit sur le lieu de travail ou à l'évolution des attitudes à l'égard de l'exposition au bruit dans les loisirs.

Mots clefs : Perte auditive due au bruit ; longitudinal ; protection auditive ; travailleurs ; prévalence, Colombie britannique

Abstract

Updated regulations, improved noise reduction, and increased use of hearing protective devices (HPDs) may result in better hearing for noise-exposed workers. In a retrospective (1980-2015) cohort study, we conducted a secondary analysis of a database of annual hearing tests from noise-exposed workers aged 20-55 years old. Sample size per cohort ranged from n=1386 to n=5165. No clinically-meaningful cohort differences in thresholds of 5 dB or greater were found for 20- or 30-year olds. For 45- and 55-year olds, later-born cohorts had better thresholds than earlier-born cohorts. Prevalence of hearing loss decreased for later-born cohorts for 30, 45, and 55-year olds. Twenty-year olds in later cohorts were more likely to use HPD than those in earlier cohorts. The lower prevalence of hearing loss and better thresholds in these noise-exposed workers may be due to increased HPD use, changes in workplace regulations, improved workplace noise control, or changed attitudes towards recreational noise exposure.

Keywords: Noise-induced hearing loss; longitudinal; hearing protection; workers; prevalence; British Columbia

1 Introduction

Hearing loss is the most common sensory deficit in older adults and is recognized to be a global social and health problem [1]. Untreated hearing loss of a moderate or greater degree affects communication and can contribute to social isolation, depression, and poorer job performance [2, 3]. Additionally, the damage associated with significant noise exposure leads to disabling hearing problems beyond audiometric changes, such as difficulties hearing in noise, tinnitus, and hyperacusis [4, 5]. Both age-related hearing loss (ARHL), and noise-induced hearing loss (NIHL), contribute significantly to the prevalence of hearing loss, particularly among older adults, with NIHL considered to be the most common occupational disease [6]. Forty percent of working-age Canadians reported noise exposure that would be considered hazardous at some time during their working lives [7], with worldwide studies indicating that the prevalence of work-related hearing loss ranges from 16-24% [8].

For decades, the World Health Organization has raised concerns that NIHL is on the rise due to recreational and industrial noise [9-11]; however, some researchers have noted that prevalence of hearing loss is decreasing in the general population, particularly in men [12]. Changes in noise control and hearing conservation strategies in noisy industries may contribute to this noted reduction in hearing loss. Though results are mixed [13], there is evidence that changes in legislation and focus on hearing loss prevention through engineered noise controls [14], and properly fitted hearing protection [15], ultimately reduce the level of noise exposure. These strategies, along with education and awareness to employers and workers, and regular hearing surveillance with one to one

*sasha.brown@audiopeech.ubc.ca
† ljenstad@audiospeech.ubc.ca
‡ angelaryall17@gmail.com
♦ ellen@psych.ubc.ca

counselling, might reduce the effects of occupational noise on hearing thresholds [16].

In British Columbia, an occupational regulation requiring hearing protection in hazardous noise has been in place since 1967, with more extensive Noise Control and Hearing Conservation programs implemented in 1978 [17]. Since that time, particularly with changes to the relevant WCB Occupational Health and Safety Regulations in 1996 [18], there has been an increased focus on education and awareness of workers and employers along with inspection and enforcement to increase compliance. It is important to understand whether these efforts have the intended result of reducing the incidence of occupational NIHL. Though there have been longitudinal studies looking at changes in hearing, most have results spanning 10 years or fewer [2, 4, 19]. Davies et al [20] specifically studied lumber mill workers' hearing test results from 1970-1996, and found that over time, the risk of shift in hearing thresholds decreased, suggesting that Hearing Conservation Programs are effective. Other than this study, we are not aware of research investigating a noise-exposed Canadian population, and none that examine the impact of new regulations introduced in British Columbia in 1996.

Audiometry is typically conducted to monitor and flag early signs of NIHL. Since 1978, employers in British Columbia must provide annual hearing tests to workers who are exposed to occupational noise that exceeds criterion levels. This allows authorities to monitor for early flags for NIHL; that is, significant changes in thresholds at the frequencies first affected by noise: 3000, 4000, and 6000 Hz. In 1979 almost 78,000 tests were submitted to WorkSafeBC annually and in 2018 this had risen to 178,000 tests. The hearing test results spanning over 40 years are maintained in a database ("Industrial Audiometric System"). By examining the data available from these hearing tests, we can address questions regarding changes in NIHL over time in individuals and across cohorts to determine whether NIHL is indeed on rise, or whether greater awareness of noise in the workplace has been successful at reducing NIHL in Canada.

The purpose of this retrospective cohort study is to analyze existing cross-sectional and longitudinal data in a large database spanning forty years, to determine whether there are cohort effects in prevalence and progression of noise-induced hearing loss. This study builds on the research of Davies et al [20] by expanding to include all noisy industries and data from 1980 to 2015. This data set will allow us to see effects of revised and additional regulations introduced in 1996 and provide current data on the prevalence of hearing loss and characteristics of hearing thresholds in an age-stratified noise-exposed population in Canada. For the purpose of this study, 5 cohorts were selected with birth years in 1935, 1960, 1970, 1985 and 1995. We compared the prevalence, degree, and configuration of hearing loss in 4 age groups (20, 30, 45, and 55-year olds) in different test years to determine whether there are age and cohort effects on hearing.

2 Method

2.1 Participants

Participants were individuals born in 1935, 1960, 1970, 1985, and 1995 who received a hearing test in British Columbia as part of an occupational hearing conservation program in at least one of the four test years of interest: 1980, 1990, 2005, 2015. The sample size for each cohort and test year varied as a function of the total number of tests available and is reported in Table 1. The de-identified hearing test results were obtained from WorkSafeBC's Data Warehouse which is populated by nightly extracts of data from the Industrial Audiometric source database. The data were derived using Tableau Developer Visualization software and presented to the researchers as an Excel spreadsheet.

Table 1: Sample size as a function of cohort and test year.

	Year of hearing test			
Year of birth	1980	1990	2005	2015
Cohort 1 (born 1935)	Age 45 n=1386	Age 55 n=2124		
Cohort 2 (born 1960)	Age 20 n=2165	Age 30 n=5165	Age 45 n=4558	Age 55 n=4158
Cohort 3 (born 1970)		Age 20 n=2326		Age 45 n=3764
Cohort 4 (born 1985)			Age 20 n=2495	Age 30 n=3949
Cohort 5 (born 1995)				Age 20 n=2322

A Privacy Impact Assessment was reviewed and approved by WorkSafeBC's Freedom of Information and Protection of Privacy office to ensure that no individual could be identified from the results. No names, other identification, or demographic information were included in the data provided to the researchers. Informed consent was not needed for this analysis. Ethical approval was received from UBC Behavioural Research Ethics Board.

Hearing test results were obtained from the WorkSafeBC database according to Table 1. For each cohort, results were gathered for each birth year, and then filtered for any tests in the chosen year. For example, Cohort 3's results were formed from test results for those born in 1970 and hearing test results in 1990 and 2015. All available hearing tests that met the criteria were included in the dataset. Because data were obtained based on birth year, not age at time of test, there is a one-year range of possible ages for each cohort/ test year. For example, individuals born in 1960 and tested in 1980 could be either 19 years of age (if tested prior to their birthday) or 20 years of age (if tested after their birthday). For ease of reporting, age at time of testing is reported as test year minus birth year, regardless of actual age. The sample size (i.e., number of tests available) for each cohort and test year is given in the table.

2.2 Procedures

All hearing tests were conducted by technicians trained to follow a testing protocol and collected in facilities meeting minimum standards set out by WorkSafeBC in accordance with

CSA Z107.6 [21]. Air-conducted pure-tone thresholds were recorded for 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz in each ear. At the time of the test, answers to questions about workers' noise history and the type of hearing protection device worn, if any, were recorded. The results were submitted to WorkSafeBC and stored in a database ("Industrial Audiometric database"). The data in this study were extracted from this database.

2.3 Data analysis

Data analysis was run in R version 3.5.1 [22]. Means and standard deviation were calculated for pure-tone thresholds for each frequency and compared for people at the same age from different birth cohorts. Comparisons were made based on clinically meaningful effect sizes (i.e., more than 5 dB change in mean thresholds across cohorts), rather than null hypothesis significance testing. With thousands of cases per cohort, all clinically meaningful differences would also be statistically significant based on conventional null hypothesis significance testing. For changes in pure-tone thresholds, only data from the left ear were used in the analysis.

To determine prevalence of hearing loss in the sample, we used a speech frequency pure-tone average (PTA) based on thresholds at 0.5, 1, 2, and 4 kHz consistent with Canadian Health Measures Survey [23]. Hearing loss was considered present if the PTA of either ear was poorer than 25 dB HL. Chi-squared tests were used to compare prevalence of hearing loss among people of the same age from different birth cohorts. If there was evidence of significant differences, additional pairwise comparisons were made between successive birth cohorts.

Chi-squared tests were also used to examine differences in the use of hearing protection among 20-year olds from different birth cohorts. If the test indicated significant differences across the four birth cohorts, a series of pairwise comparisons between successive cohorts was conducted.

3 Results

3.1 Data quality checks

The data were checked for errors or invalid results; using the rule that any thresholds better than 0 dB HL or poorer than 120 dB HL should be considered invalid given the limits of the audiometers used in testing, 11 hearing tests were dropped from the analysis. Some individuals had more than one hearing test per year, which can happen if, for example, the worker was at multiple job sites, or changed location of employment over the year. When this occurred, only the first hearing test per year was used in the analysis.

3.2 Hearing thresholds by age and cohort

Is the hearing of 20-year-olds different in 1980, 1990, 2005, and 2015?

In comparing the hearing of 20-year olds from different cohorts, we focused on the high frequencies 2000, 3000, 4000, and 6000 Hz in particular. As mentioned, given the large sample size, even small differences could be statistically significant, so we instead chose a clinically-meaningful effect of a difference of at least 5 dB between cohorts. At these frequencies of interest, group differences were all less than 5 dB, indicating no difference in hearing of 20-year-olds from different cohorts. Thresholds for this cohort at all audiometric frequencies, along with the 95%
confidence intervals, are given in Table 2 and Figure 1.

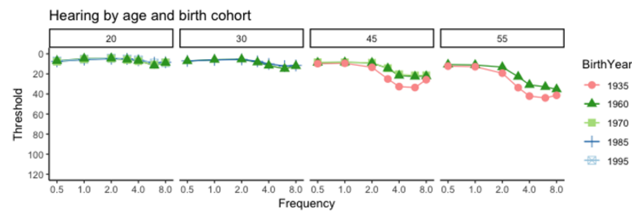


Figure 1: Threshold means and 95% confidence intervals of the mean for each cohort (separate lines) and each age group (separate panels). Note that the 95% CIs are small relative to the scale of the standard audiogram. Refer to Tables 2-5 for details of the CIs.

Table 2: Observed threshold means by cohort and frequency for 20-year olds

Freq. [Hz]	Cohort	N	Mean	sd	95% CI [LL,UL]
500	1960	2165	7.0	7.1	[6.7, 7.3]
	1970	2326	7.8	7.4	[7.5, 8.1]
	1985	2495	7.5	6.3	[7.3, 7.7]
	1995	2322	7.1	6.5	[6.8, 7.3
1000	1960	2165	4.7	7.2	[4.3, 5.0]
	1970	2326	5.4	7.6	[5.1, 5.7]
	1985	2495	5.8	6.3	[5.6, 6.0]
	1995	2322	5.3	6.0	[5.1, 5.5]
2000	1960	2165	4.5	7.5	[4.2, 4.8]
	1970	2326	4.7	8.3	[4.3, 5.0]
	1985	2495	4.9	6.3	[4.6, 5.2]
	1995	2322	4.4	6.3	[4.1, 4.7]
3000	1960	2165	5.7	8.9	[5.3, 6.1]
	1970	2326	6.0	9.5	[5.6, 6.4]
	1985	2495	5.0	7.2	[4.7, 5.3]
	1995	2322	5.2	7.1	[4.9, 5.5]
4000	1960	2165	6.8	10.0	[6.4, 7.2]
	1970	2326	7.3	10.4	[6.9, 7.7]
	1985	2495	6.4	8.2	[6.0, 6.7
	1995	2322	5.9	7.7	[5.6, 6.2]
6000	1960	2165	11.6	12.2	[11.1, 12.1]
	1970	2326	10.9	11.5	[10.4, 11.4]
	1985	2495	8.8	9.6	[8.4, 9.2]
	1995	2322	9.2	9.8	[8.8, 9.6]
8000	1960	2165	8.8	12.2	[8.3, 9.3]
	1970	2326	8.6	10.7	[8.2,9.0]
	1985	2495	8.3	9.7	[7.9,8.7]
	1995	2322	9.0	9.7	[8.6,9.4]

Is the hearing of 30-year-olds different in 1990 and 2015?

In comparing the hearing of 30-year olds from different cohorts, we again focused on the high frequencies 2000, 3000, 4000, and 6000 Hz. Again, we chose a clinically-meaningful effect of a difference of at least 5 dB between cohorts. At these frequencies of interest, group differences were all less than 5 dB, indicating no difference in hearing of 30-year-olds between the two cohorts. Thresholds for this cohort at all audiometric frequencies, along with the 95% confidence intervals, are given in Table 3 and Figure 1.

Table 3: Observed threshold means by cohort and frequency for 30-year olds.

Freq. [Hz]	Cohort	N	Mean	sd	95% CI [LL,UL]
500	1960	5165	7.2	7.5	[7.0, 7.4]
	1985	3949	7.1	7.2	[6.9, 7.3]
1000	1960	5165	5.9	7.7	[5.7, 6.1]
	1985	3949	6.1	7.3	[5.9, 6.3]
2000	1960	5165	5.5	8.5	[5.3, 5.7]
	1985	3949	5.5	7.8	[5.3, 5.7]
3000	1960	5165	8.4	11.1	[8.1, 8.7]
	1985	3949	7.5	9.6	[7.2, 7.8]
4000	1960	5165	11.7	13.5	[11.3, 12.1]
	1985	3949	10.1	11.0	[9.8, 10.4]
6000	1960	5165	14.9	13.9	[14.5, 15.3]
	1985	3949	12.2	12.0	[11.8, 12.6]
8000	1960	5165	12.1	13.2	[11.7, 12.5]
	1985	3949	11.6	12.1	[11.2, 12.0]

Is the hearing of 45-year-olds different in 1980, 2005, and 2015?

In comparing the hearing of 45-year olds from different cohorts, we again focused on the high frequencies 2000, 3000, 4000, and 6000 Hz. As with the previous cohorts, given the large sample size, even small differences could be statistically significant so instead we chose a clinically-meaningful effect of a difference of at least 5 dB between cohorts. The group differences at 2000 Hz were smaller than 5 dB, indicating no meaningful difference in thresholds across cohorts. At 3000, 4000, and 6000 Hz, the 1935 cohort had thresholds that were 10 dB or more poorer than the 1960 and 1970 cohort, which demonstrates a clinically-meaningful improvement in thresholds for later cohorts. Thresholds for this cohort at all audiometric frequencies, along with the 95% confidence intervals, are given in Table 4 and Figure 1

Is the hearing of 55-year-olds different in 1990 and 2015?

In comparing the hearing of 55-year olds from different cohorts, we again focused on the high frequencies 2000, 3000, 4000, and 6000 Hz. and chose a clinically-meaningful effect of a difference of at least 5 dB between cohorts. The group differences at all frequencies of interest were at least 5 dB, and greater than 10 dB at 3000, 4000, and 6000 Hz. The 1935 cohort had thresholds that were poorer than the 1960 cohort, which demonstrates a clinically-meaningful improvement in thresholds for the later cohort. Thresholds for this cohort at all audiometric frequencies, along with the 95% confidence intervals, are given in Table 5 and Figure 1.

Table 4: Observed threshold means by cohort and frequency for 45-year olds

Freq. [Hz]	Cohort	N	Mean	sd	95% CI [LL,UL]
500	1935	1386	9.8	10.6	[9.2, 10.4]
	1960	4558	8.8	8.5	[8.6, 9.0]
	1970	3764	8.4	8.3	[8.1, 8.7]
1000	1935	1386	9.4	11.5	[8.8, 10.0]
	1960	4558	8.4	9.0	[8.1, 8.7]
	1970	3764	8.5	8.8	[8.2, 8.8]
2000	1935	1386	13.4	15.5	[12.6, 14.2]
	1960	4558	9.0	10.3	[8.7, 9.3]
	1970	3764	8.9	10.2	[8.6, 9.2]
3000	1935	1386	25.1	20.6	[24.0, 26.2]
	1960	4558	14.6	14.8	[14.2, 15.0]
	1970	3764	14.3	13.9	[13.9, 14.7]
4000	1935	1386	32.7	20.9	[31.6, 33.8]
	1960	4558	21.7	17.1	[21.2, 22.2]
	1970	3764	20.4	16.2	[19.8, 20.9]
6000	1935	1386	33.6	21.3	[32.5, 34.7]
	1960	4558	22.7	17.0	[22.2, 23.2]
	1970	3764	21.5	16.2	[21.0, 22.0]
8000	1935	1386	25.8	22.4	[24.6, 27.0]
	1960	4558	22.3	17.9	[21.8, 22.8]
	1970	3764	21.5	17.3	[20.9, 22.1]

Table 5: Observed threshold means by cohort and frequency for 55-year olds.

Freq. [Hz]	Cohort	N	Mean	sd	95% CI [LL,UL]
500	1935	2124	12.3	11.3	[11.8, 12.8]
	1960	4158	10.7	9.8	[10.4, 11.0]
1000	1935	2124	12.8	12.6	[12.3, 13.3]
	1960	4158	11.1	11.0	[10.8, 11.4]
2000	1935	2124	19.3	18.0	[18.5, 20.0]
	1960	4158	13.2	12.8	[12.8, 13.6]
3000	1935	2124	33.7	21.5	[32.3, 34.6]
	1960	4158	22.8	18	[22.3, 23.3]
4000	1935	2124	42.1	21.2	[41.2, 43.0]
	1960	4158	30.9	19.1	[30.3, 31.5]
6000	1935	2124	43.9	21.8	[43.0, 44.8]
	1960	4158	32.9	19.4	[32.3, 33.5]
8000	1935	2124	41.4	23.0	[40.4, 42.4]
	1960	4158	35.3	21.5	[34.6, 36.0]

3.3 Prevalence of hearing loss in each cohort by age

We compared the prevalence of hearing loss for each age, that is 20-year-olds, 30-year-olds, 45-year-olds and 55-year-olds, across birth cohorts to determine if there was a significant difference based on the year of birth. The results are displayed in Figure 2 with the chi-square analysis given in Appendix A.

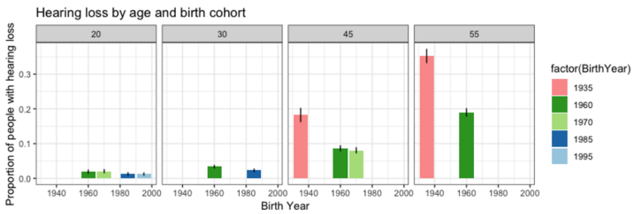


Figure 2: Proportion of sample with hearing loss and 95% confidence intervals of the proportion estimate for each cohort (separate bars) and each age group (separate panels).

20-year olds

We had four cohorts of 20-year-olds, those who were born in 1960, 1970, 1995 and 2005, and found that there were no significant differences in the prevalence of hearing loss in 20-year olds born in those years. (X^2 = 7.59, df = 3, p = .055).

30-year olds

When we compared 30-year-olds from two birth cohorts, born in 1960 and born in 1985, there were significant differences observed in the prevalence of hearing loss among 30-year olds from different birth cohorts (X^2 = 8.51, df = 1, p = .004). People born in 1960 were more likely to have hearing loss by age 30 (3.37%) compared to people born in 1985 (2.33%).

45-year olds

There were significant differences observed in the prevalence of hearing loss among 45-year olds from different birth cohorts (X^2 = 131.08, df = 2, p <.001). People born in 1935 were more likely to have hearing loss by age 45 (18.24%) compared to people born in either 1960 (8.66%, X^2 = 100.53, df = 1, p < .001) or 1970 (8.06%, X^2 = 108.441, df = 1, p <.001). There were no significant differences in the prevalence of hearing loss observed among 45-year olds born in 1960 compared to those born in 1970 (X^2 = 0.902, df = 1, p = .342).

55-year olds

There were significant differences observed in the prevalence of hearing loss among 55-year olds from different birth cohorts (X^2 = 200.9, df = 1, p < .001). People born in 1935 were more likely to have hearing loss by age 55 (35.22%) compared to people born in 1960 (18.99%).

3.4 What proportion of 20-year-olds wear hearing protection?

Table 6 shows that there were significant differences observed in the use of hearing protection among 20-year olds from different birth cohorts (X^2 = 549.9, df = 3, p < .001). Use of hearing protection was least prevalent among 20-years old born in 1970 (58.68%), with significantly higher rates observed in the preceding cohort born in 1960 (65.22%, X^2 = 20.291, df = 1, p < .001) and the subsequent cohorts born in 1985 (80.45%, X^2 = 271.32, df = 1, p <.001) and 1995 (X^2 = 405.71, df =1, p <.001).

Table 6: Results of the chi-square analysis comparing proportion of reported hearing protection use in 20-year-olds across cohorts. Post-hoc pairwise comparisons are given when appropriate to do so.

Birth Year	N	Proportion reporting "Yes" to using HPD	Pairwise comparisons
1960	2165	65.22%	1960 vs 1970: X = 20.291, df = 1, p<.001 1960 vs 1985: X = 137.63, df = 1, p<.001 1960 vs 1995: X = 242.97, df = 1, p<.001
1970	2326	58.68%	1970 vs 1985: X = 271.32, df = 1, p<.001 1970 vs 1995: X = 405.71, df = 1, p<.001
1985	2496	80.45%	1985 vs 1995: X = 19.25, df = 1, p<.001
1995	2322	85.23%	

There were also significant differences when comparing those born in 1960 to later cohorts born in 1985 (X^2 = 137.63, df = 1, p <.001) and 1995 (X^2 = 242.97, df = 1, p <.001). Use of hearing protection was most common in the most recent cohort of 20-year olds, such that a greater proportion of 20-year olds born in 1995 reported using hearing protection compared to those born in 1985 (X^2 = 19.25, df = 1, p < .001) or any of the earlier cohorts.

4 Discussion

In this retrospective cohort study examining changes in hearing and thresholds from 1980-2015 in noise-exposed workers, we found that hearing thresholds generally improved with later cohorts, prevalence of hearing loss decreased, and HPD use increased. Specifically, for 45- and 55-year olds, later-born cohorts had better thresholds than earlier-born cohorts, with no change in thresholds across cohorts for 20- or 30-year olds. Prevalence of hearing loss decreased for later-born cohorts for 30, 45, and 55-year olds. Twenty-year olds in later cohorts were more likely to use HPD than those in earlier cohorts.

It is of interest to understand these changes in hearing. While our secondary analysis of an existing database is unable to determine the reason for the change, we consider several potential factors, including changes in how hearing was tested over time, changes in provincial regulations regarding safe noise exposure, changes in recreational noise exposure, improved use of engineering controls (and other) in noisy workplaces, and finally, increased use of HPDs.

First, we consider whether improved hearing can be attributed to systematic error; that is, changes in how hearing was tested over time. It seems unlikely that systematic testing changes can explain our results. The low frequencies serve as controls; as Tables 2-5 show, we found no changes in thresholds at 500 and 1000 Hz across cohorts when using the criterion of a 5 dB change as meaningful. This helps rule out random or systematic error in testing circumstances. Additionally, we can look at results for different cohorts tested in the same year, where protocols would have been standard across the province. For example, we had data from three ages tested in 1990 (20, 30, and 55-year olds). When we compare each of those ages to the same age tested in a different year, only one cohort (age 55) showed significant differences from cohorts tested at another time, meaning that it is unlikely the different thresholds were due to different test protocols. If it were a change in test protocol, the 20- and 30-year olds would also have had significant differences relative to their age-matched peers tested in different years.

Second, we consider whether seemingly improved hearing can be attributed to changes in regulations that change the definition of a noisy workplace. A potential confound in our study was that with the change in regulations in 1996, the criteria for implementing a hearing conservation program was changed from 90 dBA Lex to 85 dBA Lex. Though between 1980 and 1996, workplaces that exceeded 90 dBA Lex were required to provide hearing tests to individual workers exposed to levels above 85 dBA Lex, the 1996 revision likely resulted in more workplaces overall meeting the criteria for hearing conservation and hearing tests. Thus, it is likely that more individuals included in later cohorts had lower doses of noise exposure (between 85 dBA Lex and 90 dBA Lex). This change may have contributed to better thresholds and lower prevalence of hearing loss than in previous cohorts. To examine this potential confound, we conducted a subset analysis for specific occupations in two different test years, minimizing the likelihood that the change in regulations would be a factor in any cohort differences noted. We identified three occupations for this analysis: Equipment operator/Heavy; Front end loader/ forklift operator; and Heavy-duty mechanic. These occupations were chosen as they were categories used in both test years with at least 20 in each cohort. We focused on 45-year olds in two cohorts: born in 1935 and born in 1970. Forty-five is when we started to see cohort differences. The relevant test years were 1980 and 2015, well before and after the change in regulations. For this analysis, again instead of conducting inferential statistics, we used the clinically-meaningful change of 5 dB difference in thresholds between groups. Appendix B shows the results for 3000, 4000, and 6000 Hz for both cohorts for each of the three occupations. For all three frequencies of interest across occupations there is at least 5 dB improvement in thresholds in the later cohorts, with most group differences being closer to 10-15 dB improvement. This lends support to the conclusion that hearing is improving with later cohorts of noise-exposed workers, not an artefact of a changed sample.

Third, we consider changes in recreational noise exposure; that is, noise outside of work environments. We do not have data on recreational noise exposure for this sample but there has been growing concern, often supported by popular media, that younger people are at increased risk for NIHL through poor listening habits and exposure to recreational noise (24). Recreational settings such as nightclubs, as well as personal stereos, are capable of producing sound well above hazardous levels [e.g., 25,26,27,28], and youth do not tend to prioritize safe listening and instead engage in "risky" listening behaviour while seldom wearing hearing protection [e.g., 24]. Together, this would suggest that NIHL is a growing concern among younger generations. Peer-reviewed literature, such as the review by Carter, et al [29], however, is cautious about drawing a link between recreational exposure and the presence of NIHL. Henderson et al. [24] for example, found that there was no significant increase in rates of NIHL (defined as thresholds 3-6 kHz 15 dB worse than .5-2 kHz, and 8 kHz) in 12-19-year olds from 1994 to 2005. Similarly, Le Prell et al. [30] found "no reliable relationships" between recreational noise exposure and hearing thresholds or other measures of NIHL (DPOAEs, etc) and Kepler et al [31] found no significant differences in 18-30 year olds' hearing between groups with low, intermediate, and high recreational noise exposure.

The improved thresholds found in our later cohorts are inconsistent with the concern that recreational noise exposure is on the rise among youth and confirm the other studies described showing no increase in NIHL among young people. It is important to remember for our sample that we examined data for people working in noisy environments, which may not be generalizable to the whole population. This group may have more awareness of NIHL due to education and counselling that should come with the annual hearing test, as required by WorkSafeBC. Employers are required to provide education about noise and NIHL annually to workers who are exposed to hazardous noise and one-on-one counselling and training regarding hearing and hearing protection fit and use.

Fourth, it is possible that workplaces have implemented additional noise control and hearing conservation methods that have been effective in reducing NIHL. In 1996, British Columbia's Occupational Health and Safety Regulation expanded on the 1980 Regulations which only required noise control, hearing protection devices, and annual hearing tests. The new regulations include noise measurements, engineered noise control, education and training about noise and NIHL, and an annual program review [18]. Other research has indicated that revisions to Hearing Conservation Program requirements can help reduce the incidence of NIHL [e.g., 32]. Since 1996, there has been a growing emphasis on the "hierarchy of control" in which employers must first explore and implement strategies to reduce the noise exposure levels if feasible. Methods including "buying quiet", the enclosure of loud machinery or workspaces, reducing noise at the source with regular maintenance, and adding noise abatement materials have all proven effective at reducing noise levels in the workplace. A study of lumber mills in British Columbia [33] and WorkSafeBC noise measurements [34] have confirmed that in many workplaces these changes have reduced noise levels. It is likely that lower noise levels have contributed to lower incidence and severity of NIHL, as has been found in other jurisdictions [14]

In this study, we gathered data on one component of the hearing conservation program: the use of hearing protection, which has been shown to be effective in reducing NIHL among workers [15, 35]. Twenty year olds' self-reported use of HPDs increased from 65 to 85% from 1980 to 2015, similar to other studies including Fredriksen and colleagues [19], who found that between 2000 and 2010, HPD use increased from 70.1 to 76.1% in Danish workers. Feder and colleagues [7] showed that younger workers aged 16-29 reported wearing HPD more (86%) than older workers aged 50-79 (77%). We only examined self-report of HPD use at 20 years and we do not know how that predicts later HPD use, but the Feder data would support the assumption that differences in the proportion of HPD use at 20 also appear in later age groups.

Although thresholds improved for the later cohorts for 45- and 55-year olds, hearing loss was still present. This leads us to question why there was hearing loss and whether more noise control and hearing protection are needed. Age-related hearing loss (ARHL) is a general term for hearing loss that increases with age without ascribing any one cause to it but is often referred to as distinct from noise-induced HL (NIHL). Both NIHL and ARHL initially present with high-frequency sensorineural hearing loss and they both tend to be bilateral and symmetrical, making them hard to distinguish [36]. However, NIHL tends to result in a notch in the audiogram affecting thresholds from 3-6 kHz, while ARHL tends to start at higher frequencies, manifesting on the audiogram first at 8 kHz [36].This difference is not a reliable diagnostic marker and the difference between the types of HL is challenging to separate because they often co-occur in the same individual [37]. In our own data, we see a difference in audiogram shape between cohorts for the 45 and 55 year old groups, where later cohorts have audiograms that are more consistent with ARHL than NIHL, with thresholds at 8 kHz that are similar to or poorer than thresholds at lower frequencies. Earlier cohorts demonstrate the characteristic notch, whereby thresholds are poorer from 3-6 kHz than at 8 kHz.

To examine the hypothesis that later cohorts had audiograms consistent with ARHL rather than NIHL, we compared our later cohorts to ISO age-matched [38] for a population without significant occupational noise exposure. If the thresholds in our later cohorts are similar to the ISO thresholds for individuals without noise exposure, then it seems likely that ARHL is the main determinant of thresholds in our later cohorts. The ISO report includes several different data sets for comparison, including data from Sweden, the US, and Norway. For our comparison, we used unscreened data from Sweden as the most similar to our sample. "Unscreened" means that the sample could have otologic dysfunction but not occupational noise exposure, whereas the data from the US included those with occupational noise exposure. The data from Sweden represented both ears, whereas data from Norway were only the most sensitive ear. Our sample examined only left ear thresholds, which could have been the better or worse ear. ISO data are separated for males and females; we calculated a weighted average of male and female thresholds, with a weighting of .9014 for male thresholds and .0986 for female thresholds, reflecting the relative male/ female distribution in our dataset. We used the 50% percentile from the ISO data with a linear interpolation between the data for 50- and 60-year olds to calculate thresholds for 55-year olds to compare to our sample. Appendix C shows the data for the 55-year olds in our sample beside the thresholds calculated from the ISO dataset. For the low frequencies, up to 2000 Hz, we see that both cohorts have thresholds similar to the ISO Swedish unscreened thresholds. For the frequencies monitored for NIHL, 3, 4, and 6 kHz, the 1935 cohort had thresholds poorer than ISO by more than 10 dB, indicating an additional contribution of noise to the hearing loss seen in this sample as a whole. The 1960 cohort was within 5 dB of the ISO thresholds for 3 and 4 kHz, but poorer than ISO by 6 dB at 6 kHz. It seems that the role of noise in determining these thresholds is likely reduced for the 1960 cohort, but may still be present, given the small decline in thresholds at 6 kHz above what is expected due to ARHL alone.

5 Limitations and future directions

The data we obtained for analysis were de-identified with only limited demographic and potential moderating variables available. No gender data were available to link to individual audiograms, but we know that for each cohort, the percentage of males ranged from 89-95%. Further gender-based modelling of the data would be helpful to further understand the trends.

We made some assumptions about the cumulative noise exposure of individuals in the database given the limited data available. We assume that if the workers received an annual hearing test, they were exposed to noise levels in excess of 85 dBA Lex during the year of the test and between test years. However, it is possible that some employers err on the side of caution and test all workers regardless of job duties and noise exposure, or it is possible that some workers were only temporarily in noisy workplaces. Although some of these details are not available from the historical database, further analyses could purposefully sample smaller, more homogeneous groups by specific occupation, analyzing annual data for both thresholds and HPD use over time.

We examined a subset of the noise-exposed population who have had hearing tests, demonstrating they received at least one element of a hearing conservation program. While this demonstrates that hearing conservation programs seem to work for this population, the findings are not generalizable to workers who are exposed to noise but do not have annual hearing tests, which might also mean that other elements of a hearing conservation program are not implemented at their worksite.

6 Conclusion

This study demonstrated that the prevalence of hearing loss decreased, and hearing thresholds generally improved in an occupationally noise exposed population between 1980 and 2015 in British Columbia. The changes correlate with revisions to Workers' Compensation Board regulations in which the criterion level for implementation of noise control and hearing conservation programs was lowered from 90 dBA Lex to 85 dBA Lex, and additional requirements were added. Increased education and awareness, improvement in engineered noise controls, and increased use of hearing protection devices might contribute to the better hearing seen in later cohorts.

Acknowledgments

Funding was provided by a Canadian Academy of Audiology (CAA) Clinical-Research Grant awarded to Sasha Brown and Lorienne Jenstad and by the Wavefront Centre for Communication Accessibility Research Division.

References

[1] Qi Huang and Jianguo Tang. Age-related hearing loss or presbycusis. European Archives of Oto-rhino-laryngology, 267(8) :1179–1191, 2010.

[2] Audrey Coll´ee, Jean-Baptiste Watelet, Hanne Vanmaele, Jozef Van Thielen, and Peter Clarys. Longitudinal changes in hearing threshold levels for noise-exposed military personnel. International archives of occupational and environmental health, 92(2) :219–226, 2019.

[3] George A Gates and John H Mills. Presbycusis. The Lancet, 366(9491) :1111–1120, 2005.

[4] Antonis Moukos, Dimitrios G Balatsouras, Thomas Nikolopoulos, Pavlos Maragoudakis, Evangelos I Yiotakis, Stavros G Korres, and Dimitrios Kandiloros. A longitudinal study of changes in distortion-product otoacoustic emissions and pure-tone thresholds in an industrial setting. European Archives of Oto-Rhino-Laryngology, 271(10):2649–2660, 2014.

[5] Kenneth S Henry, Mark Sayles, Ann E Hickox, and Michael G Heinz. Divergent auditory nerve encoding deficits between two common etiologies of sensorineural hearing loss. Journal of Neuroscience, 39(35) :6879–6887, 2019.

[6] Christa L Themann and Elizabeth A Masterson. Occupational noise exposure: A review of its effects, epidemiology, and impact with recommendations for reducing its burden. The Journal of the Acoustical Society of America, 146(5) :3879–3905, 2019.

[7] Katya Feder, David Michaud, James McNamee, Elizabeth Fitzpatrick, Hugh Davies, and Tony Leroux. Prevalence of hazardous occupational noise exposure, hearing loss, and hearing protection usage among a representative sample of working Canadians. Journal of occupational and environmental medicine, 59(1) :92, 2017.

[8] Deborah Imel Nelson, Robert Y Nelson, Marisol Concha-Barrientos, and Marilyn Fingerhut. The global burden of occupational noise-induced hearing loss. American journal of industrial medicine, 48(6) :446–458, 2005.

[9] Etienne G Krug. Hearing loss due to recreational exposure to loud sounds: a review. World Health Organization, 2015.

[10] World Health Organization et al. Occupational noise: assessing the burden of disease from work-related hearing impairment at national and local levels. Environmental burden of disease Series, (9) :1–33, 2004.

[11] Andrew W Smith et al. The world health organisation and the prevention of deafness and hearing impairment caused by noise. Noise and Health, 1(1) :6, 1998.

[12] Maria Hoff, Tomas Tengstrand, Andre´ Sadeghi, Ingmar Skoog, and Ulf Rosenhall. Improved hearing in Swedish 70-year olds—a cohort comparison over more than four decades (1971–2014). Age and ageing, 47(3) :437–444, 2018.

[13] Christina Tikka, Jos H Verbeek, Erik Kateman, Thais C Morata, Wouter A Dreschler, and Silvia Ferrite. Interventions to prevent occupational noise-induced hearing loss. Cochrane Database of Systematic Reviews, (7), 2017.

[14] Gerald J Joy and Paul J Middendorf. Noise exposure and hearing conservation in US coal mines—a surveillance report. Journal of Occupational and Environmental Hygiene, 4(1) :26–35, 2007.

[15] Nicholas Heyer, Thais C Morata, Lynne E Pinkerton, Scott E Brueck, Daniel Stancescu, Mary Prince Panaccio, Hyoshin Kim, J Stephen Sinclair, Martha A Waters, Cherie F Estill, et al. Use of historical data and a novel metric in the evaluation of the effectiveness of hearing conservation program components. Occupational and environmental medicine, 68(7) :510–517, 2011.

[16] Peter Rabinowitz, Linda F Cantley, Deron Galusha, Sally Trufan, Arthur Swersey, Christine Dixon-Ernst, Vickie Ramirez, and Richard Neitzel. Assessing hearing conservation program effectiveness. Journal of Occupational and Environmental Medicine, 60(1) :29–35, 2018.

[17] Workers' Compensation Board of British Columbia. Industrial Health & Safety Regulations. Vancouver, BC : Workers' Compensation Board of British Columbia, 1978.

[18] Workers' Compensation Board of British Columbia. Occupational Health & Safety Regulations. Vancouver, BC : Workers' Compensation Board of British Columbia, 1998.

[19] Thomas W Frederiksen, Cecilia H Ramlau-Hansen, Zara A Stokholm, Matias B Grynderup, A° se M Hansen, Jesper Kristiansen, Jesper M Vestergaard, Jens P Bonde, and Henrik A Kolstad. Noise-induced hearing loss–a preventable disease? results of a 10-year longitudinal study of workers exposed to occupational noise. Noise & health, 19(87) :103, 2017.

[20] Hugh Davies, Steve Marion, and Kay Teschke. The impact of hearing conservation programs on incidence of noise-induced hearing loss in Canadian workers. American journal of industrial medicine, 51(12) :923–931, 2008.

[21] Sasha Brown, Christian Gigu`ere, and Michael Sharpe. CSA z107. 6 audiometric testing for use in hearing loss prevention programs : A new title for a new edition. Canadian Acoustics, 44(3), 2016.

[22] R Core Team. R : A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria, 2013.

[23] Katya P Feder, David Michaud, Pamela Ramage-Morin, James McNamee, and Yves Beauregard. Prevalence of hearing loss among Canadians aged 20 to 79 : Audiometric results from the 2012/2013 Canadian Health Measures Survey. Statistics Canada, 2015.

[24] Elisabeth Henderson, Marcia A Testa, and Christopher Hartnick. Prevalence of noise-induced hearing-threshold shifts and hearing loss among US youths. Pediatrics, 127(1) :e39–e46, 2011.

[25] William E Hodgetts, Jana M Rieger, and Ryan A Szarko. The effects of listening environment and earphone style on preferred listening levels of normal hearing adults using an mp3 player. Ear and hearing, 28(3) :290–297, 2007.

[26] Mario R Serra, Ester C Biassoni, Utz Richter, Gloria Minoldo, Graciela Franco, Silvia Abraham, Jorge A Carignani, Silvia Joekes, and Mar´ıa R Yacci. Recreational noise exposure and its effects on the hearing of adolescents. Part i : An interdisciplinary long-term study. International journal of audiology, 44(2) :65–73, 2005.

[27] Mario R Serra, Ester C Biassoni,Mar´ıa Hinalaf,Mo´nica Abraham, Marta Pavlik, Jorge Pe´rez Villalobo, Carlos Curet, Silvia Joekes, Mar´ıa R Yacci, Andrea Righetti, et al. Hearing and loud music exposure in 14-15 years old adolescents. Noise and Health, 16(72) :320, 2014.

[28] Kamakshi V Gopal, Liana E Mills, Bryce S Phillips, and Rajesh Nandy. Risk assessment of recreational noise–induced hearing

loss from exposure through a personal audio system—ipod touch. Journal of the American Academy of Audiology, 30(07) :619–633, 2019.

[29] Lyndal Carter, Warwick Williams, Deborah Black, and Anita Bundy. The leisure-noise dilemma : hearing loss or hearsay? what does the literature tell us ? Ear and hearing, 35(5) :491–505, 2014.

[30] Colleen G Le Prell, Hannah W Siburt, Edward Lobarinas, Scott K Griffiths, and Christopher Spankovich. No reliable association between recreational noise exposure and threshold sensitivity, distortion product otoacoustic emission amplitude, or word-in-noise performance in a college student population. Ear and hearing, 39(6) :1057–1074, 2018.

[31] Hannah Keppler, Ingeborg Dhooge, and Bart Vinck. Hearing in young adults. Part ii : The effects of recreational noise exposure. Noise & health, 17(78) :245, 2015.

[32] PerMuhr, Ann-Christin Johnson, Bjo¨rn Skoog, and Ulf Rosenhall. A demonstrated positive effect of a hearing conservation program in the Swedish armed forces. International Journal of Audiology, 55(3) :168–172, 2016.

[33] Hugh W Davies, Kay Teschke, Susan M Kennedy, Murray R Hodgson, and Paul A Demers. A retrospective assessment of occupational noise exposures for a longitudinal epidemiological study. Occupational and environmental medicine, 66(6) :388–394, 2009.

[34] Sasha Brown. Unpublished data. n.d.

[35] LuAnn L Brink, Evelyn O Talbott, J Alton Burks, and Catherine V Palmer. Changes over time in audiometric thresholds in a group of automobile stamping and assembly workers with a hearing conservation program. AIHA Journal, 63(4) :482–487, 2002.

[36] Robert A Dobie. The burdens of age-related and occupational noise-induced hearing loss in the United States. Ear and hearing, 29(4) :565–577, 2008.

[37] Christina Hederstierna and Ulf Rosenhall. Age-related hearing decline in individuals with and without occupational noise exposure. Noise & health, 18(80) :21, 2016.

[38] International Standard Organization. Acoustics : Estimation of noise-induced hearing loss (iso-1999), 2013.

Appendix A: Results of the chi-square analysis comparing prevalence of hearing loss across cohorts at each age. Post-hoc pairwise comparisons are given when appropriate to do so.

Age (years)	Birth Cohort	N persons	% with hearing loss present	Chi-squared contingency test	Posthoc pairwise comparisons
20	1960	2165	1.94%	X = 7.59, df = 3, *p* = .055	
	1970	2326	2.06%		
	1985	2496	1.32%		
	1995	2322	1.25%		
30	1960	5167	3.37%	X = 8.51, df = 1, *p* = .004	
	1985	3949	2.33%		
45	1935	1387	18.24%	X = 131.08, df = 2, *p* < .001	1935 vs 1960: X = 100.53, df = 1, *p* < .001
	1960	4560	8.66%		1935 vs 1970: X = 108.441, df = 1, *p* < .001
	1970	3764	8.08%		1960 vs 1970: X = 0.902, df = 1, *p* = .342
55	1935	2137	35.22%	X = 200.9, df = 1, *p* < .001	
	1960	4160	18.99%		

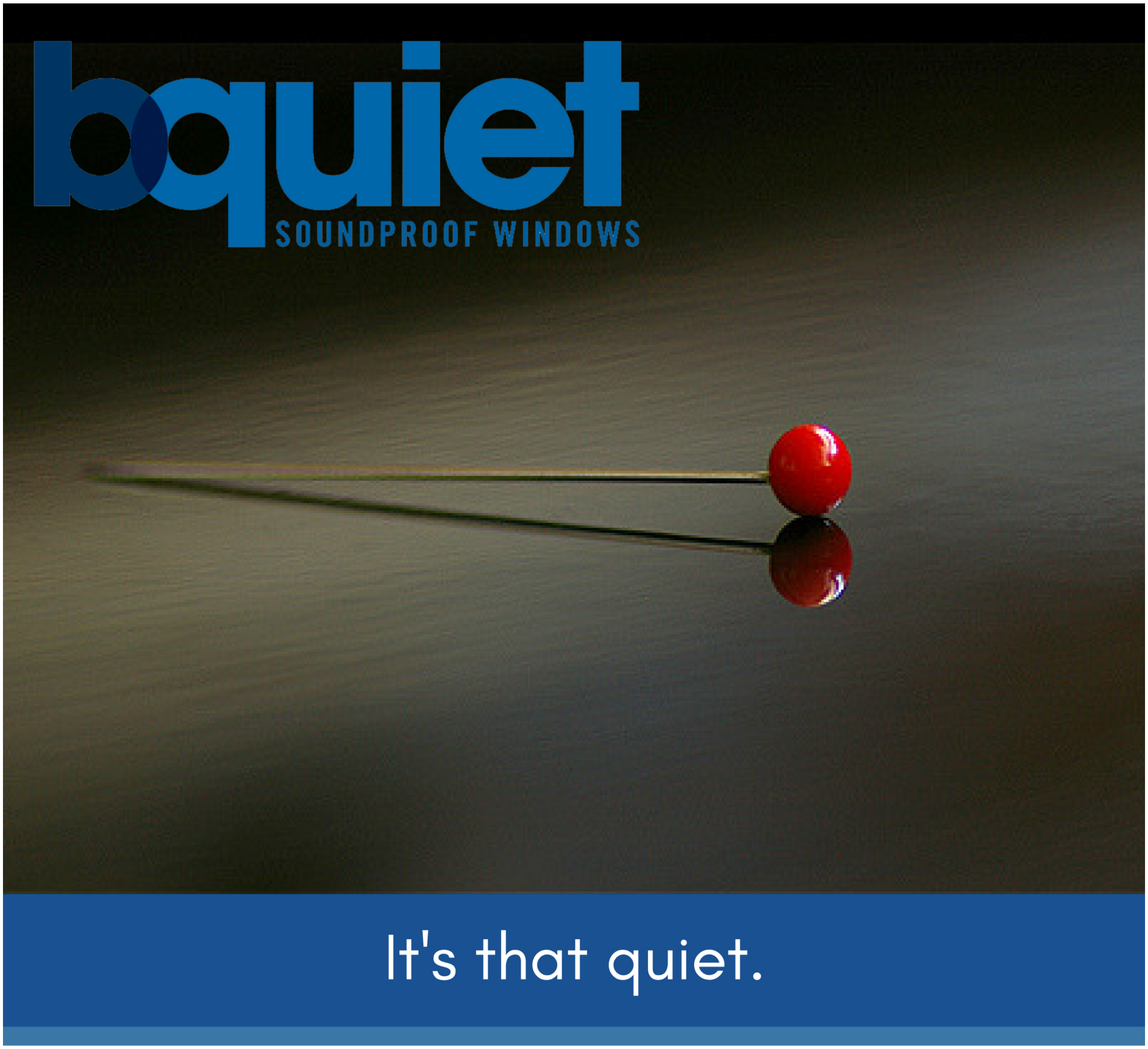
Appendix B: Observed threshold means (dB HL) by cohort and frequency for 45-year olds by occupation. Upper and lower 95% confidence intervals of the means are shown in square brackets

Occupation	Cohort	N	3000 Hz	4000 Hz	6000 Hz
Heavy equipment operator	1980 test (1935 cohort)	43	31.3 [24.2, 38.4]	37.0 [30.8, 43.1]	38.8 [32.4, 45.3]
	2015 test (1970 cohort)	99	16.5 [13.4, 19.5]	24.6 [21.2, 28.0]	23.1 [20.0, 26.3]
Front end loader/ forklift operator	1980 test (1935 cohort)	66	25.1 [21.6, 30.2]	34.5 [30.1, 38.9]	34.5 [29.1, 39.9]
	2015 test (1970 cohort)	65	17.5 [13.8, 21.2]	21.9 [18.6, 25.2]	22.2 [18.4, 26.03]
Heavy duty mechanic	1980 test (1935 cohort)	32	30.3 [22.4, 38.2]	37.7 [29.3, 46.1]	36.7 [28.7, 44.8]
	2015 test (1970 cohort)	83	14.7 [11.9, 17.5]	23.1 [19.7, 26.6]	23.8 [20.3, 27.3]

Appendix C: Thresholds and 95% confidence intervals for the 55-year olds in our sample. The ISO thresholds are calculated from the ISO 1999:2013(E) data set (see text for further details). The difference between ISO and our sample is calculated as the difference between the ISO threshold and either the upper or lower limit of the 95% CI from our sample. "Not different" indicates that ISO mean threshold fell within the 95% CI of our sample.

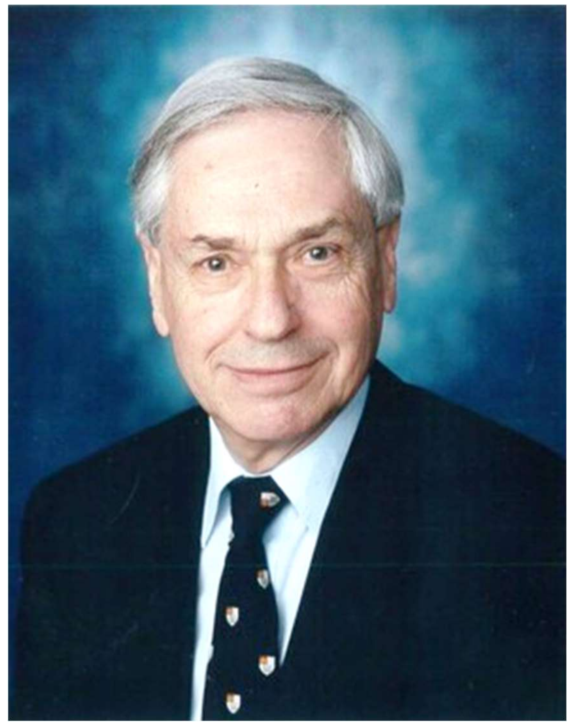
Freq (Hz)	Cohort	N	Mean	sd	95% CI [LL,UL]	ISO	Diff between ISO and our sample (dB)	Comparison relative to ISO
500	1935	2124	12.3	11.3	[11.8, 12.8]	11	-0.8	Poorer than ISO by less than 5 dB
	1960	4158	10.7	9.8	[10.4, 11.0]		0	Not different from ISO
1000	1935	2124	12.8	12.6	[12.3, 13.3]	12.9	0	Not different from ISO
	1960	4158	11.1	11	[10.8, 11.4]		1.5	Better than ISO by less than 5 dB
2000	1935	2124	19.3	18	[18.5, 20.0]	16.3	-2.2	Poorer than ISO by less than 5 dB
	1960	4158	13.2	12.8	[12.8, 13.6]		2.7	Better than ISO by less than 5 dB
3000	1935	2124	33.7	21.5	[32.3, 34.6]	21.3	**-11**	**Poorer than ISO by more than 10 dB**
	1960	4158	22.8	18	[22.3, 23.3]		-1	Poorer than ISO by less than 5 dB
4000	1935	2124	42.1	21.2	[41.2, 43.0]	27.1	**-14.1**	**Poorer than ISO by more than 10 dB**
	1960	4158	30.9	19.1	[30.3, 31.5]		-3.4	Poorer than ISO by less than 5 dB
6000	1935	2124	43.9	21.8	[43.0, 44.8]	26.4	**-16.6**	**Poorer than ISO by more than 10 dB**
	1960	4158	32.9	19.4	[32.3, 33.5]		**-5.9**	Poorer than ISO by more than 5 dB
8000	1935	2124	41.4	23	[40.4, 42.4]	33.3	**-7.1**	Poorer than ISO by more than 5 dB
	1960	4158	35.3	21.5	[34.6, 36.0]		-1.3	Poorer than ISO by less than 5 dB


Sound and Vibration Instrumentation
Scantek, Inc.
Sound Level Meters
Selection of sound level meters for simple noise level measurements or advanced acoustical analysis
Vibration Meters
Vibration meters for measuring overall vibration levels, simple to advanced FFT analysis and human exposure to vibration
Prediction Software
Software for prediction of environmental noise, building insulation and room acoustics using the latest standards
Building Acoustics
Systems for airborne sound transmission, impact insulation, STIPA, reverberation and other room acoustics measurements
Sound Localization
Near-field or far-field sound localization and identification using Norsonic's state of the art acoustic camera
Monitoring
Temporary or permanent remote monitoring of noise or vibration levels with notifications of exceeded limits
Scantek, Inc.
Sales, Rental, Calibration
www.ScantekInc.com
800-224-3813


bquiet
SOUNDPROOF WINDOWS
It's that quiet.

A tribute to Tony F.W. Embleton

Tony F.W. Embleton, FRSC, passed away on 13 November 2020. He was a leader in acoustics in Canada and internationally. Tony was a founding member of the Canadian Acoustical Association and the first Editor-in-Chief of its journal.



Tony was born in Hornchurch, Essex, England, 1 October 1929. He earned a PhD in physics in 1952 from Imperial College London, under R.W.B. Stephens. A one-year post-doctoral fellowship at the National Research Council in Ottawa turned into a four-decade career there.

Tony has been a guiding light for acoustics in Canada. In the early 1960's, he was a key participant in discussions to form a national acoustics organization in Canada. He was elected as the first Secretary of the Canadian Acoustical Association (then known as the Canadian Committee on Acoustics). A few years later when it was decided that a regular newsletter was essential, Tony became the first Editor-in-Chief of Acoustics and Noise Control in Canada / L'acoustique et la lutte antibruit au Canada which later became Canadian Acoustics / Acoustique canadienne. A major event for the CAA was hosting the 1986 International Congress on Acoustics – Tony Embleton was the Technical Program Chair for this meeting. He also served on the CAA Board of Directors.

His research addressed many significant and practical concerns in Canada. His earlier work focussed on the noise generated by suction rolls in the paper industry. The intense siren-like noise generated by the large suction rolls had become a matter of major national concern. This was followed by work on noise reduction in centrifugal blowers and axial-flow compressors, quietening jet engines, precision reciprocity calibration of microphones, and the outdoor propagation of community noise. His work showed how theoretical and experimental research could go hand-in-hand to solve practical problems. Early in his career (1964), his scientific skills were recognized with the ASA's R. Bruce Lindsay award.

Tony also participated in many other organizations, Canadian and international. He chaired the Acoustics and Noise Control Committee of the Canadian Standards Association. Tony served in many capacities for the Institute of Noise Control Engineers (INCE) and for the International-INCE. With the Acoustical Society of America (ASA), he has chaired their Technical Committee on Noise, served on numerous committees, led the society as its President, and been their Standards Director. In 1986 he was awarded their Silver Medal in Noise and, in 2002, he received their Gold Medal. He was Technical Chair for ASA meetings in 1968 (Ottawa), 1978 (Honolulu), 1988 (Honolulu), and 1996 (Honolulu) and General Chair for the 1981 ASA meeting.

His research was significant and of the highest quality; his service to societies was diligent, efficient, and cooperative. He was always willing to help, whether you were a society president or a student new to acoustics. At meetings, he was often surrounded by people, young and old, wanting to access his vast store of knowledge. Tony was predeceased by his wife Eileen in 2016 and is survived by his daughter Sheila and granddaughter Anne.

Mike Stinson
Gilles Daigle
Sheila Embleton
Umberto Berardi

26 Dec 2020

Steven Garrett's ***Understanding Acoustics: An experimentalist's view of sound and vibration***

AVAILABLE FOR **OPEN ACCESS FREE DOWNLOAD**

Dear Sir or Madam,

The Paul S. Veneklasen Research Foundation is asking that you make members of the Canadian Acoustical Society aware that the first "open access" **acoustics textbook** is now available for **free download worldwide**. The e-book version of the second edition of Steven Garrett's *Understanding Acoustics: An experimentalist's view of sound and vibration* can be downloaded from the **Springer** web site at the link provided below:

https://www.springer.com/in/book/9783030447861

The 100-page *Solution Manual* for all of the end-of-chapter problems in the second edition is also available at that site to qualified instructors, as are links to purchase the print versions or request an instructor examination copy for possible course use.

The first edition of Dr. Garrett's textbook received enthusiastic reviews (*e.g.*, P. Joseph, *Physics Today* **70**(10), 62 (2017); M. Kleiner, *J. Audio Eng. Soc.* **65**(11), 972 (2017)) and the second edition corrects some first edition errors, includes many improved figures, as well as new material in such areas as the radiation from an unbaffled piston, the introduction of phasor notation to clearly distinguish complex variables, additional problems, and a much more detailed and comprehensive index.

We hope that the members of your acoustical society will find this "open access" second edition useful for both instruction and for reference. If a member of your acoustical society would like to review the second edition in your journal or newsletter, requests for a review copy can be addressed to Springer at Barbara.Amorese@Springer.com.

Sincerely yours,

JOHN LOVERDE, President
The Paul S. Veneklasen Research Foundation

Canadian Acoustical Association
Association canadienne d'acoustique

Announcement

ACOUSTICS WEEK IN CANADA

Sherbrooke (Québec) October 6-8, 2021

GAUS
Groupe d'acoustique de l'Université de Sherbrooke

Following its postponement from 2020, Acoustics Week in Canada 2021 will be held on October 6-8, in Sherbrooke, Québec.

View of Mont-Orford from downtown Sherbrooke

Given the current context related to the COVID-19 pandemic, you are invited to be part of this three-day online conference featuring the latest developments in Canadian acoustics and vibration. Sherbrooke is well known in acoustics for the Groupe d'Acoustique de l'Université de Sherbrooke (GAUS) founded in 1984.

The theme of this unusual conference will be 'STEMulating Canadian Acoustics'. Each day will have a more specific theme: "Sound and objects" (October 06), "Sound and living beings" (October 07) and "Sound and computers" (08 October 08).
Sessions will be organized from noon to 5:30 p.m., so as to consider the different time zones of Canada

Plenary, technical sessions.

Each half-day will begin with a keynote of broader interest and relevance to the acoustics community. This keynote will be followed by alternating 'lightning' presentations and a period of exchange / discussion in dedicated virtual spaces. Technical sessions are typically planned to cover all areas of acoustics, and will then be gathered under the general themes 'Sound and objects', 'Sound and living beings' and 'Sound and computers'. Accepted research areas include:

Aeroacoustics / Architectural and Building Acoustics / Bio-Acoustics and Biomedical Acoustics / Musical Acoustics / Noise and Noise Control / Physical Acoustics / Psycho- and Physio-Acoustics / Shock and Vibration / Signal Processing / Speech Sciences and Hearing Sciences / Standards and Guidelines in Acoustics / Ultrasonics / Underwater Acoustics

Lightning presentations, to foster exchanges.

To improve interactivity, we propose to generalize a lightning presentation format. Objective: Illustrate your key point in 3 minutes or less, generate interest and create an anchor point for people so that they will join later online. This format will be generalized to all participants.

Extended abstracts and articles on a voluntary basis.

For this year, only short abstracts and lightning videos will be mandatory, so as to organize and build the program. Extended abstracts and articles submission will be possible, but on a voluntary basis. This is proposed in order to motivate people to participate and to lighten the associated workload.

'All virtual' rooms, always opened during the three afternoons.

To discuss online after or during lightning presentations, for students' poster presentations, a room entirely dedicated to exhibitors and a room to display job offers and CV.

A unifying event.

To structure the event around a common goal, we aim at creating the largest noise map ever implemented in Canada by multiplying local initiatives (the largest, not in terms of measurement points but in terms of spatial extension). This will be linked to the International Year of Sound 2020-2021, a global initiative to highlight the importance of sound and related sciences and technologies for all in society (https://sound2020.org/). For each involved chapter, the committee will be interested in receiving nominations to help collect data locally (the application used will be Noise Capture, https://noise-planet.org/noisecapture.html). Each local section will also be able to take advantage of this opportunity to discuss noise problems in their areas of specialization (underwater noise, noise for wildlife, consequences of noise for society).

Anechoic room and wind-tunnel opening at GAUS

Exhibition and sponsorship.

The conference offers product and service providers the opportunity to engage the acoustical community through exhibition and sponsorship. The conference will offer sponsorship opportunities for various conference events. Sponsors can place their logo on the conference website within 10 days of sponsorship. Additional sponsorship features and benefits can be obtained from the Exhibit and Sponsorship Coordinator or on the conference website.

Students.

Students are strongly encouraged to participate. Students presenting papers will be eligible for one of three Best Presentation Student prizes to be awarded.

Registration details.

For registration details, please refer to the conference web site https://awc.caa-aca.ca/index.php/AWC/AWC21

Contacts.

Conference Chair:
Olivier Robin
(Olivier.Robin@USherbrooke.ca)

Technical co-Chairs:
Patrice Masson and
Sebastian Ghinet
(Patrice.Masson@USherbrooke.ca)
(Sebastian.Ghinet@nrc-cnrc.gc.ca)

Exhibits and Sponsorships:
Julien Biboud
(Julien.Biboud@mecanum.com)

Enjoy (virtually) the Mont Bellevue in the center of Sherbrooke during Fall

ANNONCE

SEMAINE CANADIENNE D'ACOUSTIQUE

SHERBROOKE (QUÉBEC) 6-8 OCTOBRE 2021

Suite à son report en 2020, la Semaine canadienne d'acoustique 2021 se tiendra du 06 au 08 octobre 2021 à Sherbrooke, Québec.

Vue du mont Orford depuis le centre-ville de Sherbrooke

Étant donné le contexte actuel lié à la pandémie de COVID-19, nous vous invitons à prendre part en ligne à cette conférence de trois jours sur les derniers développements en matière d'acoustique et de vibrations au Canada. Sherbrooke est reconnue en acoustique pour le Groupe d'Acoustique de l'Université de Sherbrooke (GAUS) fondé en 1984.

Le thème de cette conférence inhabituelle sera 'STIMuler l'acoustique canadienne'. Chaque journée aura un thème spécifique : 'Son et objets' (06 octobre), 'Son et êtres vivants' (07 octobre) et 'Son et ordinateurs' (08 octobre).

Des demi-journées seront organisées, de midi à 17h30, afin de tenir compte des différentes fuseaux horaires du Canada.

Des séances plénières, techniques.

Chaque demi-journée débutera par une plénière d'un intérêt et d'une pertinence plus larges pour la communauté de l'acoustique. Cette plénière sera suivie par une alternance entre présentations 'éclair' et période d'échange/discussion dans des espaces virtuels dédiés. Des sessions techniques sont typiquement prévues pour couvrir tous les domaines de l'acoustique, et seront ensuite regroupées sous les grandes bannières 'Son et objets', 'Son et êtres vivants' et 'Son et ordinateurs'. Les thèmes acceptés incluent :

AÉROACOUSTIQUE / ACOUSTIQUE DU BÂTIMENT ET ARCHITECTURALE / BIOACOUSTIQUE / ACOUSTIQUE BIOMÉDICALE / ACOUSTIQUE MUSICALE / BRUIT ET CONTRÔLE DU BRUIT / ACOUSTIQUE PHYSIQUE / PSYCHOACOUSTIQUE / CHOCS ET VIBRATION / LINGUISTIQUE / AUDIOLOGIE / ULTRASONS / ACOUSTIQUE SOUS-MARINE / NORMES EN ACOUSTIQUE

Des présentations 'éclair' pour stimuler les échanges.

Afin de rendre les échanges plus interactifs, nous proposons de généraliser un format de présentation 'éclair'. Objectif : donner votre point de vue en 3 minutes maximum, susciter l'intérêt et créer un point d'ancrage pour que les gens se joignent plus tard pour discuter directement avec vous en ligne. Ce format sera généralisé à toutes les personnes participantes.

Résumés et articles sur une base volontaire.

Pour cette année, les résumés étendus et articles pour le journal d'Acoustique Canadienne seront à fournir sur une base purement volontaire. Les résumés et les vidéos 'éclair' seront obligatoires et devront être soumis en avance pour assurer le processus de sélection, la qualité du programme et la construction de ce dernier**.**

Uniquement des salles virtuelles, ouvertes en tout temps durant les trois après-midis.

Pour discuter avant, pendant et après les présentations 'éclair', pour les présentations posters pour étudiant.e.s qui le désirent, une salle entièrement dédiée aux exposants et une salle pour afficher offres d'emploi et CV.

Un évènement structurant et visible.

Afin de structurer l'événement autour d'un objectif commun, nous visons à créer la plus grande carte de bruit jamais mise en œuvre au Canada en multipliant les initiatives locales (pas en nombre de points de mesure mais en termes d'étendue spatiale). Cela se reliera à l'année internationale du son 2020-2021, une initiative globale destinée à illustrer l'importance du son et de ses sciences et technologies dans la société (https://sound2020.org/). Pour chaque section locale, le comité sera intéressé de recevoir des candidatures pour aider à collecter localement des données (l'application utilisée sera Noise Capture, https://noise-planet.org/noisecapture.html). Chaque section locale pourra également profiter de cette occasion pour évoquer les problèmes de bruit dans ses domaines de spécialisation (bruit sous-marin, bruit pour la faune, conséquences du bruit pour la société)

Salle anéchoïque et soufflerie au GAUS

Exposition et Parrainage.

La conférence offre aux fournisseurs de produits et de services la possibilité de faire participer la communauté acoustique par l'exposition et le parrainage. La conférence offrira des possibilités de parrainage de divers évènements de la conférence. Les commanditaires peuvent placer leur logo sur le site Web de la conférence dans les 10 jours suivant leur parrainage. Les caractéristiques et avantages supplémentaires du parrainage peuvent être obtenus auprès du coordonnateur des expositions et des commandites ou sur le site Web de la conférence.

Les étudiant.e.s.

Les étudiant.e.s sont fortement encouragé.e.s à participer. Les étudiants qui présenteront seront admissibles à l'un des trois prix pour les meilleures présentations.

Informations sur l'inscription.

Pour plus d'information sur l'inscription, veuillez consulter le site Web de la conférence : http://awc.caa-aca.ca/AWC/AWC21.

Contacts.

Président de la conférence :
Olivier Robin
(Olivier.Robin@USherbrooke.ca)

Présidents techniques :
Patrice Masson and
Sebastian Ghinet
(Patrice.Masson@USherbrooke.ca)
(Sebastian.Ghinet@nrc-cnrc.gc.ca)

Exposants et commandites :
Julien Biboud
(Julien.Biboud@mecanum.com)

Appréciez (virtuellement) le Mont Bellevue au centre de Sherbrooke durant l'automne

CANADIAN ACOUSTICS ANNOUNCEMENTS - ANNONCES TÉLÉGRAPHIQUES DE L'ACOUSTIQUE CANADIENNE

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

Acoustics Week in Canada 2021

Because of the COVID-19 situation, the Acoustics Week in Canada (AWC) originally planned for October 2020 in Sherbrooke (QC) will be postpone to October 2021. Nevertheless, and as a "warm up", Sherbrooke"s organising committee is currently looking into setting up a little 1-day online celebration for October 2020. You can find more information on the AWC20 and AWC21 websites. Please note that St-John's (NL) will host the AWC2022 conference.

May 3rd 2019

COVID-19 Situation

Because of the COVID-19 situation, the Acoustics Week in Canada (AWC) originally planned for October 2020 in Sherbrooke (QC) will be postpone to October 2021. Nevertheless, and as a "warm up", Sherbrooke"s organising committee is currently looking into setting up a little 1-day online celebration for October 2020. You can find more information on the AWC20 and AWC21 websites. Please note that St-John's (NL) will host the AWC2022 conference.

May 13th 2020

Canada Sound Week

The second edition of Canada Sound Week will be held online from March 22 to 27, 2021.

All information is available online at https://lasemainedusoncanada.wordpress.com

March 11th 2021

À la recherche d'un emploi en acoustique ?

De nombreuses offre d'emploi sont affichées sur le site de l'Association canadienne d'acoustique !

Vous pouvez les consulter en ligne à l'adresse http://www.caa-aca.ca/jobs/

August 5th 2015

Semaine canadienne de l'acoustique 2021

En raison de la situation COVID-19, la Semaine canadienne de l'acoustique (AWC) initialement prévue en octobre 2020 à Sherbrooke (QC) sera reportée à octobre 2021. Néanmoins, et comme "échauffement", le comité organisateur de Sherbrooke étudie actuellement la possibilité de mettre en place une petite célébration d'une journée en ligne pour octobre 2020. Vous pouvez trouver plus d'informations sur le site des conférences AWC20 et AWC21. Veuillez noter que St-John's (NL) sera l'hôte de la conférence AWC2022.

May 3rd 2019

Situation COVID-19

En raison de la situation COVID-19, la Semaine canadienne de l'acoustique (AWC) initialement prévue en octobre 2020 à Sherbrooke (QC) sera reportée à octobre 2021. Néanmoins, et comme "échauffement", le comité organisateur de Sherbrooke étudie actuellement la possibilité de mettre en place une petite célébration d'une journée en ligne pour octobre 2020. Vous pouvez trouver plus d'informations sur le site des conférences AWC20 et AWC21. Veuillez noter que St-John's (NL) sera l'hôte de la conférence AWC2022.

May 13th 2020

La Semaine du son Canada

La deuxième édition de la Semaine du son Canada se tiendra en ligne du 22 au 27 mars 2021.

Toutes les informations sont disponibles en ligne via https://lasemainedusoncanada.wordpress.com

March 11th 2021

MEMBERSHIP DIRECTORY 2020 - ANNUAIRE DES MEMBRES 2020

This member directory is generated from the Canadian Acoustical Association membership database records. Please feel free to update or correct this information directly on http://jcaa.caa-aca.ca.

Ce répertoire des membres est généré à partir des informations de la base de données des membres de l'Association canadienne d'acoustique. Mercci de mettre à jour ou corriger toute information directement sur http://jcaa.caa-aca.ca.

Code	Subscription type	Type d'inscription
1	Individual Member	Membre individuel
2	Student Member	Membre étudiant
3	Indirect Subscriber (Canada)	Abonné institutionnel indirect (Canada)
4	Sustaining Subscriber	Abonné de soutien
5	Indirect Subscriber (USA)	Abonné institutionnel indirect (É-U)
6	Indirect Subscriber (International)	Abonné institutionnel indirect (International)
7	Emeritus Member	Membre Emeritus
10	Direct Subscriber	Abonné institutionnel - Direct

Daniel Aalto [1]
University of Alberta
University of Alberta, 2-70 Corbett Hall, Edmonton, AB, T6G 2G4, - CA
aalto@ualberta.ca
N/A
Expertises: speech production; MRI; head and neck cancer; biofeedback

Dr. Adel A. Abdou [1]
King Fahd University of Petroleum and Minerals, (KFUPM)
Architectural Engineering Dept. P.O. Box 1917 Dharan 31261 - SA
adel@kfupm.edu.sa
+966504987206
Expertises: Architectural Acoustics

Noor Al-Zanoon [2]
University of Alberta
N/A - CA
alzanoon@ualberta.ca
N/A
Expertises: Speech Sciences, modelling, acoustics, speech production

Brian Allen [1]
N/A
571 Chrislea Road Woodbridge, ON L4L 8A2, - CA
BAllen@ehpricesales.com
N/A
Expertises: N/A

Maedot S. Andargie [2]
University of Toronto
Maedot Andargie, , 86 Lowther Ave., Unit #2, , Toronto, ON M5R1E1, - CA
maedot.andargie@mail.utoronto.ca
N/A
Expertises: Architectural Acoustics, Building Acoustics, noise perception, Acoustic Comfort

Marko Arezina [1]
RWDI
RWDI, , 600 Southgate Dr, Guelph, ON, , N1G 4P6, - CA
marko.arezina@rwdi.com
N/A
Expertises: N/A

G. Robert Arrabito [1]
N/A
1133 Sheppard Ave. West, North York, ON, M3K 2C9, - CA
robert.arrabito@drdc-rddc.gc.ca
N/A
Expertises: Psychological / Physiological Acoustic, Underwater Acoustics

Dr. Angeliki Athanasopoulou [1]
University of Calgary
School of Languages, Linguistics, Literatures and Cultures , University of Calgary , Craigie Hall D310, 2500 University Dr. N.W. , Calgary, AB T2N 1N4 Canada - CA
angeliki.athanasopou@ucalgary.ca
N/A
Expertises: N/A

James Au [1]
AECOM Canada Ltd., 5080 Commerce Boulevard, Mississauga, Ontario, Canada, L4W4P2
5080 Commerce Boulevard, Mississauga, Ontario, Canada, L4W4P2 - CA
jamesau1@gmail.com
905-712-7056
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Frank Babic [1]
Stantec Consulting Ltd.
N/A - CA
fbabic1@hotmail.com
6472876773
Expertises: N/A

Magdaleen Bahour [1]
N/A
353 Skyline AveLondon, ON N5X 0A5 - CA
magdaleenbahour@gmail.com
N/A
Expertises: N/A

Jeff Bamford [1]
Engineering Harmonics Inc
1249 McCraney Street East L6H 3A3, - CA
jBamford@EngineeringHarmonics.com
4164653378
Expertises: Engineering Acoustics / Noise Control, Signal Processing / Numerical Methods, Other

Mr. Alberto Behar [1]
Ryerson University
307 - 355 St Clair W, Toronto, M5P 1T5 - CA
albehar31@gmail.com
(416) 265-1816
Expertises: Hearing Conservation, Hearing, hearing loss

Josee Belcourt [2]
N/A
N/A - N/A
joseebelcourt@uvic.ca
N/A
Expertises: N/A

Danielle Benesch [2]
École de technologie supérieure
N/A - CA
danielle.benesch.1@ens.etsmtl.ca
N/A
Expertises: Psychological / Physiological Acoustic

M Abdelghani Benghanem [2]
N/A
359 Rue Alexandre Sherbrooke, Quebec J1H4S9, - CA
abdelghani.benghanem@usherbrooke.ca
819-919-2343
Expertises: Psychological / Physiological Acoustic, Perception, Perception sonore

Dr. Umberto Berardi [1]
Ryerson University
350 Victoria Street,, , Ryerson University, Dep Architectural Science,, , Toronto, Ontario, M5B 2K3, - CA
uberardi@ryerson.ca
416 979 5000 (3263)
Expertises: Architectural Acoustics, Acoustic materials

Mr. Elliott H. Berger [1]
3M Personal Safety Division
7911 Zionsville Rd 46268 - US
elliott.berger@mmm.com
N/A
Expertises: N/A

M Serge Berube [1]
N/A
1625, route Marie-Victorin, Sorel, QC, J3R 1M6 - CA
serge.berube@riotinto.com
450-746-3118
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Ryan Bessey [1]
N/A
358 Soudan Avenue, Toronto, ON, M4S 1W7 - CA
ryan.bessey@hotmail.com
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

CSIC Biblioteca [6]
N/A
Ctro Tecnol Fisicas L Torres Quevedo Serrano 144 28006 Madrid, - ES
Alex.Clemente@Lminfo.es
N/A
Expertises: N/A

Ben Biffard [1]
Ocean Networks Canada
Ocean Networks Canada , University of Victoria Queenswood Campus , 2474 Arbutus Road , Victoria, BC V8N 1V8 , - CA
bbiffard@uvic.ca
N/A
Expertises: N/A

Sophie Bishop [2]
University of British Columbia
3475 W 14th Avenue, Vancouver, B.C., V6R 2W2, - CA
sophie.bishop@alumni.ubc.ca
N/A
Expertises: N/A

Mark Bliss [1]
BKL Consultants Ltd.
BKL Consultants Ltd., , 301 - 3999 Henning Drive, , Burnaby, BC ; V5C 6P9, - CA
bliss@bkl.ca
604-988-2508
Expertises: N/A

Atif Bokhari [1]
N/A
7101 Branigan Gate, #17, Mississauga, ON, L5N 7S2 - CA
atif.bokhari@aecom.com
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Mr. Michael Bolduc [1]
RWDI Air Inc.
54 Nisbet Boulevard, Unit 22, L8B 0Y3, Waterdown, Ontario, Canada, - CA
bolducmr@gmail.com
9059123333
Expertises: N/A

Ian Bonsma [1]
HGC Engineering
444-5th Avenue SW Suite 1620 Calgary, Alberta T2P 2T8, - CA
ibonsma@hgcengineering.com
587-441-1583
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Forest Borch [1]
N/A
N/A - CA
borch@bkl.ca
N/A
Expertises: N/A

Dr. Rachel Bouserhal [2]
École de technologie supérieure
N/A - N/A
rachel.bouserhal@etsmtl.ca
N/A
Expertises: Speech Sciences, Hearing Conservation, noise, Speech Communication

Mr. Colin Bradley [1]
Pliteq Inc.
4211 Yonge St, Suite 400, Toronto, ON, M2P 2A9, - CA
cbradley@pliteq.com
6476439752
Expertises: N/A

Dr. A.J. Brammer [1]
Envir-O-Health Solutions
4792 Massey Lane, K1J 8W9 - CA
anthonybrammer@hotmail.com
613 744 5376
Expertises: Engineering Acoustics / Noise Control, Psychological / Physiological Acoustic, Hearing Sciences, Shock and Vibration

Matthew Brenner [1]
GHD Limited
88 Dekay Street, , Kitchener, ON, , N2H3T6, - CA
matthew.brenner@ghd.com
N/A
Expertises: N/A

British Library [6]
British Library
Acquisitions Unit (DSC-AO) Boston Spa Wetherby LS23 7BQ, - GB
indirectint1@caa-aca.ca
N/A
Expertises: N/A

David W. Brown [1]
N/A
Brown Strachan Assoc. ; 130 - 1020 Mainland Street, Vancouver, BC ; V6B 2T5, - CA
bsa@brownstrachan.com
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Ellen Buchan [1]
N/A
Alberta Infrastructure, Technical Services Branch, 3rd Floor, 6950-113 St, Edmonton, AB, T6H 5V7 - CA
ellen.buchan@gov.ab.ca
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Physical Acoustics / Ultrasound

Claudio Bulfone [1]
N/A
531 - 55A St. Delta, BC V4M 3M2 - CA
cbulfone@gmail.com
N/A
Expertises: N/A

Giorgio Burella [1]
BAP Acoustics Ltd.
2227 St Johns St Suite 122,, , Port Moody, BC, , V3H 2A6, - CA
giorgio@bapacoustics.com
+1 (604) 210 5548
Expertises: Shipboard noise, Noise exposure, Structural noise, Structural vibration

Mr. Todd Anthony Busch [1]
Todd Busch Consulting
Todd Busch Consulting #604 - 1177 Bloor Street East, Mississauga, Ontario L4Y2N9, - CA
toddbusch@hotmail.com
647-545-7357
Expertises: N/A

Wil Byrick [4]
N/A
1370 Don Mills Rd, Unit 300 Toronto, ON M3B 3N7 - CA
wbyrick@pliteq.com
416-449-0049
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Mrs Isabelle Champagne [1]
N/A
72 Felicity Drive, Scarborough, ON, M1H 1E3 - CA
isabelle.champagne@rockfon.com
647-269-8580
Expertises: N/A

Mandy Chan [1]
N/A
HGC Engineering, 2000 Argentia Road, Plaza 1, Suite 203, Mississauga, ON, L5N 1P7 , - CA
machan@hgcengineering.com
N/A
Expertises: Psychological / Physiological Acoustic, Musical Acoustics / Electro-acoustics

Marshall Chasin [1]
N/A
34 Bankstock Dr., North York, ON, M2K 2H6 , - CA
marshall.chasin@rogers.com
N/A
Expertises: Engineering Acoustics / Noise Control, Psychological / Physiological Acoustic, Shock and Vibration

Mark Christopher Cheng [1]
Vancouver Airport Authority
Vancouver Airport Authority, PO Box 44638, YVR Domestic Terminal Building RPO, Richmond, BC V7B 1W2, - CA
mark_cheng@yvr.ca
6042766366
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Other

Trevor Cheng [1]
BKL Consultants Ltd.
308-1200 Lynn Valley Road, , North Vancouver, BC, V7J 2A2, - CA
cheng@bkl.ca
N/A
Expertises: N/A

Chinese Academy of Sciences Library [5]
N/A
PO Box 830470 Birmingham, AL 35283, - US
indirectUSA1@caa-aca.ca
N/A
Expertises: N/A

Chenhao Chiu [1]
Graduate Institute of Linguistics, National Taiwan University
No. 1, Sec. 4, Roosevelt Road, Taipei - TW
chenhaochiu@ntu.edu.tw
N/A
Expertises: N/A

Tony Chiu [1]
Ryerson University
69 Drew Kelly Way, Markham, Ontario, Canada, L3R 5P5, - CA
tonychiu@hotmail.com
416-839-9556
Expertises: N/A

Dr. Ken Cho [1]
Stantec
2024 Glenada Crescent, , Oakville, , ON, , L6H 4M6, - CA
jihyun.cho@gmail.com
437-533-8848
Expertises: Engineering Acoustics / Noise Control, Signal Processing / Numerical Methods, Shock and Vibration

Wladyslaw Cichocki [1]
University of New Brunswick
University of New Brunswick, Dept of French, Fredericton, NB E3B 5A3, - CA
cicho@unb.ca
506-447-3236
Expertises: N/A

Gregory Clunis [4]
Integral DX Engineering Ltd.
907 Admiral Ave. Ottawa, ON K1Z 6L6 - CA
greg@integraldxengineering.ca
613-761-1565
Expertises: Architectural Acoustics, Psychological / Physiological Acoustic, Hearing Sciences

Prof. Annabel J Cohen [1]
University of P.E.I.
Department of Psychology, University of Prince Edward Island, 550 University Ave., Charlottetown, PE, C1A 4P3 - CA
acohen@upei.ca
N/A
Expertises: N/A

Sarah Colby [2]
University of Iowa
N/A - US
sarah-colby@uiowa.edu
5149197432
Expertises: N/A

Adam Collins [1]
Aercoustics Engineering Limited
10 Parkview Place, Brampton, ON, L6W 2G1 - CA
adamc@aercoustics.com
6476383858
Expertises: Architectural Acoustics

Dr Maureen R Connelly [1]
BCIT
Building NE03 Room 107, 3700 Willingdon Street, Burnaby Bc V5G 3H2, - CA
maureen_connelly@bcit.ca
604 456 8045
Expertises: N/A

Dr Briony Elizabeth Croft [1]
SLR Consulting (Canada)
Suite 200 - 1620 West 8th Avenue, , Vancouver, BC, , V6J 1V4, - CA
bcroft@slrconsulting.com
6047904202
Expertises: Underwater Acoustics, Railway noise and vibration, Transportation noise, Mining noise and vibration, Noise and wildlife, Noise policy

Eric Cui [2]
University of Toronto
CC4150, Human Communication Lab, , CCT Building,, , University of Toronto Mississauga ;, , 3359 Mississauga Road, ;Mississauga, ON L5L 1C6, - CA
mo.eric.cui@gmail.com
N/A
Expertises: N/A

Dr Gilles Daigle [1]
N/A
48, rue de Juan-les-Pins, Gatineau (QC), J8T 6H2, - CA
gilles_daigle@sympatico.ca
819-561-7857
Expertises: Engineering Acoustics / Noise Control, Physical Acoustics / Ultrasound

Dr Tom Dakin [1]
Sea to Shore Systems Ltd.
2098 Skylark Lane Sidney, BC V8L 1Y4, - CA
tomdakin@seatoshoresystems.ca
250-514-2883
Expertises: Underwater sound speed, underwater sensors

Steve Davidson [10]
Davidson Acoustics & Noise Control * Division of Bouthillette Parizeau
1699, boulevard Le Cordusier, , Bureau #320, , Laval (Quebec) H7S 1Z3, - CA
sdavidson@bpa.ca
N/A
Expertises: N/A

Jack Davis [1]
N/A
6331 Travois Cres NW, Calgary, AB, T2K 3S8 - CA
davisjd@telus.net
403-275-6868
Expertises: N/A

Henk de Haan [1]
dBA Noise Consultants Ltd.
dBA Noise Consultants Ltd. RR1, Site 14, Box 55 Okotoks, AB T1S 1A1, - CA
henk@dbanoise.com
403 836 8806
Expertises: N/A

Corentin Delain [2]
École de technologie Supérieure
N/A - CA
corentin.delain@insa-strasbourg.fr
N/A
Expertises: N/A

N/A Adrian Alejandro Delgado Siutt [2]
GEORGE BROWN
N/A - CA
adstt86@outlook.com
4165097643
Expertises: N/A

Lucas Demysh [1]
N/A
Metallurgical Sensors Inc., 630-420 Main Street East, Milton, ON, L9T 5G3, , - CA
ldemysh@metsen.com
905-876-0966
Expertises: N/A

Mr. Terry J. Deveau [1]
Jasco Applied Sciences
3 Shore Road Herring Cove, NS B3V 1G6 - CA
deveau@chebucto.ns.ca
902-430-8417
Expertises: N/A

Mr. Andrew Dobson [1]
Howe Gastmeier Chapnik Ltd., (HGC Engineering)
HGC Engineering, 2000 Argentia Road, Plaza One, Suite 203, Mississauga, Ontario, L5N 1P7 - CA
adobson@hgcengineering.com
905-826-4044
Expertises: N/A

Centre de documentation [1]
N/A
IRSST - Centre de documentation, 505 boul de Maisonneuve O, 11e étage, Montréal, QC, H3A 3C2 - CA
documentation@irsst.qc.ca
514-288-1551
Expertises: N/A

Ric Doedens [1]
K R Moeller Associates Ltd.
3-1050 Pachino Court, Burlington, Ontario, L7L 6B9 - CA
rdoedens@logison.com
905-332-1730
Expertises: N/A

Justin Dos Ramos [1]
Patching Associates Acoustical Engineering
2031 3 Avenue N.W., Calgary, AB, T2N 0K3, - CA
jdosramos@ffaacoustics.com
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Musical Acoustics / Electro-acoustics

Stan Dosso [1]
University of Victoria
University of Victoria, School of Earth and Ocean Sciences, P.O. Box 3055, Victoria, BC, V8W 3P6 - CA
sdosso@uvic.ca
N/A
Expertises: Signal Processing / Numerical Methods, Other, Underwater Acoustics

Olivier Doutres [1]
École de technologie supérieure (ÉTS)
École de technologie supérieure, 1100 Rue Notre-Dame Ouest, Montréal, QC H3C 1K3 , - CA
olivier.doutres@etsmtl.ca
N/A
Expertises: Acoustic materials

Mr. Robert William Drinnan [2]
University of British Columbia
2284 Cooperidge Drive, Saanichton BC, V8M1N2, - CA
robert.drinnan@gmail.com
N/A
Expertises: N/A

Raphael DUEE [1]
Atelier 7hz
4633 rue de Bordeaux, Montreal (Qc), H2H 1Z9 - CA
raphael.duee@atelier7hz.com
4388702749
Expertises: N/A

M. Yvon Duhamel [1]
Soprema
3100, rue Kunz, Drummondville, QC J2C 6Y4, - CA
yduhamel@soprema.ca
819-478-8166
Expertises: N/A

M. Yvon Duhamel [10]
Soprema
3100, rue Kunz, Drummondville, QC J2C 6Y4, - CA
yduhamel@soprema.ca
819-478-8166
Expertises: N/A

Romain Dumoulin [1]
CIRMMT - McGill University
3427 rue d'Iberville, H2K 3E3 Montreal - CA
dumoulin.acoustics@gmail.com
N/A
Expertises: N/A

Thomas Dupont [1]
École de technologie supérieure (ÉTS)
1100, rue Notre-Dame Ouest ;, , Montréal (Qc) Canada, , H3C 1K3, - CA
thomas.dupont@etsmtl.ca
+1-514 396-8771
Expertises: N/A

Mr. Simon Edwards [1]
HGC Engineering
2000 Argentia Road, Plaza 1, Suite 203, Mississauga, Ontario, L5N1P7, - CA
sedwards@hgcengineering.com
9058264044
Expertises: N/A

Lucas Einig [2]
Grenoble INP
N/A - FR
lucas.einig@grenoble-inp.org
N/A
Expertises: N/A

Dale D. Ellis [1]
N/A
18 Hugh Allen Drive, Dartmouth, NS B2W 2K8 - CA
daledellis@gmail.com
902-464-9616
Expertises: N/A

Pascal Everton [1]
SLR Consulting (Canada) Ltd.
#1185, 10201 Southport Road S.W., Calgary, AB T2W 4X9 - CA
peverton@slrconsulting.com
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Other

Jake Ezerzer [4]
JAD Contracting Ltd
1136 Centre St, Suite 194, Thornhill, ON , L4J 3M8, - CA
info@jadcontracting.ca
1-855-523-2668 toll free
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Musical Acoustics / Electro-acoustics

Clifford Faszer [1]
N/A
FFA Consultants in Acoustics & Noise Control, Suite 210 3015 - 5th Avenue N.E., Calgary, AB, T2A 6T8 - CA
cfaszer@ffaacoustics.com
N/A
Expertises: N/A

Clifford Faszer [4]
N/A
Suite 210N, 3015-5th Ave NE Calgary, AB T2A 6T8 T2A 6T8 - CA
info@ffaacoustics.com
403.508.4996
Expertises: N/A

Zachary Fraser [2]
N/A
505 Terrace St, , Sydney, NS, , B1P 7H6, - CA
zach.fraser88@gmail.com
N/A
Expertises: N/A

Fabio Frazao [1]
Dalhousie University
;, , Office 449, Institute for Big Data Analytics-Faculty of Computer Science, , Dalhousie University- ; 6050 University Avenue, Halifax, NS, , B3H 1W5, , ;, - CA
fsfrazao@dal.ca
+1 902 494 4334
Expertises: N/A

Mr Vince Gambino [1]
N/A
3327 Eglinton Avenue West, Mississauga, Ontario, L5M 7W8, - CA
vgambino@vintecacoustics.com
4164555265
Expertises: N/A

Nathan Gara [1]
HGC Engineering
N/A - CA
ngara@hgcengineering.com
N/A
Expertises: N/A

Bill Gastmeier [1]
HGC Engineering
12 Roslin Ave S. Waterloo, ON N2L 2G5 - CA
bill@gastmeier.ca
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Musical Acoustics / Electro-acoustics

Bill Gastmeier [4]
HGC Engineering
12 Roslin Ave S. Waterloo, ON N2L 2G5 - CA
bill@gastmeier.ca
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Musical Acoustics / Electro-acoustics

Pr Marc-André Gaudreau [1]
UQTR (Université du Québec à Trois-Rivières), Campus de Drummondville
38 rue Descoteaux, Drummondville, Québec, J1Z 2L2, - CA
marc-andre.gaudreau@uqtr.ca
819-478-5011 #2984
Expertises: N/A

Wintta Ghebreiyesus [2]
Ryerson University
N/A - CA
wghebrei@ryerson.ca
N/A
Expertises: Aircraft noise, anc, virtual sensing

Prof. Bryan Gick [1]
University of British Columbia
N/A - CA
gick@mail.ubc.ca
N/A
Expertises: N/A

Prof. Christian Giguère [1]
University of Ottawa
Audiology/SLP Program, 451 Smyth Road, Ottawa, Ontario, K1H8M5 - CA
cgiguere@uottawa.ca
(613) 562-5800 x4649
Expertises: N/A

Sean Alexander Gilmore [2]
Ryerson University
1168 Dufferin st. Toronto, ON M6H 4B8 - CA
sean.gilmore@ryerson.ca
N/A
Expertises: N/A

Ms. Dalila Giusti [1]
Jade Acoustics Inc.
411 Confederation Parkway Unit 19 Concord Ontario L4K 0A8 - CA
dalila@jadeacoustics.com
905-660-2444
Expertises: N/A

Ms. Dalila Giusti [4]
Jade Acoustics Inc.
411 Confederation Parkway Unit 19 Concord Ontario L4K 0A8 - CA
dalila@jadeacoustics.com
905-660-2444
Expertises: N/A

Mr Matthew V Golden [1]
Pliteq
3114 Quesada St NW, , Washington DC, 20015, - US
mgolden@pliteq.com
2027140600
Expertises: Building Acoustics

Huiwen Goy [2]
Ryerson University
N/A - CA
huiwen.goy@mail.utoronto.ca
N/A
Expertises: N/A

Himanshu Goyal [2]
University of British Columbia
N/A - CA
h.goyal@alumni.ubc.ca
2369867503
Expertises: N/A

Pierre Grandjean [2]
Université de Sherbrooke
N/A - CA
pierre.grandjean@usherbrooke.ca
N/A
Expertises: N/A

Dr. Anant Grewal [1]
National Research Council
National Research Council, 1200 Montreal Road, Ottawa, Ontario, K1A-0R6, - CA
anant.grewal@nrc-cnrc.gc.ca
(613) 991-5465
Expertises: N/A

Mr. Manfred Grote [1]
ARCOS Acoustical Consulting
2828 Toronto Cres. N.W. , Calgary, AB T2N 3W2 - CA
arcosacoustic@shaw.ca
403-826-3968
Expertises: N/A

Seanna Guillemin [2]
N/A
3434 Regina Ave, Regina, SK. Canada, S4S7J9, - CA
seanna@1080architecture.com
N/A
Expertises: N/A

Mr. Tim Gully [1]
N/A
141 Adelaide Street West, Suite 910, Toronto, Ontario, M5H 3L5 - CA
Timothy_Gully@golder.com
416-454-9102
Expertises: N/A

Peter Hanes [1]
N/A
National Research Council Bldg M-36 Ottawa, ON , K1A 0R6 - CA
ph3238@yahoo.ca
N/A
Expertises: N/A

Harriet Irving Library [3]
N/A
University of New Brunswick PO Box 7500 Fredericton, NB E3B 5H5, - CA
indirectcan3@caa-aca.ca
N/A
Expertises: N/A

Kyle Hellewell [1]
N/A
RWDI Air, 650 Woodlawn Rd West, Guelph, ON, N1K 1B8 , - CA
kyle.hellewell@rwdi.com
N/A
Expertises: Signal Processing / Numerical Methods, Physical Acoustics / Ultrasound, Underwater Acoustics

Dr. Ines Hessler [1]
MERIDIAN - Marine Environmental Research Infrastructure for Data Integration and Application Network, Dalhousie University
6050 University Ave, Halifax, NS, B3H 4R2, Canada - CA
ines.hessler@dal.ca
9024941373
Expertises: N/A

Dr. Christoph Hoeller [1]
N/A
1414 Palmerston Dr, Gloucester, Ontario, K1J 8P1, Canada, - CA
drchristophhoeller@gmail.com
N/A
Expertises: N/A

Brian Howe [1]
Howe Gastmeier Chapnik Limited
HGC Engineering, Plaza One, Suite 203 2000 Argentia Rd. Mississauga, ON L5N 1P7 - CA
bhowe@hgcengineering.com
9058264044
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Mr Christopher Hugh [1]
Stantec
3875 Trelawny Circle, Mississauga, Onario, L5N 6S4, - CA
chris.hugh@stantec.com
437 240-2138
Expertises: N/A

Hyosung Hwang [1]
N/A
N/A - KR
believeinhyosung@hotmail.com
N/A
Expertises: N/A

Sélim Izrar [1]
EERS
4570 rue Messier ;, H2H 2J1 MONTREAL QC, - CA
sysadmin@caa-aca.ca
Sélim IZRAR
Expertises: N/A

Johns Hopkins University [5]
N/A
Serials / Acquisitions - 001ACF5829EI Milton S. Eisenhower Library Baltimore, MD 21218, - US
indirectusa2@caa-aca.ca
N/A
Expertises: N/A

Stephen Johnson [1]
UBC
#3, 2160 West 39th Ave., Vancouver, BC, V6M 1T5, - CA
stephen.johnson@alumni.ubc.ca
N/A
Expertises: N/A

Prof. Jeffery A. Jones [1]
Wilfrid Laurier University
75 University Ave. W., Waterloo, ON, N2L 3C5, - CA
jjones@wlu.ca
N/A
Expertises: N/A

Francis Juanes [1]
N/A
N/A - N/A
juanes@uvic.ca
N/A
Expertises: N/A

Dr Stephen E. Keith [1]
Health Canada
775 Brookfield Rd., 6301B, , Ottawa, ON, , K1A 1C1, - CA
stephen.keith@canada.ca
+1 613 941-8942
Expertises: N/A

Matthew Kelley [2]
University of Alberta
11-10651 106 St NW, , Edmonton, AB T5H 2X7, - CA
matthew.c.kelley@ualberta.ca
N/A
Expertises: N/A

Douglas S. Kennedy [1]
N/A
BKL Consultants Ltd. #301-3999 Henning Drive, Burnaby, BC V5C 6P9, - CA
kennedy@bkl.ca
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Megan Keough [2]
University of British Columbia
2613 West Mall, Vancouver, BC V6T 1Z4 - CA
mkeough@alumni.ubc.ca
N/A
Expertises: N/A

Roujan Khaledan [2]
University of Alberta
N/A - CA
khaledan@ualberta.ca
N/A
Expertises: N/A

Andrew Khoury [4]
N/A
12 310 ave. Wilfrid-Lazure, Montréal, Qc H4K 2W9, - CA
andrew.khoury@hbkworld.com
514-695-8225
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Michael Kiefte [1]
Dalhousie University
Sir Charles Tupper Medical Building, 5850 College St. 2nd Floor, Room 2C01, PO Box 15000, Halifax NS B3H 4R2 Canada, - CA
mkiefte@dal.ca
+1 902 494 5150
Expertises: Speech Communication

Mr. Corey Kinart [1]
HGC Engineering
2000 Argentia Road, Plaza One, Suite 203, Mississauga, Ontario, L5N 1P7, - CA
ckinart@hgcengineering.com
905-826-4044
Expertises: N/A

Oliver Kirsebom [1]
MERIDIAN, Institute for Big Data Analytics, Faculty of Computer Sciences, Dalhousie University
6050 University Ave, Halifax, NS, B3H 4R2 - CA
oliver.kirsebom@dal.ca
902 209 9788
Expertises: N/A

Masanori Kondo [4]
RION Co., Ltd
3-20-41 Higashimotomachi, Kokubunji, , Tokyo ;185-8533, - JP
m-kondo@rion.co.jp
+81-42-359-7888
Expertises: N/A

Viken Koukounian [1]
K.R. Moeller Associates Ltd.
3-1050 Pachino Court, Burlington, ON L7L 6B9, - CA
viken@logison.com
N/A
Expertises: Acoustics ; Noise Control ; Aeroacoustics, acoustics, speech perception, Acoustic Measuring Techniques Room and Building Acoustics, Speech Communication

Mr. Ivan Koval [1]
Reliable Connections Inc.
2 Englemount Avenue, Toronto ON M6B 4E9, - CA
soundproofing.expert@gmail.com
416-471-2130
Expertises: N/A

Kelly Kruger [1]
N/A
5407 109A Ave NW, Edmonton, AB, T6A 1S6 - CA
kkruger@telus.net
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Sam Kulendran [1]
N/A
1210 Sheppard Avenue East, Suite 211, Toronto, ON, M2K 1E3 - CA
skulendran@jecoulterassoc.com
N/A
Expertises: N/A

Ms. Ilse Bernadette Labuschagne [2]
The University of British Columbia
310-825 East 7th Ave, Vancouver, , V5T1P4, - CA
ilse.labuschagne@alumni.ubc.ca
N/A
Expertises: N/A

Alexane Lahaie [2]
University of Ottawa and, Integral DX Engineering Ltd.
6163 Lariviere Crescent, Ottawa, ON, K1W 1C7, - CA
alexla@rogers.com
N/A
Expertises: N/A

Pier-Gui Lalonde [1]
N/A
686-77 River Lane, L'Orignal ON K0B 1K0, - CA
Pier-gui@integraldxengineering.ca
N/A
Expertises: N/A

Mark Adam Langhirt [2]
Penn State University, Applied Research Laboratories: PSU, Naval Surface Warfare Center, Panama City
558 Clarence Ave., State College, PA 16803, - US
mark.a.langhirt@gmail.com
8508197314
Expertises: N/A

Dr. Chantal Laroche [1]
N/A
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
613-562-5800 3066
Expertises: N/A

Monsieur Daniel Larose [4]
Dalimar Instruments ULC
193 Joseph Carrier Vaudreuil-Dorion, QC J7V 5V5 - CA
daniel@dalimar.ca
450-424-0033
Expertises: Architectural Acoustics, Psychological / Physiological Acoustic, Musical Acoustics / Electro-acoustics

Jean-François Latour [1]
SNC-Lavalin
2271 Fernand-Lafontaine Longueuil, Quebec J4G 2R7, - CA
jefflatour000@gmail.com
(514) 393-8000
Expertises: N/A

Frédéric Laville [1]
École de technologie supérieure
Ecole de technologie supérieure Université du Québec 1100 Notre-Dame Ouest Montréal, QC H3C 1K3 - CA
frederic.laville@etsmtl.ca
N/A
Expertises: Engineering Acoustics / Noise Control, Hearing Sciences, Shock and Vibration

Jack Lawson [2]
University of Victoria
N/A - CA
jack.lawson.1313@gmail.com
N/A
Expertises: N/A

Cécile Le Cocq [1]
ÉTS, Université du Québec
1100 Notre Dame Ouest, Montréal (Qc) H3C 1K3, - CA
journal@caa-aca.ca
N/A
Expertises: N/A

Learning Res. Center [5]
N/A
A T Still Univ Hlth Sci 5850 E Still Circ Mesa, AZ 85206, - US
indirectusa3@caa-aca.ca
N/A
Expertises: N/A

Buddy Ledger [1]
N/A
5248 Cedar Springs Road, Burlington, Ontario L7P 0B9, - CA
buddyledger@gmail.com
N/A
Expertises: N/A

Dr Joonhee Lee [1]
Concordia University
EV 6.231, 1515 Rue Sainte-Catherine O, Montréal, H3G 2W1 - CA
Joonhee.Lee@concordia.ca
514-848-2424 ext. 5320
Expertises: Architectural Acoustics, noise and vibration control

Marcus Li [1]
N/A
177 Westfield Trail, Oakville, ON, L6H 6H7 - CA
Li.MarcusTW@gmail.com
N/A
Expertises: N/A

Weidong Li [1]
N/A
N/A - N/A
wli@pinchin.com
N/A
Expertises: N/A

Yadong Liu [2]
The University of British Columbia
N/A - CA
liuyadong08@gmail.com
N/A
Expertises: N/A

Chang Liu [3]
Editorial Development Dept., Thomson Reuters
N/A - N/A
chang.liu@thomsonreuters.com
N/A
Expertises: N/A

Banda Logawa [1]
BKL Consultants
706-575 Delestre Ave, Coquitlam BC V3K0A6 - CA
logawa.b@gmail.com
6046003857
Expertises: N/A

Alexander P. Lorimer [1]
N/A
HGC Engineering Ltd. Plaza One, Suite 203 2000 Argentia Rd. Mississauga, ON L5N 1P7 - CA
alorimer@hgcengineering.com
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Matthew Lorimer [2]
Student
3-184 Osgoode Street, Ottawa ON, K1N6S8, - CA
mlori100@uottawa.ca
N/A
Expertises: N/A

Parnia Lotfi Moghaddam [1]
Arcadis Canada Inc.
121 Granton Drive, Suite 12, Richmond Hill ON, L4B 3N4, - CA
parnia.lotfimoghaddam@arcadis.com
289-982-4740
Expertises: N/A

Yu Luan [2]
École de Technologie Supérieure
3777 Rue Saint Urbain, #211, Montréal, QC ; ; H2W 1T5 , - CA
yu.luan.1@ens.etsmtl.ca
N/A
Expertises: N/A

Dr. Roderick Mackenzie [1]
SoftdB
250 Avenue Dunbar, Suite 203, Montreal, Qc, Canada, H3P 2H5, - CA
r.mackenzie@softdb.com
5148056734
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control

Dr. Roderick Mackenzie [4]
SoftdB
250 Avenue Dunbar, Suite 203, Montreal, Qc, Canada, H3P 2H5, - CA
r.mackenzie@softdb.com
5148056734
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control

Ewan Andrew Macpherson [1]
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
Expertises: N/A

Dr. Gary S. Madaras [1]
Rockfon
4849 S. Austin Ave., Chicago, IL 60638 - US
gary.madaras@rockfon.com
708.563.4548
Expertises: Architectural Acoustics

MD AMIN MAHMUD [1]
MASc, EIT
6679 Shelter Bay Road, Unit 8, , Mississauga, Ontario L5N 2A2, - CA
amin1448@gmail.com
778-681-2348
Expertises: Helmholz Resonator

Jeffrey Mahn [1]
National Research Council Canada
National Research Council Canada, 1200 Montreal Road, Building M27, Ottawa, ON K1C 4N4 - CA
jeffrey.mahn@nrc-cnrc.gc.ca
N/A
Expertises: N/A

Mr Paul E Marks [1]
BKL Consultants Ltd
BKL Consultants Ltd, #308 - 1200 Lynn Valley Road, North Vancouver, BC, Canada, V7J 2A2 - CA
marks@bkl.ca
604-988-2508
Expertises: N/A

President, Scantek, Inc. [4]
Scantek, Inc.
Scantek, Inc., 6430 Dobbin Road, Suite C, Columbia, MD 21045, - US
steve.scantek@gmail.com
1-410-290-7726
Expertises: N/A

Christian Martel [1]
N/A
Octave Acoustique Inc., 6575, chemin Royal, Saint-Laurent-de-l'Ile-d'Orleans, QC, G0A 3Z0, - CA
octave@videotron.ca
418-828-0001
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Musical Acoustics / Electro-acoustics

Michael Masschaele [1]
GHD
455 Phillip Street, Waterloo, Ontario, N2L 3X2 - CA
michael.masschaele@ghd.com
+1 519 340 3818
Expertises: N/A

Mr Nigel Maybee [1]
SLR Consulting (Canada) Ltd.
SLR Consulting (Canada) Ltd., #1185-10201 Southport Road SW, Calgary, AB, T2W 4X9 - CA
nmaybee@slrconsulting.com
403-385-1308
Expertises: Engineering Acoustics / Noise Control

Connor Mayer [2]
UCLA
7100 Hillside Ave, #108, Los Angeles, CA, 90046, - US
connor.joseph.mayer@gmail.com
N/A
Expertises: Speech Sciences

Stephen McCann [1]
Swallow Acoustic Consultants Ltd.
597 Homewood Avenue, Peterborough, Ontario K9H2N4 - CA
smccann@thorntontomasetti.com
9052717888
Expertises: N/A

Mr. Darryl McCumber [1]
HGC Engineering
N/A - N/A
dmccumber@hgcengineering.com
9058264044
Expertises: N/A

Cory McKenzie [2]
University of Alberta
11314 79 ave NW, , Edmonton, Alberta, , T6G 0P3, - CA
ccmckenz@ualberta.ca
780-680-0986
Expertises: N/A

MDDELCC [3]
N/A
Dir politique de la qualité de l'atmosphère 675 Rene-Levesque Est ; 5E-B30 Québec, QC G1R 5V7, - CA
indirectcan4@caa-aca.ca
N/A
Expertises: N/A

Michael Medal [1]
N/A
Aercoustics Engineering, 50 Ronson Drive, Suite 165, Toronto, ON, M9W 1B3 , - CA
michaelm@aercoustics.com
N/A
Expertises: Speech Sciences

Terry Medwedyk [1]
N/A
Group One Acoustics Inc. 1538 Sherway Dr. Mississauga, ON L4X 1C4 - CA
goainc@rogers.com
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Hearing Sciences, Musical Acoustics / Electro-acoustics

Steve Meszaros [1]
RWDI
Suite 280, 1385 West 8th Avenue, Vancouver, BC, V6H 3V9, - CA
steve.meszaros@rwdi.com
N/A
Expertises: N/A

Mr. Andy Metelka [1]
SVS Canada Inc.
13652 Fourth Line Acton, ON L7J 2L8 - CA
ametelka@cogeco.ca
519-853-4495
Expertises: N/A

Andy Metelka [1]
Sound & Vibration Solutions Canada Inc.
13652 Fourth Line, Acton, Ontario, L7J 2L8, - CA
bmetelka@cogeco.ca
5198534495
Expertises: N/A

M. Jean-Philippe Migneron [2]
Université Laval
204-1393, rue de Jupiter, Lévis, QC G6W 8J3 - CA
jean-philippe.migneron.1@ulaval.ca
418-906-0333
Expertises: N/A

Jean-Philippe Migneron [4]
Acoustec Inc.
90, rue Hormidas-Poirier, Lévis, QC G7A 2W1 - CA
info@acoustec.qc.ca
418-496-6600
Expertises: N/A

Rachel Min [1]
Vancouver Airport Authority
PO Box 44638 , YVR Domestic Terminal RPO , Richmond BC V7B 1W2 - CA
rachel_min@yvr.ca
N/A
Expertises: N/A

Ministère des transports [3]
N/A
Centre Documentation 35 Port-Royal Est, 4e étage Montréal, QC H3L 3T1, - CA
indirectcan5@caa-aca.ca
N/A
Expertises: N/A

Farid Moshgelani [2]
N/A
1026 Kimball Cres., , London, ON, N6G 0A8, - CA
fmoshgel@uwo.ca
N/A
Expertises: N/A

Xavier Mouy [2]
JASCO Applied Sciences
N/A - N/A
xavier.mouy@jasco.com
N/A
Expertises: N/A

Todd Mudge [1]
ASL Environmental Sciences Inc
N/A - N/A
tmudge@aslenv.com
N/A
Expertises: N/A

Kirsten Mulder [2]
University of Alberta
9-603 Watt Blvd SW, , Edmonton, AB, , T6X 0P3, - CA
kjesau@ualberta.ca
N/A
Expertises: N/A

Kristen Mulderrig [2]
Student Researcher
N/A - CA
mulderrigk@mymacewan.ca
N/A
Expertises: N/A

Kevin Munhall [1]
Queen's University
Dept. of Psychology, , Humphrey Hall, , 62 Arch St. ;, , Queen's University, , Kingston, ON K7L 3N6, - CA
munhallk@queensu.ca
613 533-6012
Expertises: N/A

M. Vincent Nadon [2]
École de technologie supérieure
6298 rue d'Aragon,, Montréal, Qc,, H4E 3B1, Canada, - CA
vincent.nadon@etsmtl.ca
N/A
Expertises: N/A

Ann Nakashima [1]
Defence Research and Development Canada, Toronto Research Centre
DRDC Toronto 1133 Sheppard Ave. W. Toronto, ON M3K2C9 - CA
ann.nakashima@drdc-rddc.gc.ca
N/A
Expertises: Hearing Protection, noise, impulse noise, communication

Daniel Nault [2]
Queen's University (Department of Psychology)
N/A - CA
14drn1@queensu.ca
N/A
Expertises: N/A

Hugues Nelisse [1]
Institut de Recherche Robert-Sauvé en Santé et Sécurité du Travail (IRSST)
IRSST 505 Boul de Maisonneuve Ouest Montréal, QC H3A 3C2 - CA
nelisse.hugues@irsst.qc.ca
514-288-1551 x 221
Expertises: N/A

Mr. Phat Nguyen [1]
N/A
Produits Acoustiques PN Inc., 2875 Rue Jasmin, Saint-Laurent, QC, H4R 1H8 - CA
pn@acoustiquepn.ca
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Joonas Niinivaara [1]
N/A
28 Elizabeth St. N., Apt 1207, L5G2Z6, Mississauga, ON, - CA
jniinivaara@hgcengineering.com
9053176154
Expertises: N/A

NOAA National Marine Mammal Lab [10]
N/A
Library Bldg 4 Rm 2030 7600 Sand Point Way NE Seattle, WA 98115-6349, - US
cgore@wtcox.com
N/A
Expertises: N/A

Dr. Colin Novak [1]
Akoustik Engineering Limited
138 Angstrom Cres., Amherstburg, ON, N9V 3S3 - CA
novak1@uwindsor.ca
(519)903-7193
Expertises: N/A

Tomasz Nowak [1]
N/A
266 Ave Lagace, H9S 2M1, Dorval, Quebec , - CA
now.tomek@gmail.com
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Musical Acoustics / Electro-acoustics

Mr. John O'Keefe [1]
O'Keefe Acoustics
10 Ridley Gardens Toronto, Canada. M6R 2T8 - CA
john@okeefeacoustics.com
4164554382
Expertises: Architectural Acoustics

Mr. Brian Obratoski [1]
Acoustex Specialty Products
15 Crooks St ; Fort Erie ; Ontario ; L2A 4H1, - CA
Brian@acoustex.ca
2893895564
Expertises: N/A

Mr. Brian Obratoski [4]
Acoustex Specialty Products
15 Crooks St ; Fort Erie ; Ontario ; L2A 4H1, - CA
Brian@acoustex.ca
2893895564
Expertises: N/A

Alan Oldfield [1]
AECOM
5080 Commerce Blvd, Mississauga, ON, L4W 4P2 - CA
alan.oldfield@aecom.com
9057127058
Expertises: Architectural Acoustics

Alan Oldfield [4]
AECOM
5080 Commerce Blvd, Mississauga, ON, L4W 4P2 - CA
alan.oldfield@aecom.com
9057127058
Expertises: Architectural Acoustics

Donald Olynyk [1]
Acoustical Consultant
9224 - 90 Street NW, Edmonton, AB T6C 3M1 - CA
don.olynyk@shaw.ca
7804654125
Expertises: N/A

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

William K.G. Palmer [1]
N/A
TRI-LEA-EM RR 5, 76 Sideroad 33/34 Saugeen, Paisley, ON, N0G 2N0 , - CA
trileaem@bmts.com
N/A
Expertises: Engineering Acoustics / Noise Control, Psychological / Physiological Acoustic, Hearing Sciences

Richard Patching [1]
Patching Associates Acoustical
23 Harvest Oak Green NE, , Calgary Alberta, , T3K 3Y2, - CA
argeepy@gmail.com
N/A
Expertises: N/A

Jamie Paterson [1]
Actinium Engineering Inc.
11 Lloyd Cook Drive E, Minesing ON L9X 0H5 - CA
jamie@actinium.ca
289-468-1221x101
Expertises: Engineering Acoustics / Noise Control, Musical Acoustics / Electro-acoustics

McKae Pawlenchuk [2]
University of Alberta
11311 57 Ave NW , Edmonton AB , T6H 0Z7, - CA
mckae@ualberta.ca
N/A
Expertises: N/A

Michel Pearson [1]
Soft dB
Soft dB , 1040 Belvedere Suite 215 , Québec, QC , G1S 3G3 - CA
m.pearson@softdb.com
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration, industrial acoustics, environmental noise

Richard Joseph Peppin [1]
Engineers for Change, Inc. & RION Co., Ltd.
5012 Macon Rd Rockville, MD 20852 - US
peppinR@asme.org
301-910-2813
Expertises: industrial acoustics, noise, arch acoustics, environmental noise

April Pereira [2]
University of Waterloo
c/o Dept. of Sociology & Legal Studies ;, , PAS Building ;, , University of Waterloo, , 200 University Ave West ;, , Waterloo ON N2L 3G1, - CA
april.pereira@uwaterloo.ca
N/A
Expertises: N/A

Dr. Sebastien S Perrier [1]
Echologics
165 Legion Road North, Apt 2027, Etobicoke, ON, M8Y 0B3, - CA
sperrier@echologics.com
N/A
Expertises: vibration, Sensors and instrumentation, signal processing, Sound propagation in wave guides, coupling of structures

Scott Perry [2]
University of Alberta
Department of Linguistics, 3-28 Assiniboia Hall, University of Alberta, Edmonton, AB, T6G 2E7, Canada, - CA
sperry1@ualberta.ca
N/A
Expertises: L2 speech learning

Aaron Peterson [1]
Brown Strachan Associates
130 - 1020 Mainland Street, Vancouver, BC ; V6B 2T5, - CA
bsadrafts@hotmail.com
(604) 689-0514
Expertises: N/A

Prof. Kathleen Pichora Fuller [1]
University of Toronto
590 Galadriel Lane, Bowen Island, British Columbia, Canada V0N1G2, - CA
k.pichora.fuller@utoronto.ca
778-722-0143
Expertises: N/A

Howard Podolsky [4]
Pyrok Inc.
121 Sunset Rd. Mamaroneck, NY, 10543 - US
mrpyrok@aol.com
914-777-7770
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control

Linda Polka [1]
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
Expertises: Hearing Sciences, Speech Sciences

Tim Preager [1]
N/A
N/A - N/A
timp@aercoustics.com
N/A
Expertises: N/A

Monsieur Etienne Proulx [1]
N/A
201-255, avenue Saint-Sacrement, Québec (QC), G1n 3X, - CA
e.proulx@yockell.com
418-688-5941
Expertises: N/A

Daniel P. Prusinowski [1]
Aurora Acoustical Consultants Inc.
745 Warren Drive, , East Aurora, NY ;14052, , USA, - US
dprusinowski@verizon.net
1-716-655-2200
Expertises: N/A

Dr. John David Quirt [1]
Consultant
1949 Mulberry Crescent, Ottawa, ON, K1J 8J8 - CA
jdq.acoustics@bell.net
613-745-2793
Expertises: N/A

Roberto Racca [1]
JASCO Applied Sciences
JASCO ;Applied Sciences ;Ltd. , 2305 - 4464 Markham Street , Victoria, BC V8Z 7X8, - CA
roberto.racca@jasco.com
+1.250.483.3300 ext.2001
Expertises: Underwater Acoustics, Bioacoustics, Regulations, Acoustic modelling, Conservation

Roberto Racca [4]
JASCO Applied Sciences
JASCO ;Applied Sciences ;Ltd. , 2305 - 4464 Markham Street , Victoria, BC V8Z 7X8, - CA
roberto.racca@jasco.com
+1.250.483.3300 ext.2001
Expertises: Underwater Acoustics, Bioacoustics, Regulations, Acoustic modelling, Conservation

Anoushka Rajan [1]
APEGBC
N/A - CA
anoushka.rajan@iicanada.net
N/A
Expertises: room acoustics, sound insulation

Prof. Ramani Ramakrishnan [1]
Ryerson University
27 Ashmount Crescent, Toronto, ON, M9R 1C8, M9R 1C8 - CA
rramakri@ryerson.ca
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Kayla Raulino [1]
ARCACOUSTICS
23-260 Holiday Inn Drive, Cambridge, ON, N3C 4E8 - CA
kraulino@arcacoustics.com
1-877-337-9312
Expertises: N/A

Dr Werner Richarz [1]
Richarz Technical Solutions
76 Roxborough Lane, Thornhill, ON, L4J 4T4, - CA
werner@richarztechnicalsolutions.com
6475023361
Expertises: N/A

Prof. Joana Rocha [1]
Carleton University
Department of Mechanical and Aerospace Engineering, , Carleton University, 1125 Colonel By Drive, , Ottawa, ON, K1S 5B6, , ;, - CA
Joana.Rocha@carleton.ca
N/A
Expertises: N/A

Mr. Tim WE Rosenberger [1]
SPL Control Inc
200 Avenue Rd., Cambridge, ON, N1R 8H5 - CA
trosenberger@splcontrol.com
5196236100
Expertises: N/A

Ronald Roth [1]
N/A
Edmonton Police Service, 9620-103A Ave, Edmonton, AB, T5H 0H7 , - CA
ron.roth@edmontonpolice.ca
N/A
Expertises: Engineering Acoustics / Noise Control, Shock and Vibration

Prof. Frank A. Russo [1]
Ryerson University
Department of Psychology Ryerson University 350 Victoria Street Toronto, Ontario M5B 2K3 - CA
russo@ryerson.ca
416-979-5000
Expertises: N/A

Ryerson University Library [3]
N/A
LIB-551 350 Victoria Street Toronto, ON M5B 2K3, - CA
indirectcan7@caa-aca.ca
N/A
Expertises: N/A

Shivraj Sagar [1]
N/A
7566 Saint Barbara Blvd, Mississauga, ON, L5W 0B6, - CA
shivraj.sagar@gmail.com
N/A
Expertises: N/A

Mehrzad Salkhordeh [1]
dB Noise Reduction Inc.
23-260 Holiday Inn Drive Cambridge ON N3C 4E8, - CA
mehrzad@dbnoisereduction.com
519-651-3330 x 220
Expertises: N/A

Mehrzad Salkhordeh [4]
dB Noise Reduction Inc.
23-260 Holiday Inn Drive Cambridge ON N3C 4E8, - CA
mehrzad@dbnoisereduction.com
519-651-3330 x 220
Expertises: N/A

Jacques Savard [1]
N/A
254 Chemin Smith, Canton de Cleveland, QC, J0B 2H0, - CA
jacques.savard@jsgb.com
514 989-8598
Expertises: Bruit des avions, Aircraft noise

William Brett Sceli [2]
Lawrence Tech University
440 Southfield Rd., Birmingham, Michigan, United States, 48009 - CA
brettsceli1@gmail.com
N/A
Expertises: N/A

Dr. Murray Schellenberg [1]
University of British Columbia
2613 West Mal , , Vancouver, BC , , V6T 1Z4 , - CA
mschell@mail.ubc.ca
N/A
Expertises: N/A

Katrina Scherebnyj [1]
BKL Consultants Ltd.
471 Cabot Trail, Waterloo, Ontario, N2K 4C8, - CA
kscherebnyj@gmail.com
N/A
Expertises: N/A

Stefan Schoenwald [1]
Swiss Federal Laboratories for Materials Science and Technology
Überlandstrasse 129 CH-8600 Dübendorf, Switzerland - CA
stefan.schoenwald@empa.ch
41 58 765 6579
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Cynthia Sedlezky [2]
Queen's University
N/A - CA
16cs54@queensu.ca
N/A
Expertises: N/A

Virgini Senden [1]
dBA Noise Consultants
Henk de Haan & Virgini Senden, RR1, site 14, box 55 , Okotoks, AB , T1S 1A1 - CA
senden.virgini@gmail.com
587 439 9980
Expertises: Engineering Acoustics / Noise Control, Shock and Vibration, Physical Acoustics / Ultrasound

Arian Shamei [2]
UBC
2613 West Mall, Vancouver, BC V6T 1Z4 - CA
arianshamei@gmail.com
N/A
Expertises: N/A

Davor Sikic [1]
N/A
Jade Acoustics Inc. 411 Confederation Parkway, Unit 19 Concord, ON L4K 0A8 - CA
davor@jadeacoustics.com
905-660-2444
Expertises: N/A

Mr cyril simon [1]
Institute Of Electrical Electronic Engineers (IEEE)Member No: 41405809
Cyber City Apartment Phase 2, Block U, U15-1, Jalan Lintas Kepayan, Kota Kinabalu, 88200, Sabah. Malaysia, - MY
cyrilsm@gmail.com
N/A
Expertises: audiology, soundproof

Dr. Devinder Pal Singh [1]
Acoustics Research Group,
215 Mississauga Valley Blvd., unit # 4, Mississauga, ON , L5C 3H1 - CA
drdpsn@hotmail.com
4168591856
Expertises: Physical Acoustics / Ultrasound

Alex Slonimer [2]
University of Victoria
1164 Ranger Place,, , Saanich, BC, , V8X 3P6, - CA
alexslonimer@hotmail.com
N/A
Expertises: N/A

W. Robert Snelgrove [1]
GerrAudio Distribution Inc.
2611 Development Drive, Unit 8, , PO Box 427, , Brockville, ON ;K6V 5V6, - CA
bob@gerr.com
6133426999
Expertises: N/A

Robert D. Stevens [1]
N/A
HGC Engineering Ltd., Plaza One, Suite 203, 2000 Argentia Rd., Mississauga, ON, L5N 1P7 - CA
rstevens@hgcengineering.com
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Musical Acoustics / Electro-acoustics

Mr. Andreas Strasser [1]
Merlin Integrated Solutions, Inc.
#42 - 5400 Dalhousie Dr. NW, Calgary, AB T3A 2B4, - CA
astrasser@merlinis.ca
4039704841
Expertises: N/A

Mr. Rob W Sunderland [4]
Xprt Integration
Xprt Integration, 108-1515 Barrow Street, North Vancouver, BC, V7J 1B7 - CA
rob@xprt.ca
604-985-9778
Expertises: N/A

Nicholas Sylvestre-Williams [4]
Aercoustics Engineering Ltd.
1004 Middlegate Road, Suite 1100 , Mississauga, ON , L4Y 0G1 - CA
NicholasS@aercoustics.com
(416) 249-3361
Expertises: N/A

Prof. Jahan Tavakkoli [1]
Ryerson University
Dept of Physics, Ryerson University, 350 Victoria Street, Toronto, ON , M5B 2K3 - CA
jtavakkoli@ryerson.ca
(416) 979-5000
Expertises: N/A

Techniche Informationsbib. TIB [6]
N/A
Team Zeitschriften Welfengarten 1 B D-30167 Hannover, - DE
indirectint5@caa-aca.ca
N/A
Expertises: N/A

Dr. John Terhune [1]
University of New Brunswick, Saint John campus
University of New Brunswick, Dept. of Biological Sciences, ; 100 Tucker Park Road, Saint John, NB E2L 4L5, - CA
terhune@unb.ca
506-832-5464
Expertises: Psychological / Physiological Acoustic, Hearing Sciences, Underwater Acoustics, marine mammals

Mr. Peter Terroux [1]
N/A
Atlantic Acoustical Associates, 47 Boscobel Road, Halifax, NS, B3P 2J2 - CA
peteraaa@eastlink.ca
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Psychological / Physiological Acoustic

Jessica Tinianov [1]
HGC Engineering
34 Superior Ave , Toronto ON , M8V 2M6 - CA
jtinianov@hgcengineering.com
N/A
Expertises: N/A

Mihkel Toome [1]
RWDI
77 Woodside Avenue, , Toronto, Ontario, , M6P 1L9, - CA
mikk.toome@rwdi.com
416-727-3461
Expertises: noise control, room acoustics, Building Acoustics

Mr Patrick Trahan [1]
Integral DX Engineering
966 Warbler Bay, Ottawa, ON, K1E 2A2 - CA
patrick@integraldxengineering.ca
613-761-1565 x119
Expertises: N/A

Miss Deirdre M. Truesdale [2]
McGill University
School of Communication Sciences and Disorders, 2001 Ave McGill College, 8th Floor, Montreal, Quebec H3A 1G1, - CA
deirdre.truesdale@mail.mcgill.ca
N/A
Expertises: N/A

Mr. Jason Timothy Tsang [1]
Canadian Transportation Agency
20 Parkridge Crescent, Gloucester, Ontario, K1B3E7, - CA
jason.tsang@otc-cta.gc.ca
613-986-0398
Expertises: N/A

Benjamin V. Tucker [1]
University of Alberta
Univ. of Alberta, Dept. of Linguistics 4-32 Assiniboia Hall Edmonton, AB T6G 2E7, - CA
bvtucker@ualberta.ca
7804925952
Expertises: Signal Processing / Numerical Methods, Hearing Sciences, Speech Sciences

Jeremy TURPIN [1]
SIXENSE Inc.
1801 Robert Fulton Drive, , Suite 570, Reston, VA 20191, USA, , - US
jeremy.turpin@sixense-group.com
412 398 0976
Expertises: N/A

Dr Helen Ule [1]
Akoustik Engineering Limited
138 Angstrom Cres., Amherstburg, ON, N9V 3S3 - CA
helen@akoustik.ca
(519) 979-5050
Expertises: N/A

Jim Ulicki [1]
Xscala
234 - 5149 Country Hills Blvd., Suite 516 Calgary, AB T3A 5K8 - CA
rentals@xscala.com
403-274-7577
Expertises: N/A

Svein Vagle [1]
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
Expertises: N/A

Olivier Valentin, M.Sc., Ph.D. [2]
GAUS - Groupe d'Acoustique de l'Université de Sherbrooke
6435 Boulevard Rosemont, MONTREAL, QC, H1M 3B1, - CA
m.olivier.valentin@gmail.com
514-885-5515
Expertises: N/A

Mr. Peter VanDelden [4]
N/A
600 Southgate Drive , Guelph, ON , N1G 4P6 - CA
peter.vandelden@rwdi.com
519-823-1311
Expertises: N/A

Guilhem Viallet [1]
N/A
Ecole de technologie supérieure, département génie mécanique, 1100 rue Notre-Dame Ouest, Montreal, Québec, H3C 1K3 - CA
guilhem.viallet@etsmtl.ca
N/A
Expertises: N/A

Mercedes Eileen Villanueva [2]
Georgian College / University of Toronto
N/A - CA
me.villanueva@mail.utoronto.ca
N/A
Expertises: N/A

Prof. Jérémie Voix [1]
ÉTS, Université du Québec
1100 Notre-Dame Ouest Montréal (QC) H3C 1K3, - CA
voix@caa-aca.ca
+1 514 396-8437
Expertises: Engineering Acoustics / Noise Control, Signal Processing / Numerical Methods, Hearing Protection, auditory and speech perception, hearables

Tien-Dat (Danny) Vu [1]
N/A
1487, rue Bégin, Saint-Laurent, Québec, H4R 1V8 - CA
dat@vinacoustik.com
514-946-6299
Expertises: N/A

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

Lina Wang [1]
Stantec
200 - 325 25th Street SE , Calgary AB , T2A 7H8 - CA
lina.wang@stantec.com
N/A
Expertises: N/A

Graham Warner [1]
JASCO Applied Sciences
2396 Forbes St, Victoria BC V8R 4B6, - CA
graham.warner@jasco.com
250-483-3300
Expertises: N/A

Michael Wells [1]
N/A
, , P.O. Box 74056, RPO Beechwood, Ottawa, Ontario, K1M 2H9, - CA
michael@freefieldacoustics.com
N/A
Expertises: Architectural Acoustics, Engineering Acoustics / Noise Control, Shock and Vibration

Dr. Paul Wierzba [1]
N/A
300-805 8th Avenue SW Calgary, AB T2P 1H7 CA, - CA
paul.wierzba@stantec.com
N/A
Expertises: N/A

Mr Donald V Wilkinson [1]
Wilrep Ltd.
1515 Matheson Blvd. E., Unit
C-10Mississauga, ON, L4W 2P5 - CA
don@wilrep.com
905-625-8944
Expertises: N/A

Mr. William T. Wilkinson [1]
Wilrep Ltd.
1515 Matheson Blvd. E. Unit C10
Mississauga, ON L4W 2P5, - CA
wtw@wilrep.com
888-625-8944
Expertises: N/A

Mr. William T. Wilkinson [4]
Wilrep Ltd.
1515 Matheson Blvd. E. Unit C10
Mississauga, ON L4W 2P5, - CA
wtw@wilrep.com
888-625-8944
Expertises: N/A

Hugh Williamson [1]
Hugh Williamson Associates Inc.
Hugh Williamson Assoc. Inc., , PO Box 74056
RPO Beechwood, , Ottawa, ON K1M 2H9, -
CA
hugh@hwacoustics.ca
613 747 0983
Expertises: N/A

Dr Douglas James Wilson [1]
Imagenex Technology Corp.
3621 Evergreen Street Port Coquitlam, BC
V3B 4X2 - CA
dougww3@aol.com
604 468 9406
Expertises: N/A

Mr. Benjamin Wiseman [1]
GHD Ltd.
455 Phillip Street , Waterloo, Ontario , N2L
3X2 - CA
benlpwiseman@gmail.com
5193404121
Expertises: N/A

Bryce Jacob Wittrock [2]
University of Alberta Department of
Linguistics (Undergraduate Student)
10819 69 Avenue NW, , Edmonton Alberta, ,
T6H 2E3, - CA
wittrock@ualberta.ca
N/A
Expertises: N/A

Galen Wong [1]
N/A
1820 Haig Drive, Ottawa, ON, K1G 2J4 , - CA
galen.wong@gmail.com
N/A
Expertises: Architectural Acoustics,
Engineering Acoustics / Noise Control,
Musical Acoustics / Electro-acoustics

Mr Richard Wright [1]
SLR Consulting (Canada) Ltd.
#200, 708 - 11 Avenue SW, , Calgary, AB ; T2R
0E4, - CA
rwright@slrconsulting.com
403-385-1313
Expertises: industrial acoustics, noise control,
environmental noise, wind turbine noise,
noise identification, road traffic noise,
Regulations, Acoustic modelling

Jakub Wrobel [1]
N/A
O2E Inc., Environmental Consultants, 399
South Edgeware Road, Unit 5, St. Thomas,
ON, N5P 4B8, - CA
j.wrobel@o2e.ca
N/A
Expertises: N/A

Yihan Yanglou [1]
N/A
1510 - 908 Quayside Dr, , New Westminster
BC, , V3M 0L5, - CA
yanglou@ualberta.ca
7789392553
Expertises: N/A

Behrooz Yousefzadeh [1]
Concordia University
MIAE Department , 1455 de Maisonneauve
Blvd. West, EV4.139 , Montreal, QC, Canada ,
H3G 1M8 , - CA
behrooz.yousefzadeh@concordia.ca
N/A
Expertises: Architectural Acoustics, room
acoustics, vibration

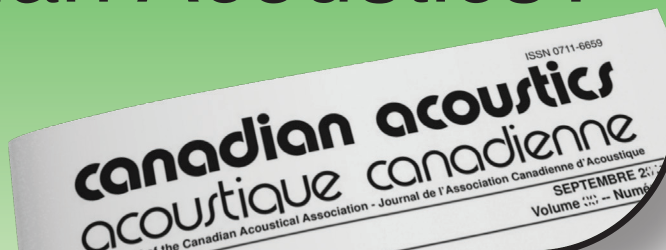
Pearlie Yung [1]
N/A
1296 Chee Chee Landing, Milton, ON L9E
1L1, - CA
pearlie_yung@yahoo.com
N/A
Expertises: Architectural Acoustics,
Engineering Acoustics / Noise Control,
Psychological / Physiological Acoustic

Jianhui Zhou [1]
University of Northern British Columbia
Wood Innovation and Design Centre, 499
George St., Prince George, V2L 1R6 - CA
jianhui.zhou@unbc.ca
2509606717
Expertises: Building Acoustics, vibration,
sound insulation

Michel Zielinski [1]
N/A
51427 Range Road 270, Spruce Grove, AB,
T7Y 1E9 - CA
sales@fabra-wall.com
780-987-4444
Expertises: N/A

Dejan Zivkovic [1]
Ontario Ministry of the Environment
2286 Glastonbury Rd., Burlington, ON, L7P
4C8 - CA
dejan.zivkovic@ontario.ca
N/A
Expertises: Engineering Acoustics / Noise
Control, Shock and Vibration, Physical
Acoustics / Ultrasound

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 $120.00 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 $120.00 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 $ 120.00
[ ] CAA Student Membership $ 50.00

Corporate Subscriptions (4 issues/yr)
[ ] $120 including mailing in Canada
[ ] $128 including mailing to USA,
[ ] $135 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, Canadian Acoustical:
Dr. Roberto Racca
c/o JASCO Applied Sciences
2305–4464 Markham Street
Victoria, BC V8Z 7X8 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 120.00$ pour les membres individuels, et de 50.00$ pour les étudiants. Tous les membres reçoivent ***l'Acoustique Canadienne***, la revue de l'association.

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 120.00$. Des compagnies et établissements préfèrent souvent la cotisation de membre bienfaiteur, de 475.00$ par année, pour assister financièrement l'ACA. La liste des membres bienfaiteurs est publiée dans chaque issue de la revue ***Acoustique Canadienne***..

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 120.00 $
[ ] Membre étudiant(e) 50.00 $

Abonnement institutionnel
[ ] 120 $ à l'intérieur du Canada
[ ] 128 $ vers les États-Unis
[ ] 135 $ 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 :
Dr. Roberto Racca
c/o JASCO Applied Sciences
2305–4464 Markham Street
Victoria, BC V8Z 7X8 Canada

Canadian Acoustical Association
Association canadienne d'acoustique

Board of Directors - Conseil d'administration

SUSTAINING SUBSCRIBERS - ABONNÉS DE SOUTIEN

The Canadian Acoustical Association gratefully acknowledges the financial assistance of the Sustaining Subscribers listed below. Their annual donations (of $475 or more) enable the journal to be distributed to all at a reasonable cost.
L'Association Canadienne d'Acoustique tient à témoigner sa reconnaissance à l'égard de ses Abonnés de Soutien en publiant ci-dessous leur nom et leur adresse. En amortissants les coûts de publication et de distribution, les dons annuels (de 475$ et plus) rendent le journal accessible à tous les membres.

Acoustec Inc.
Jean-Philippe Migneron - 418-496-6600
info@acoustec.qc.ca
acoustec.qc.ca

Acoustex Specialty Products
Mr. Brian Obratoski - 2893895564
Brian@acoustex.ca
www.acoustex.net

AcoustiGuard-Wilrep Ltd.
Mr. William T. Wilkinson - 888-625-8944
wtw@wilrep.com
acoustiguard.com

AECOM
Alan Oldfield - 9057127058
alan.oldfield@aecom.com
aecom.com

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

HGC Engineering Ltd.
Bill Gastmeier -
bill@gastmeier.ca
hgcengineering.com

Hottinger Bruel & Kjaer inc.
Andrew Khoury - 514-695-8225
andrew.khoury@hbkworld.com
bksv.com

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

JAD Contracting Ltd
Jake Ezerzer - 1-855-523-2668 toll free
info@jadcontracting.ca
jadcontracting.ca

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

JASCO Applied Sciences (Canada) Ltd.
Roberto Racca - +1.250.483.3300 ext.2001
roberto.racca@jasco.com
www.jasco.com

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

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

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

Scantek Inc.
President, Scantek, Inc. - 1-410-290-7726
steve.scantek@gmail.com
scantekinc.com

Soft dB Inc.
Dr. Roderick Mackenzie - 5148056734
r.mackenzie@softdb.com
softdb.com

Xprt Integration
Mr. Rob W Sunderland - 604-985-9778
rob@xprt.ca