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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, on vous invite à compléter le formulaire d'adhésion et l'envoyer avec votre chèque ou mandat au secrétaire de l'association (voir adresse ci-dessus). - Canadian Acoustical Association/Association Canadienne d'Acoustique P.B. 74068 Ottawa, Ontario K1M 2H9 Canada - - - secretary@caa-aca.ca - Dr. Roberto Racca

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Éditorial
Editor's note

Appel à l'action...

Ce numéro de décembre nous permet de réaliser les nombreux accomplissements des 12 derniers mois à l'Association canadienne d'acoustique, et ceux-ci sont résumés en page 57 dans le compte-rendu de l'assemblée générale des membres rédigé par notre secrétaire exécutif, Roberto Racca. C'est également le moment de souhaiter la bienvenue à notre rédacteur adjoint, Umberto Berardi et de reconnaître le formidable travail accompli par notre comité éditorial, présenté en page 47. Les normes scientifiques élevées maintenues par la revue Acoustique canadienne doivent beaucoup au dévouement constant des réviseurs de la revue, qui donnent généreusement de leur temps et de leur expertise. C'est un plaisir de rendre hommage à cette contribution en reconnaissant ceux, listés à la page 49, qui ont participé au processus d’examen en 2015.

Suite au succès remporté par le premier numéro portant sur des sujets régionaux de la grande région de Montréal, ce sera donc la grande région de Toronto qui sera l'objet du numéro de juin 2016, tel que détaillé dans l'appel à soumissions en page 52. Assurez-vous d'y contribuer, si vous êtes concernés, car ces numéros devraient rapidement devenir le « Who's Who » en acoustique au sein des principales villes canadiennes.

Inscrivez également dans vos agendas la prochaine Semaine canadienne d'acoustique (AWC16), qui aura lieu du 22 au 24 septembre

Call for action...

This December issue gives us an opportunity to recognize the many accomplishments that took place over the past 12 months for the Canadian Acoustical Association, and that you will see highlighted in the report from the AGM prepared by our Executive Secretary, Dr. Roberto Racca and presented on page 57. It is also now time to welcome our new Deputy Editor, Prof. Umberto Berardi and to acknoledge the great work of our editorial board, presented on page 47. The high scientific standards maintained by Canadian Acoustics in its papers owe much to the continuing dedication of the journal's reviewers, who give freely of their time and expertise. It is a pleasure to pay tribute to this contribution by recognizing those who have participated in the review process in 2015, as listed on page 49.

After the success of the special issues in June 2015 with regional content from the greater Montreal area, it is the greater Toronto area that will be covered, as detailed in the call for paper on page 51. Make sure to contribute, if you are elligible, as these issues will become nothing less than a veritable “Who's who” in acoustics among Canada's major cities.

Also mark your calendar for the upcoming Acoustics Week in Canada (AWC16) to be chaired by long-time CAA members Prof. Kathy Pichora-Fuller and Dr. Marshall Chasin. It will take place September 22-24, 2016, in Vancouver (BC), right after the World Congress of Audiology

2016 à Vancouver (BC), juste après le World Congress on Audiology (WCA2016), permettant ainsi une occasion unique d'échanges inter-disciplinaires sur l'audition et l'acoustique. Deux belles conférences en une semaine, avec une journée commune pour des sessions conjointes!

Avant de commencer la lecture de ce numéro, avec 5 substantiels articles, veuillez vérifier que vos coordonnées, listées dans l'annuaire des membres, à partir de la page 69, soient bien à jour. Ainsi que vous le réalisez, nous sommes une association de bénévoles et nous comptons maintenant beaucoup sur nos membres pour visiter notre site web à http://jcaa.caa-aca.ca, certainement pour y lire leur journal sous forme électronique ou y consulter chacun des articles paru durant les 41 dernières années, mais aussi pour maintenir leurs coordonnées à jour!;-)

Sur cet appel à l'action, je vous souhaite à tous un très joyeux temps des fêtes.

Jérémie Voix
Rédacteur-en-chef

(WCA2016), enabling a very special opportunity for inter-disciplinary dialogue about hearing and acoustics. Two great conferences in one week with a day of overlap for joint sessions!

Before you start reading this issue, with its 5 fine and substantial articles, please make sure that your contact information is up-to-date; please check the membership directory starting on page 69. As you know, we are a volunteer-based association and we now count on our members to visit the journal’s website, at http://jcaa.caa-aca.ca to read their electronic journal issues (or access one of any articles published over the last 41 years), but also to maintain their contact information up-to-date! ;-)

On this call for action, I wish you all season's greetings and happy holidays.

Jérémie Voix
Editor

PRELIMINARY ASSESSMENT OF THE ACOUSTICS OF THE GUAÍRA THEATER IN CURITIBA, STATE OF PARANÁ, BRAZIL

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Résumé

Cet article présente une évaluation préliminaire de l'acoustique du Théâtre Guaira. Ce dernier est l'un des théâtres les plus importants du Brésil, dont l'espace est conçu pour les présentations de concerts symphoniques, des opéras, des ballets et des pièces de théâtre. L'acoustique de la salle principale du Théâtre Guaira a été évaluée sur la base des temps de réverbération calculées pour les conditions suivantes: 1) 1/3 de la capacité des sièges occupés, 2) 2/3 de la capacité des sièges occupés, et 3) tous les sièges occupés. En plus de ces calculs, les temps de réverbération ont également été mesurés en suivant les directives de la norme internationale ISO 3382-1: 2009.

Mots clefs: Guaíra Theater, le temps de réverbération, des mesures de temps de réverbération, l'acoustique des salles

Abstract

This paper presents a preliminary assessment of the acoustics of the Guaíra Theater. This is one of Brazil's most important theaters, whose space is designed for presentations of symphony concerts, operas, ballets and plays. The acoustics of the main auditorium of the Guaíra Theater was evaluated based on reverberation times calculated for the following conditions: 1) 1/3 of seat occupancy, 2) 2/3 of seat occupancy, and 3) full seat occupancy. In addition to these calculations, reverberation times were also measured following the guidelines of the ISO 3382-1: 2009 standard.

Keywords: Guaíra Theater, reverberation time, measurements of reverberation time, room acoustics

1 Introduction

The history of the Guaíra Theatre, located in the city of Curitiba, capital of Paraná, Brazil, began in the 19th century. However, although the theater – at that time called São Teodoro Theatre – was slated to open in September 1884, its inauguration was canceled due to political unrest in Brazil [1, 2]. A curious fact is that the facilities of this theater were used as a political prison at that time. After undergoing renovations, the theater was finally opened to the public in 1900, but then demolished in 1937 for safety reasons [1, 2].

The current Guaíra Theater complex comprises three auditoriums: 1) Bento Munhoz da Rocha Netto Auditorium, which is the largest of the three and is nicknamed "Guairão," with seating capacity for 2173 people; 2) Salvador de Ferrante Auditorium, with seating capacity for 504 people; and 3) Glauco Flores de Sá Brito Auditorium, with seating capacity for 104 people.

Work on Guairão Auditorium, the most popular of the three auditoriums, started in 1954 and its inauguration took place in 1974 (Figure 1).

Its 2173 seats are distributed as follows: 1) Orchestra – 1,156 seats, 2) Mezzanine – 539 seats, and 3) Balcony – 478 seats. The design of this auditorium, along with the calculations of reverberation time, were completed in 1955, and are the work of Engineer Rubens Meister [3]. Guaíra Theater is one of the largest and most important theaters in Brazil. However, little is known about its acoustics.

This paper presents calculations of reverberation times by the designer of the Guaíra Theater – "Guairão" Auditorium (Figure 2), Engineer Rubens Meister [3], as well as the reverberation times calculated by the authors of this article, using Sabine's reverberation formula [4]. In addition to the calculations, the reverberation time, RT, was measured according to ISO 3382:1-2009 – Acoustics – Measurement of room acoustic parameters. Part 1: Performance spaces [5] while the theater was unoccupied.

Figure 1: Inaugural poster of the activities of the Guaíra Theater.

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*paulo.zannin@gmail.com

Figure 2: Front façade of the Guaíra Theater (main entrance).

2 Method

Reverberation times can be determined from mathematical formulas and measurements using appropriate instrumentation [4, 5]. The reverberation time can be calculated by the well-known Sabine Formula [4], since the average ambient sound absorption coefficient is less than 0.3. This is the case of the theater considered here. Therefore, the Sabine formula was used for the calculations presented in the next section using absorption coefficients (α) listed in Table 1.

$$RT = \frac{0.163.V}{A + 4mV} \text{[s]} \qquad [1]$$

where:

V is the volume of the room under analysis [m^3],

A is the equivalent sound absorption, $A = \sum_{i=1}^{n} \alpha_i \cdot S_i$,

where S_i is the area of the materials that make up the room,

and α_i is the sound absorption coefficient of these materials,

$4mV$ corresponds to air sound absorption, expressed in [m^2], and m is the energy attenuation coefficient of air, expressed in [10^{-3} m^{-1}].

According to ISO 3382-1:2009 [5], reverberation time can be measured by the interrupted noise method and the integrated impulse response method. These two methods were employed in this study.

Measurement of the RT by the interrupted noise method consisted of exciting the room with a pseudo-random pink noise and calculating the RT from the room's response to this excitation [5].

The measurements were taken using the following devices: 1) B&K 4296 dodecahedron loudspeaker; 2) B&K 2716 audio power amplifier; 3) B&K 2260 real-time sound analyzer; 4) Brüel & Kjaer Qualifier Type 7830 room acoustics software.

Table 1: Summary of the absorption coefficients of the materials used by Meister to calculate the RT of Guaíra Theater [3].

Materials	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Gypsum [6]	0.016	0.032	0.039	0.050	0.030	0.028
Plaster on masonry walls [3]	0.02	0.02	0.02	0.02	0.03	0.06
Perforated gypsum panels [3]	0.04	0.06	0.08	0.10	0.06	0.06
Wood paneling [3]	0.020	0.02	0.02	0.02	0.02	0.02
Varnished wood [6]	0.05	0.03	0.03	0.035	0.03	0.02
Eucatex hardboard [6]	0.05	0.03	0.03	0.035	0.03	0.02
Wood (flooring) [6]	0.15	0.10	0.10	0.10	0.10	0.10
Carpeting [6]	0.10	0.15	0.25	0.35	0.40	0.45
Seats [6]	0.30	0.30	0.30	0.30	0.30	0.30
Air conditioning grills [6]	0.30	0.40	0.50	0.55	0.50	0.33
Curtains and drapes [6]	0.08	0.29	0.44	0.50	0.40	0.35
Glass [6]	0.03	0.03	0.03	0.02	0.02	0.01

RT measured by the integrated impulse response method is similar to the previous method, but the room's response is given by an integrated impulse response. As in the previous measurement, the room is excited with a sound signal, but in this case a sine sweep signal. The difference lies in the way this signal is captured, transformed into an impulse, and the RT extrapolated from the decay of this impulse [5]. This mode of measuring is less biased by background noise than the previous one [4, 7]. Dirac 3.1 software was used to take this measurement and process the data [7]. The equipment consisted of: 1) a omnidirectional source, 2) a sound amplifier, 3) audio interface, 4) a sound level meter (receives the room's response), and 5) a portable computer with Dirac 3.1 software. Changes were made in the wavelength, number of repetitions and intensity of the signal in order to obtain a more accurate measurement of the RT. This precision is observed by means of the signal-to-noise ratio, which, according to the ISO 3382-1 standard [5], should be higher than 35 dB to calculate T20 and higher than 45 dB to calculate T30. If these signal-to-noise ratios are not reached, parameters T20 and T30 are considered inaccurate [5]. In the present study, it was assured a signal-to-noise ratio higher than 45 dB in all measurements.

The measurements presented here are part of a preliminary study of the acoustics of the Guaíra Theater.

The RT was measured by the interrupted noise method (ISO 3382-1) at the seven points indicated in Figure 3, and the results are described in Table 5. Sound source positions were used for the measurements by the integrated impulse response (ISO 3382-1) and the results of those measurements are given in Table 5. These measurements were taken at 11 points (see Figure 4). Figure 4 shows the interior of the Guaíra Theater.

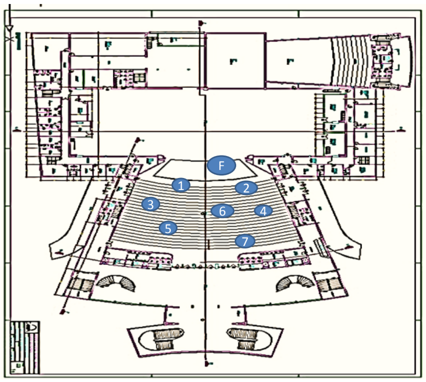

Figure 3: Measuring points at the audience seats and position of the dodecahedron loudspeaker: F = Source.

Figure 4: View of audience seats, orchestra pit and stage – Guaíra Theater. F1 = Sound source position 1; F2 = Sound source position 2.

3. Results and Discussion

Tables 2, 3 and 4 list the reverberation times, RT, of the main auditorium of the Guaíra Theater, Guairão, with 1/3 of seat occupancy, 2) 2/3 of seat occupancy, and 3) full seat occupancy, respectively, determined by the authors of this study and by the original designer of the theater, Engineer Rubens Meister [3].

Table 2: Calculated reverberation time (RT) of the theater with 1/3 of seat occupancy

Frequency [Hz]	Calculated in this study RT (s)	Calculated in 1955 by Rubens Meister [3] RT (s)
125	2.08	2.26
250	2.46	2.07
500	2.08	1.87
1000	1.95	1.78
2000	1.89	1.93
4000	1.84	1.87
Average RT	**2.05**	**1.96**

Table 3: Calculated reverberation time (RT) of the theater with 2/3 of seat occupancy.

Frequency [Hz]	Calculated in this study RT (s)	Calculated in 1955 by Rubens Meister RT (s) [3]
125	1.73	2.22
250	2.35	1.96
500	1.93	1.72
1000	1.79	1.63
2000	1.74	1.75
4000	1.71	1.71
Average RT	**1.87**	**1.83**

Table 4: Calculated reverberation time (RT) of the theater with full seat occupancy

Frequency [Hz]	Calculated in this study RT (s)	Calculated in 1955 by Rubens Meister [3] RT (s)
125	1.48	2.18
250	2.25	1.90
500	1.79	1.59
1000	1.66	1.50
2000	1.61	1.60
4000	1.59	1.57
Average RT	**1.73**	**1.72**

Despite the reforms that took place during the years, the original RT value calculated by Meister was kept, as shown in Tables 2, 3 and 4. This fact is explained by the RT calculations made in the present work, which are very similar to the original ones of the Guaíra Theater project.

Table 5 shows the results of the RT calculated in this work and the RT measured by the interrupted noise and integrated impulse response methods, according to ISO 3382-1, considering the fully unoccupied theater (no seat occupied).

The calculated RT values listed in Table 5 are based on the sound absorption coefficients used in the original design of the theater and considering unoccupied seats [3].

The original design of the theater indicated a sound absorption coefficient of α = 0.3 (broadband) for unoccupied seats; this coefficient was used for the unoccupied RT evaluation described herein [3].

Table 5: Calculated and measured reverberation time (RT) considering the unoccupied theater.

Frequency [Hz]	**RT calculated in this study RT [s]**	**RT measured by the Interrupted Noise Method RT [s]**	**RT measured by the Integrated Impulse Response Method RT [s]**
125	2.60	2.50	1.84
250	2.60	1.72	1.57
500	2.26	1.47	1.50
1000	2.14	1.37	1.45
2000	2.06	1.32	1.38
4000	2.00	1.26	1.25
Average RT [s]	**2.27**	**1.56**	**1.50**

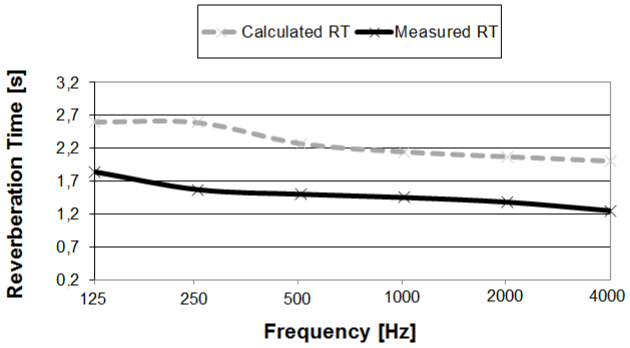

Figure 5: Comparison of measured RT per integrate impulse response method and calculated RT.

On the other hand, in his highly relevant book Concert Halls and Opera Houses, page 640, Appendix 3, Leo Beranek [8] lists the following values for the sound absorption coefficient for unoccupied seats – medium and heavily upholstered seats, see Table 6.

Table 6: Absorption coefficients for unoccupied seats, according to Beranek [8]

Frequency [Hz]	Sound absorption coefficient (α) for unoccupied seats medium-upholstered seats [8]	Sound absorption coefficient (α) for unoccupied seats heavily upholstered seats [8]
125	0.54	0.70
250	0.62	0.76
500	0.68	0.81
1000	0.70	0.84
2000	0.68	0.84
4000	0.66	0.81

Considering these absorption coefficients [8], for medium-upholstered and heavily-upholstered unoccupied seats, Figure 6 and Figure 7 compares the calculated RT values against the RT values measured by the integrated impulse response method.

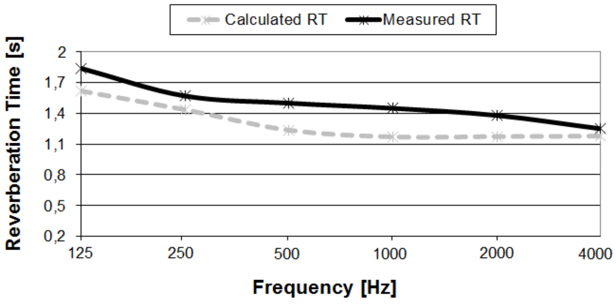

Figure 6: Comparison of measured RT as per integrated impulse response and calculated RT, considering the unoccupied theater with medium-upholstered seats [8].

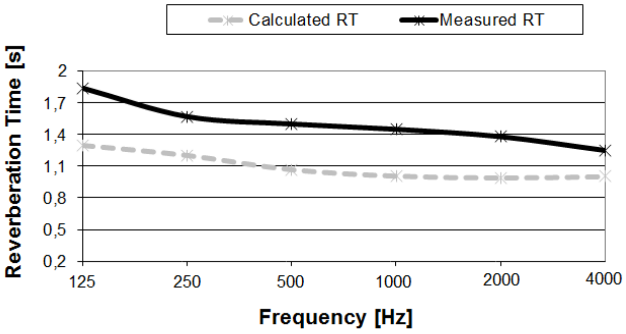

Figure 7: Comparison of measured RT as per integrated impulse response and calculated RT, considering the unoccupied theater with heavily-upholstered seats [8].

The seats in this theater today are practically the same as the original ones, except for minor renovations. In order to determine the correct sound absorption coefficient for these seats, their sound absorption coefficient should be measured in a reverberation chamber.

The Guaíra Theater is an important Brazilian cultural center designed for presentations of symphony concerts, operas, ballets and plays, i.e., for multiple purposes. Its dimensions of 13760 m^3 and its 2173 seats are comparable to those of other concert halls and opera halls around the world. To exemplify, we can cite the following concert and opera halls:

Table 7: Concert Halls and Opera Halls [4]

Place	Volume [m^3]	Seats	RT [s] (full occupancy)
Metropolitan Opera House in New York [4]	30500	3800	1.8
Colon Theatre in Buenos Aires [4]	20550	2500	1.7
War Memorial Opera House in San Francisco [4]	20900	2070	1.6
Neues Festspielhaus in Salzburg [4]	14000	2160	1.4
Opera de la Bastille in Paris [4]	21000	2700	1.5
Symphony Hall in Boston [4]	18800	2630	1.8
Concertgebouw in Amsterdam [4]	18800	2210	2.0
Barbican Concert Hall in London [4]	17750	2030	1.7
Liederhalle in Stuttgart [4]	1600	2000	1.7

4 Conclusions

The present work is a tribute to Professor Rubens Meister, who made the necessary acoustical calculations for the design and construction of this great theater. The measured RT values show that Guaíra Theater has a high acoustic performance, being suitable for theater plays, speech and opera. Very different types of artistic presentations take place in the Guairão Auditorium, such as ballets, symphony concerts, operas, chamber music and semi-classical concerts, choral groups, plays and bands using sound system. Therefore, the Guaíra Theatre is a place for general purpose activities which demands compromise among the acoustic parameters values and the type of activity, i.e., a space for speech and a space for music [9].

Acknowledgments

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Résumé

Ce travail se concentre sur la recherche d'une solution numérique pour les études acoustiques du véhicule et l'amélioration de l'utilité des paramètres numériques "expérimentaux" pour la phase de développement d'un nouveau projet automobile. Plus précisément, cette recherche porte sur l'importance de la cavité d'amortissement modal pour véhicule exerce pendant les études numériques. Cette recherche vise alors à suggérer les valeurs de paramètres normalisés de la cavité d'amortissement modal dans les études acoustiques des véhicules.

Cette valeur normalisée de modal cavité d'amortissement est d'une grande importance pour l'étude de l'acoustique des véhicules dans l'industrie automobile, car elle permettrait à l'industrie de commencer des études de la performance acoustique d'un véhicule neuf au début de la phase de conception avec une estimation fiable qui serait proche de la valeur finale mesurée dans la phase de conception. Il est commun pour l'industrie automobile à atteindre de bons niveaux de corrélation numérique-expérimentale dans les études acoustiques après la phase de prototypage parce que cette phase peut être étudiée par les commentaires de la simulation et les paramètres modaux expérimentaux.

Ainsi, cette recherche suggère des valeurs de cavité amortissement modal, qui sont divisés en deux parties en raison de leur comportement: celui qui va jusqu'à 100 Hz, et un autre au-dessus de cette valeur.

La séquence de cette étude montre comment nous sommes arrivés à ces valeurs.

Mots clefs : Méthode des éléments finis. Contrôle acoustique. véhicule entier. Corrélation expérimentale numérique. Amortissement modal.

Abstract

This work focuses on finding a numerical solution for vehicle acoustic studies and improving the usefulness of the “Numerical experimental” parameters for the development stage of a new automotive project. Specifically, this research addresses the importance of cavity modal damping for vehicle exerts during numerical studies. This research then seeks to suggest standardized parameter values of modal cavity damping in vehicular acoustic studies.

This standardized value of modal damping cavity is of great importance for the study of vehicular acoustics in the automotive industry because it would allow the industry to begin studies of the acoustic performance of a new vehicle early in the conception phase with a reliable estimation that would be close to the final value measured in the design phase. It is common for the automotive industry to achieve good levels of numerical-experimental correlation in acoustic studies after the prototyping phase because this phase can be studied with feedback from the simulation and experimental modal parameters.

Thus, this research suggests values for cavity modal damping, which are divided into two parts due to their behavior: one that goes up to 100Hz, and another above this value.

The sequence of this study shows how we arrived at these values.

Keywords: Finite Element Methods. Acoustic Control. Trimmed body. Numerical Experimental Correlation. Modal Damping.

1 Introduction

This study has been motivated by the conflict during the final stages of the development of a vehicle, as well as by the comparison between the results generated by the simulation team with those acquired from the experimental team.

For an appropriate correlation, it is always necessary to acquire cavity modal damping data originated from prototypes and subsequently assign them to the numerical model. In this manner, the phase of refinement of the numerical results requires a prototype, and this slows the progress of work and research.

With respect to the simulation methods used today, the finite element method (FEM), as described by Braess et al [1] proposes a quite different situation. Ever-increasing demands for greater comfort have elevated the dynamic design criteria as the primary elements of modern body engineering.

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Damping and sound-insulation measures are strictly applied to automotive body panels to prevent noise in the vehicle cabin [2]. Automotive body panels, which are made of steel sheets press-molded into a required form, are laminated with damping materials to reduce the vibration level. Furthermore, porous media, resin sheets (surface) and carpet are laminated and used to work as damping materials [3,4].

For this study 2 (two) different categories of vehicles were investigated: a pick-up truck and a popular compact vehicle. Hence, the study is expected to determine a range of values that cover the cavity damping behavior by analyzing these vehicles in the Trimmed-Body configuration [5].

Acoustic FEM analysis of the system was performed using standard MSC Nastran 2010 software. Following the FEM analysis, a modal analysis of the entire vehicle and cavity was performed; the data were treated as described by Moura et al. [6], in CRF VEIPROD 5.0® software for the evaluation of the SPL (Sound Pressure level).

With respect to the experimental data campaign, the bodyshell (TBIW) testing was performed in a laboratory at NVH in a semi-anechoic room, exploiting LMS Test Lab 11B [7].

Finally, this research work seeks to accomplish the following:

A) Determine the influence of this observed cavity modal damping variation in the physical testing on the simulation models, seeking to better identify the existence of the resonance modes between the cavity and the body-shell.

B) Propose a medium cavity modal damping (Cavity Damping Design) that can be used even in the early stages of vehicle development and provide results similar to those generated using the actual variable damping.

Figure 1 shows a schematic flowchart of the ideas presented previously.

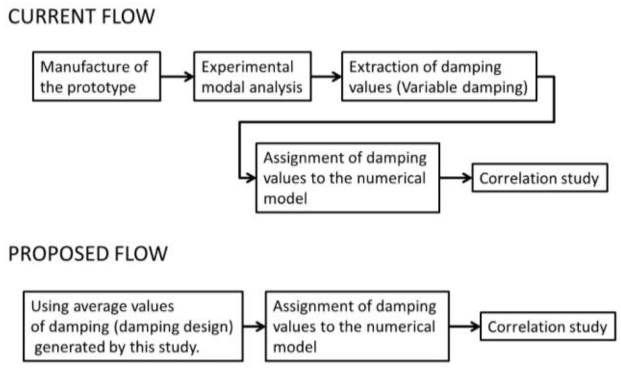

Figure 1: Flowchart of job steps (current and proposed).

2 Experimental methodology

As part of the validation process of the numerical experiment, the first step adopted in this study was to perform experimental modal analysis of the cavity, in which one expects a correlation regarding the global modes and to determine how the damping behavior of these cavities would vary in frequency when comparing various types of vehicles [8].

Consequently, all vehicles (two from different categories) underwent the same instrumentation as shown in figures 2 and 3. The experimental results were obtained by processing the data using LMS Test Lab 11B software. Table 1 shows the list of equipment used for the experimental measurements.

Table 1 : - List of Equipment

Equipment's	Sensitivity / Details
ASQ (Acoustic Source quantification)	41.15 mV/m³/s²
Microphone	50 mV/Pa
LMS Test Lab	Scadas Mobile - Modulo spectral Testing

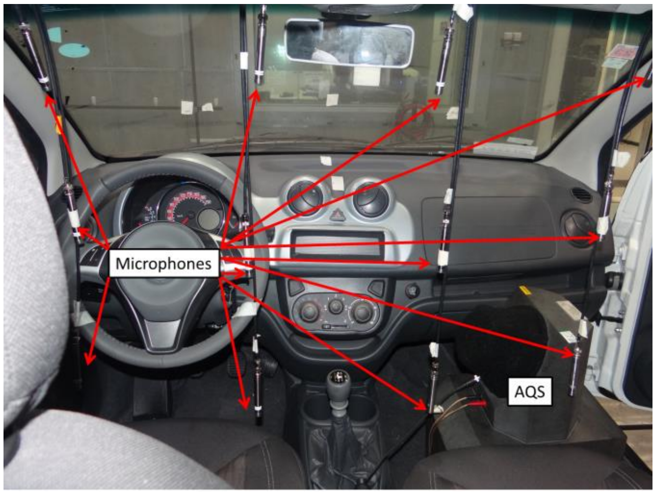

Figure 2: Instrumentation for cavity modal analysis.

The vehicle (TBIW) is placed in an acoustic camera (isolated) with the glass windows closed; a random noise source is placed inside the front and rear of the vehicle for reciprocal testing, and the vehicle has a cavity internally divided in planes defined by microphone chains. The excitation measured by the microphones (SPL) defines the modal behavior of the cavity of the vehicle.

Placement of accelerometers is presented in figure 3.

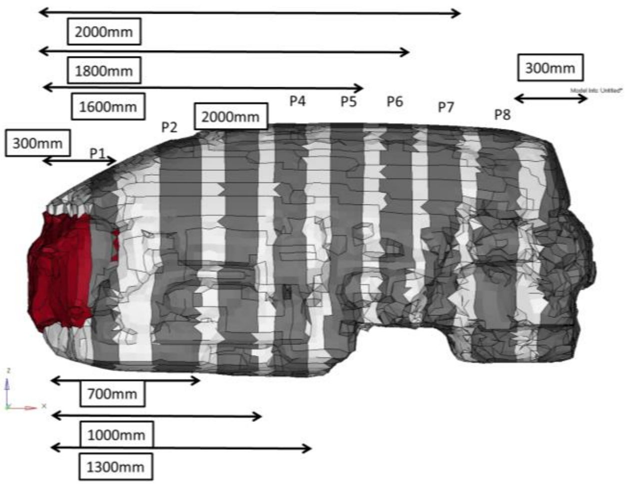

Figure 3: Measurement Planes - modal cavity.

Planes P2 and P7 were chosen to represent the performance of the instrumentation process of the vehicle. This example is shown in Figure 4.

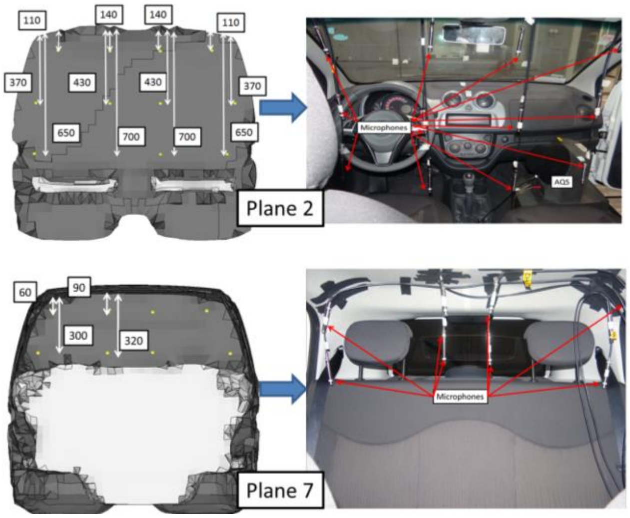

Figure 4: Measurement Plans definition.

For the initial assessment of the vehicle cavity modal behavior in the early stages of its development, the frequency response functions, known as "SPL", are analyzed at the various points of the microphone positions in the Trimmed-Body configuration. The FRF "SPL" provides the ratio of (P/F), where "P" is the pressure [dB] and the "F" is the force [N] of an excitation point on the structure. The vehicle model is evaluated with the response measured at the points indicated in planes showed at figure 3.

In Figure 5, an example of the results of the experimental cavity model analysis is shown; all vehicles were subjected to the same test.

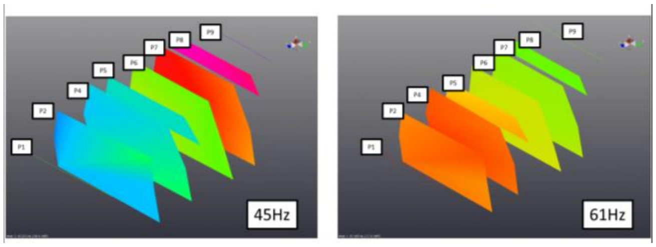

Figure 5: Experimental cavity modal analysis of the studied vehicles.

After plane-by-plane measurements were made, the results were compiled and processed by the LMS-PolyMax (Modulo spectral Testing) method. Figure 6 shows this processing; the left hand side is presented in addition to the overall mode of the cavity, the main modal frequencies of the cavity and its damping. The middle line of this measurement is highlighted at the center of the figure.

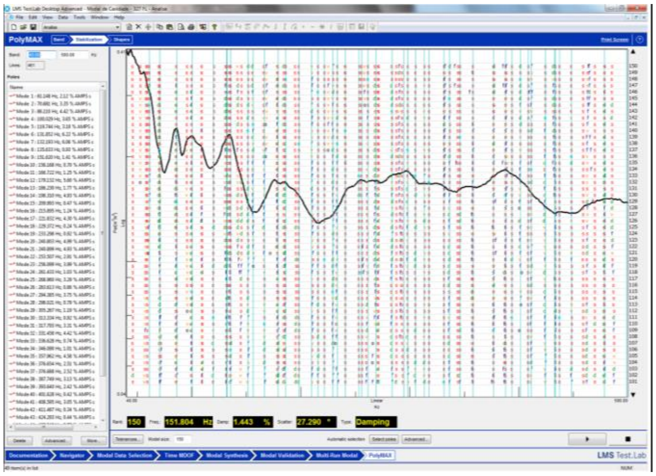

Figure 6: Cavity modal analysis processed by the LMS-PolyMax method.

Figure 7 presents the results of cavity modal analysis. When the measurements were complete, it was possible to extract the modal behavior (Cavity Damping factor) of all vehicles (the two different categories of vehicles) and analyze the results to obtain the value of each modal damping [5,10] of the cavity along the frequency (actual variable damping). This response is presented in figure 7; the damping factor was extracted from a frequency (Hz) sweep.

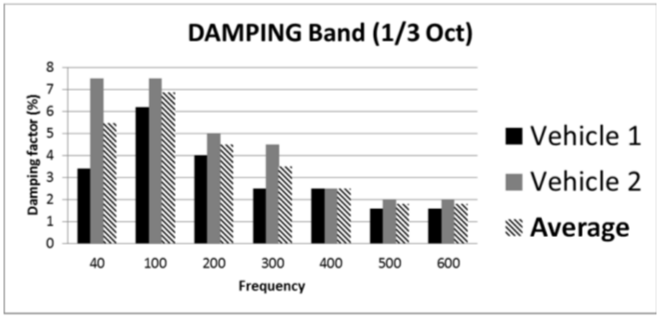

Figure 7: Damping factor response in frequency for different vehicles.

The half-power method was used to find the damping value. Half-power bandwidth is defined as the ratio of the frequency range between the two half power points to the natural frequency at this mode. Thus, although the analysis presented in figure 7 covers the frequency range of 0-500 Hz, the results of the damping factor (%) appear only starting at the 1/3 octave band of 40 Hz where the first natural modes of the cavity begins.

Next, the modal test vehicles were characterized to determine the dynamic “SPL” type. This test is performed with microphones positioned at the height of the right ear of the driver that collected the data as acoustic pressure was generated.

Figures 8 and 9 illustrate the excitation points used by the team during the experimental tests. The impact generated by the impact hammer occurred directly adjacent to the accelerometer presented in this figure.

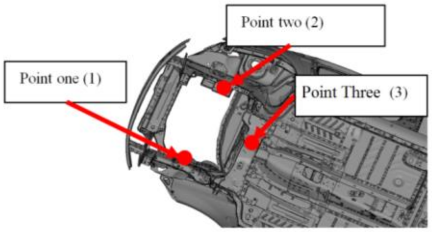

Figure 8 : Layout of experimental test, under view (point 1,2 e 3).

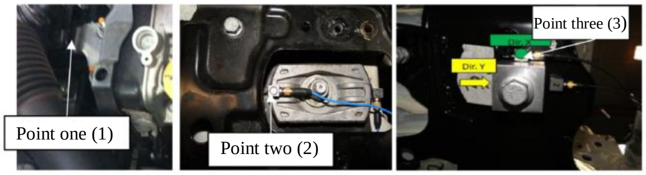

Figure 9 : Layout of experimental test, engine mount (point 1, 2 and 3).

After defining the excitation points, the measured acoustic point detailed above is presented in figure 10 in a Standard Fiat (2004). The figure presents the fixation point of the microphone at the height of the driver's right ear (left side of figure) and details the microphone positioning (right side of figure).

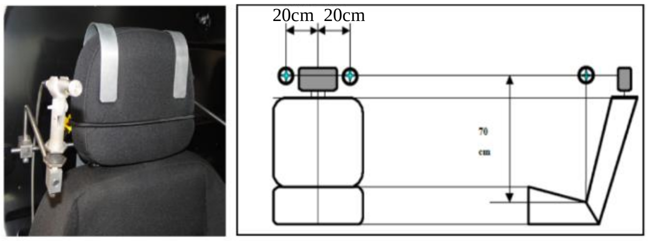

Figure 10 : Experimental configuration of the microphone position (the point of measurement).

With respect to the experimental data campaign, full vehicle testing was performed in a laboratory at NVH in a semi-anechoic room, using LMS Test Lab 11B software. Table 2 shows the list of equipment used for the experimental measurements.

Table 2 : List of equipment

Equipment’s	Sensitivity / Details
Impact Hammer	2 mV/N
Microphone	50 mV/Pa
LMS Test Lab	Scadas Mobile - Modulo Impact Testing

The following results allow a comparison with numerical results; therefore, the frequency range used in this study is 0-500 Hz. The new frequency range was selected to concentrate on the influence of damping and avoid any influences caused by numerical errors in high frequency [11].

The results of the “SPL” of the settings shown previously are displayed in Figures 11 (Pickup) and 12 (popular compact vehicle). All of the results bellow were collected at the point illustrated in Figure 9 and are on a logarithmic scale.

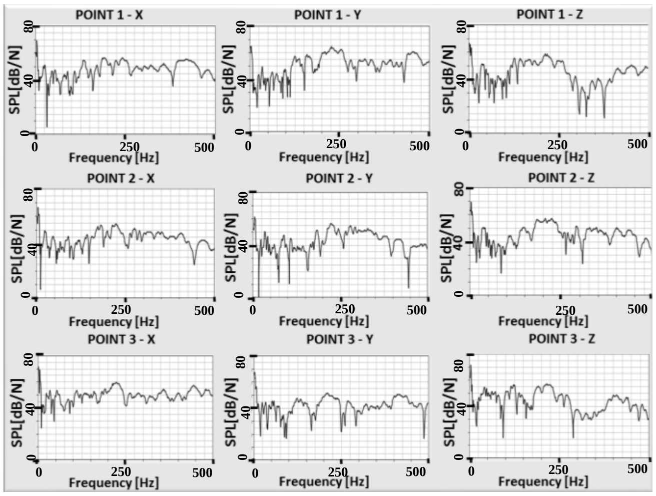

Figure 11: Pickup model; SPL experimental response of the attachment point of the engine. (The ordinate grid step is LOG scale.)

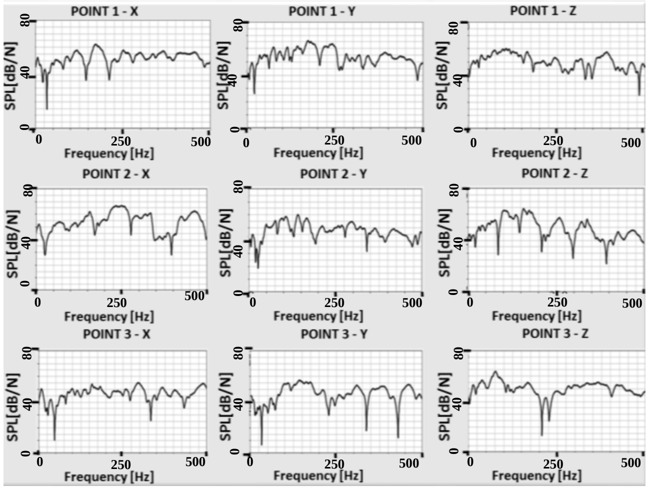

Figure 12: Popular compact vehicle model; SPL experimental response of the attachment point of the engine. (The ordinate grid step is LOG scale.)

3 Numerical formulation

This section describes the details of the FEM models of each vehicle. In addition to the modal behavior of the structure, it is also important to consider the residual vectors to compensate for the higher-order frequencies that are not directly extracted. The mesh size was tuned for the weaker part to have 8 elements for each wavelength at 500 Hz.
Table 3 describes the characteristics that make up each virtual model [12].

Table 3 - Virtual model characteristics.

FE structure – Vehicle 1	FE structure – Vehicle 2
Mass: 352 Kg	Mass: 251 Kg
WELD:5234	WELD:4336
RIGID:622	RIGID:172
RBE3:169	RBE3:0
SPRING:1	SPRING:0
Shell 3 nodes: 15349	Shell 3 nodes: 19122
Shell 4 nodes: 497450	Shell 4 nodes: 593584
Solid 6 nodes: 114	Solid 6 nodes: 120
Solid 8 nodes: 6545	Solid 8 nodes: 7079
Total elements: 536767	Total elements: 633389
Total nodes: 560135	Total nodes: 657227

The numerical models were implemented with damping data according to the experimental results to determine how the damping behavior of these structures would be effected by the frequency response of the various types of vehicles. Additionally, for this numerical study, we used the same two different categories of vehicles: a pick-up truck and a compact vehicle.
For this research, all vehicles were subjected to the same procedure in which HyperMesh 11.0 was used for all computational pre-processing, and NASTRAN software was used for the processing. Figure 13 illustrates the numerical models of vehicles in the Body-in-White configuration.

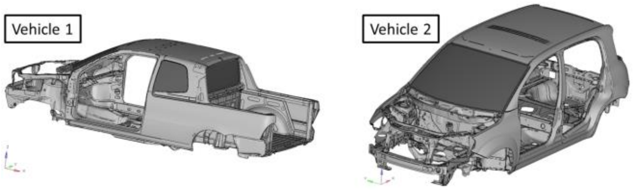

Figure 13: Numerical models in Body White version.

4 Numerical and experimental correlation

The responses of the numerical models were loaded with their respective cavity modal damping (actual variable damping, experimentally extracted from their respective prototype) presented in figure 7 and then generated using the SPL acoustic curves. These curves, Experimental (continuous line) x Numerical (dashed line), were extracted and compared and are shown in Figures 14 and 15. All results are on a logarithmic scale.

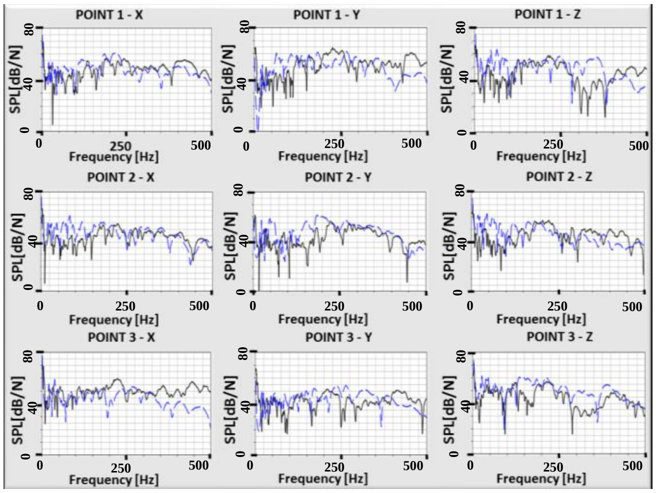

Figure 14: Pick-up model; Numerical and experimental SPL confrontation of the engine mount. (The ordinate grid step is LOG from 0.1.)

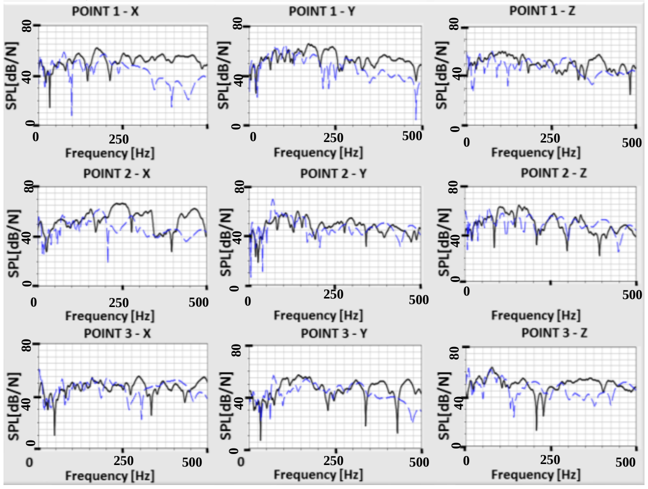

Figure 15: Popular compact vehicle model; Numerical and experimental SPL confrontation of the engine mount. (The ordinate grid step is LOG from 0.1.)

4.1 Data analysis

Based on the previous results, it is noticeable how the numerical results compare to the experimental results. Next, the challenge that faces NVH engineering simulation is to obtain a standard value of cavity modal damping for the TBIW vehicle model to present the same level of correlation when used with the actual experimentally measured cavity damping values.

Thus, based on the values in figure 7, a study was conducted to understand the variation of the average damping of these vehicles and the individual difference among them.
This result is shown in figure 16.

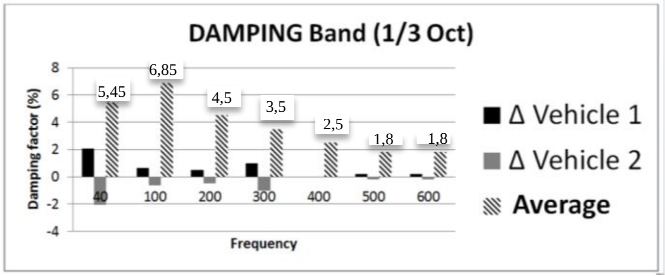

Figure 16: Overall average of the damping factor for all cavity vehicles and the individual differences.

Observing the behavior of the average variation of the cavity damping along the frequency, this graph can be separated into two regions: one up to 100 Hz and the other up to 600 Hz. For this reason, this study was remodeled by remaking an overall average up to 100 Hz and an average up to 600 Hz. With this methodology, we reached a modal damping that varies in its mean obeying a decreasing damping function.

In this first stage, we have a 6.15% cavity modal damping (100 Hz< x), and in the second step, we have a variable function: $\xi(x)=-0.0126(x-100)+6.15$ (to 100 Hz< x <600 Hz). Figure 17 illustrates this new average and the individual differences of these vehicles at this new average.

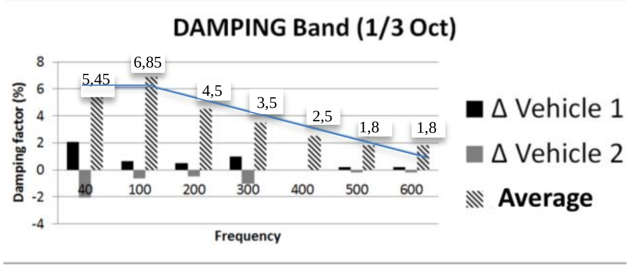

Figure 17: New general average damping factor (Damping_Design).

With a new average damping (here called Damping_Design), new results of Sound Pressure Level (SPL) were generated. Figures 18 and 19 compare the numerical results, one with damping measured experimentally and the other generated by this study (Damping_Design). The curves, Experimental (continuous black line), numerical results with damping experimental values (dashed blue line) and numerical results with "damping design" (continuous red line with triangle marks) from the average presented above, were extracted and compared and are shown in these figures. All results are shown on a logarithmic scale.

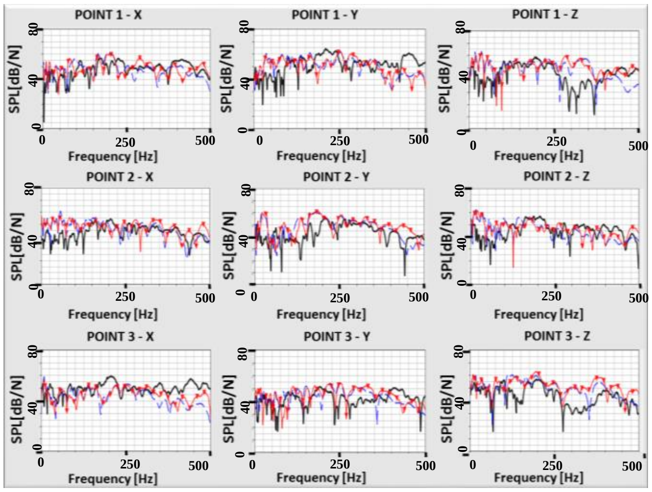

Figure 18: Pick-up model; Numerical confrontation of SPL models with experimental damping and Damping_Design of the engine mount point [1,2 & 3]. (the ordinate grid step is LOG from 0.1).

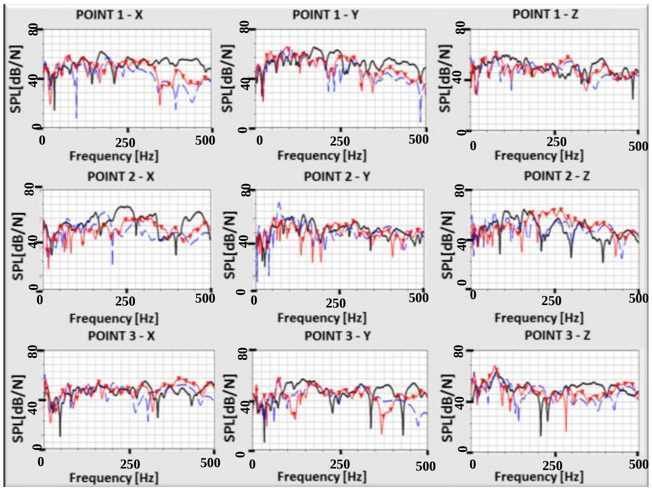

Figure 19: Popular compact vehicle model; Numerical confrontation of SPL models with experimental damping (Constant Cavity Damping – 6%) and Damping_Design of the engine mount point [1,2 & 3]. (the ordinate grid step is LOG from 0.1).

Analyzing the results illustrated in Figures 18 and 19, the numerical response loaded with their respective cavity modal damping (actual variable damping, experimentally extracted from their respective prototype) and the numerical response using the average of damping (Damping Design) developed in this paper show that the response sound pressure level (SPL) was very close to experimental response (black continuous curve).

This is observed in both vehicles used in this research and at the three points of the engine mount. The points with their respective directions of excitation that do not show good correlation responded best when the damping function was used. An example of this is point 3 in the X direction the pick-up and point 1 for the X direction.

It is also possible to see from the analysis of the results shown in Figures 18 and 19 that the use of the function $\xi(x)=-0.0126(x-100)+6.15$ (to 100 Hz< x <600 Hz) and 6.15% (to 30 Hz<x<100 Hz) to represent the modal damping of the cavity of the vehicles used maintained a good numerical-experimental correlation of sound pressure results.

5 Conclusions

Based on the results, there was a good numerical-experimental correlation when using a modal cavity damping function extracted experimentally and including it in the numerical models. Thus, this research sought to ensure this same performance using a standard damping (Damping-Design) as input as could be used to identify the acoustic behavior of vehicles in the general TBIW configuration.

This study used two (2) types of vehicles as a sample to ensure reliable coverage of the results.

It was observed that the results used for modal damping vary in their mean, obeying a decreasing function such as ξ(x=-0.0126(x-100)+6.15 up to 100 Hz and 6.15%; up to this and when applied to the numerical model, it was observed that the performance in which the variation of the initial result (with damping retrieved from experimental measurements) is very small, less than 0.5 dB. Thus, making these values an appropriate option for the standardization of values of “cavity modal damping” for acoustic analysis in the early stages of a new automotive project.

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SOUND PRESSURE LEVELS MEASURED IN FITNESS GYMS IN BRAZIL

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Résumé

Salles de fitness sont des lieux où les gens cherchent la santé et les loisir. Par conséquent, il est important de connaître les niveaux de pression sonore (SPL) généralement appliqués dans ces environnements. Cette étude a évalué l'éventail des niveaux de pression acoustique mesurée dans dix salles de fitness. Les mesures ont été prises au cours des séances de gym suivants: sauter, se balancer, localisée et l'exercice aérobie. Les mesures indiquées niveaux de pression sonore équivalent de 80 à 100 dB (A). Par conséquent, les niveaux de bruit générés actuellement dans les gymnases de l'échantillon dans cette étude, il ya certainement une possibilité de danger lié au bruit en milieu de travail.

Mots-clés: niveaux de pression acoustique, les mesures de bruit, gymnases, inconfort acoustique.

Abstract

Fitness gyms are venues where people seek health and leisure. Therefore, it is important to know the sound pressure levels (SPLs) usually applied in these environments. This study assessed the range of SPLs measured in ten fitness gyms. The measurements were taken during the following gym workouts: jumping, swinging, localized and aerobic exercise. The measurements showed equivalent sound pressure levels ranging from 80 to 100 dB(A). Therefore, with the noise levels currently generated in the fitness gyms sampled in this study, there is certainly a possibility of workplace noise hazard.

Keywords: sound pressure levels, noise measurements, fitness gyms, acoustic discomfort.

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1 Introduction

Fitness gyms offer a wide variety of physical activities aimed at improving their users health and quality of life. This environment is characterized as occupational for the instructor and as a leisure environment for its patrons. Although the purpose of these gyms is to improve their users' physical fitness and health, these environments can also pose risks to both instructors and users. One of these risks comes from excessively loud music, since, according to Maia et al. [1].

As for the worker's health, it should be pointed out that work environments offer a variety of environmental and organizational risks that are responsible for triggering and increasing the prevalence and incidence of work-related diseases. Note that, among the environmental and occupational health risks, noise is currently considered the most common physical agent in workplaces [2, 3].

According to Costa et al. [4], high noise levels in Brazil are increasingly related to leisure activities, be it through excessively loud music, motor sports, or sports shooting. Fitness gyms offer a wide variety of sports activities aimed at improving the quality of life of their patrons. Notwithstanding the concept of a better quality of life and the pursuit of a healthier life, this environment may also pose health risks to both professionals and users. One of these risks comes from the use of excessively loud music, since, as Maia et al. [5] point out, although music is pleasurable, it can be harmful to hearing and hence to the quality of life when presented at high sound pressure levels. Regarding the use of music in fitness gyms, Zucki and Lacerda [6] argue that it has become a common practice, since patrons and personal trainers believe it stimulates physical activity, making it more enjoyable and thus enhancing performance.

Given the importance of the theme of leisure activity linked to fitness gyms, this study documented noise levels normally found in such environments. To this end, sound levels were measured in ten fitness gyms in the city of Curitiba, in southern Brazil.

2 Materials and Method

The sound pressure levels (SPLs) in the 10 fitness gyms were measured during the following gym workouts: jumping, swinging, localized and aerobic exercise. The SPLs were measured with a class I Brüel & Kjaer 2238 sound level meter. Measurements of the equivalent continuous sound pressure level, Leq, were taken for 40 minutes and A-weighted, because this is the duration of a workout session with loud music. The last 10 minutes of each session are for relaxation, and are usually accompanied by very low or no music. Therefore, SPLs were not measured during the last 10 minutes of workout sessions. The sound level meter was placed on a tripod at a height of 1.20 m from the floor.

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Fitness gyms are a work environment for physical education instructors and a leisure environment for patrons. The noise levels measured in the fitness gyms were characterized according to the guidelines of Regulatory Standard NR 15 of the Brazilian Ministry of Labor and Employment, which establishes guidelines for managing occupational noise in the country [7]. According to Brazil's NR 15 standard, "*Noise measurements should be taken close to the worker's ears.* "

Table 1 list the limits established by NR 15 [7] for workplace noise levels, and the resulting maximum permissible length of stay of workers in these environments. The NR 15 standard establishes an equivalent sound level, Leq, of 85 dB(A) as the reference level to which a worker may be exposed during a standard 8-hour work day. An 8-hour workday at a noise level of 85 dB(A) corresponds to 100% of the daily noise dose. If this daily noise dose is exceeded, the employee is entitled to receive additional compensation over and above his salary. Brazil's NR 15 standard uses an exchange rate of *q*=5. Table 2 describes the permissible noise levels for fitness gyms.

Table 1: Limits of tolerance to daily occupational noise exposure – NR 15 standard

Noise levels Leq dB(A)	Maximum permissible daily exposure time (*Te*)
85	8 hours
86	7 hours
87	6 hours
88	5 hours
89	4 hours and 30 min
90	4 hours
91	3 hours and 30 min
92	3 hours
93	2 hours and 40 min
94	2 hours and 15 min
95	2 hours
96	1 hour and 45 min
98	1 hour and 15 min
100	1 hour
102	45 minutes
104	35 minutes
105	30 minutes
106	25 minutes
108	20 minutes
110	15 minutes
112	10 minutes
114	8 minutes
115	7 minutes

Table 2: Spatial volume of the fitness gyms

Fitness Gym	Volume [m^3]
G1	259.09
G2	249.80
G3	124.33
G4	252.84
G5	393.24
G6	258.74
G7	202.00
G8	228.19
G9	279.65
G10	449.38

The noise dose [8] is calculated by the following expression [1]:

$$D = (Te/TE)\,x100x2^{\frac{NE-85}{q}} \qquad [1]$$

where: *D* [%] is the daily noise dose; *Te* is the duration of exposure, in minutes, during a workday; *TE* is the duration of the standard workday, which in Brazil is *TE* = 480 minutes (or 8 hours); *NE* is the equivalent sound level measured during the workday, *Te*; and *q* is the exchange rate, which, in Brazil, is equal to *q =5*.

Figures 1 to 10 show the layout of the fitness gyms evaluated in this study. Computer simulations were performed using Odeon Combined version 9.2 software to evaluate the acoustic quality of the fitness gyms and measure their reverberation time, RT [9]. An OmniSource^{TM} Type 4295 single speaker omnidirectional sound source (Brüel & Kjær) was used to calculate the RT. A grid was designed with receivers positioned in a 10x10 centimeter mesh for all the fitness gyms. Table 3 describes the RT of the fitness gyms.

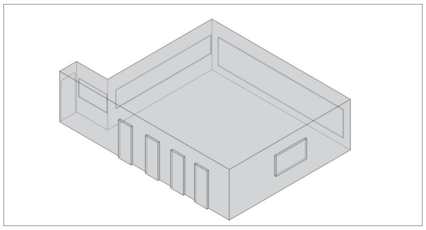

Figure 1: Layout of fitness gym G1

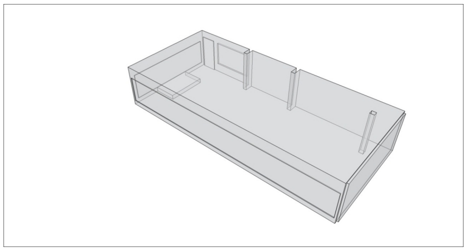

Figure 2: Layout of fitness gym G2

Fitness gym G1 has a concrete ceiling and ceramic tile flooring. G2 has a PVC ceiling tiles and wooden flooring. G3 has a wooden ceiling and ceramic tile and wooden flooring. G4 has a PVC ceiling tiles and wooden flooring.

G5 has a wooden ceiling and flooring. G6 has a wooden ceiling and rubberized flooring. G7 has a concrete ceiling and rubberized flooring. G8 has a concrete ceiling with rockwool insulation and wooden flooring. G9 has a concrete ceiling and granite floor tiles. G10 has a concrete ceiling and ceramic floor tiles.

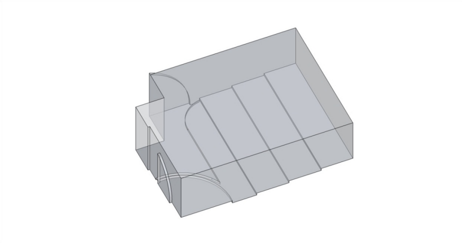

Figure 3: Layout of fitness gym G3

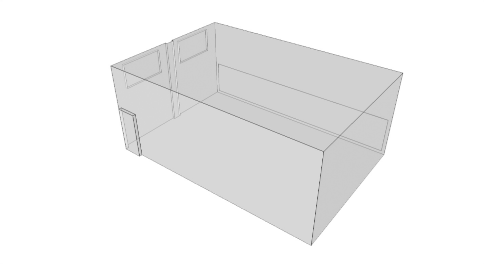

Figure 4: Layout of fitness gym G4

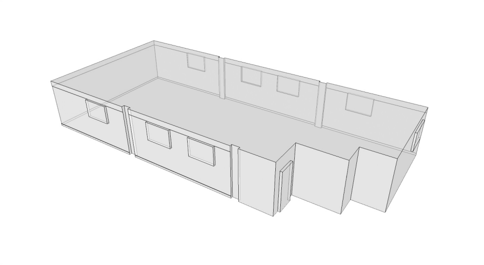

Figure 5: Layout of fitness gym G5

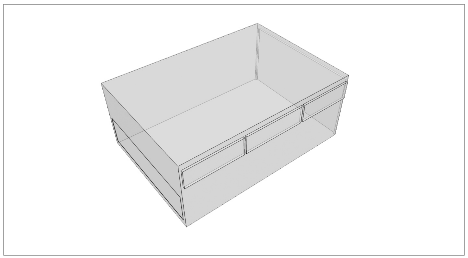

Figure 6: Layout of fitness gym G6

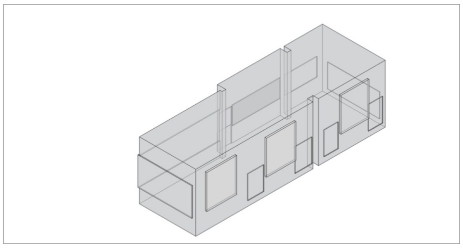

Figure 7: Layout of fitness gym G7

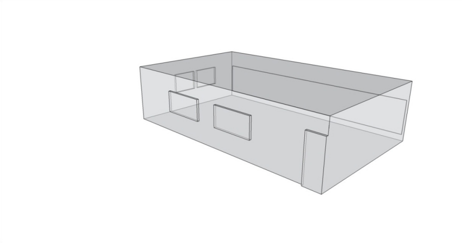

Figure 8: Layout of fitness gym G8

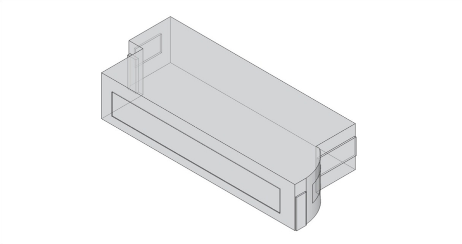

Figure 9: Layout of fitness gym G9

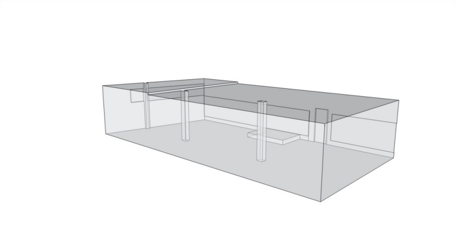

Figure 10: Layout of fitness gym G10

Table 3: RT of the fitness gyms

Fitness Gym	RT [s]			Mean RT [s]
	500 Hz	1 kHz	2 kHz	
G1	5.9	4.5	3.8	4.7
G2	2.6	2.5	3.4	2.8
G3	1.4	1.7	2.3	**1.8**
G4	2.4	1.7	2.9	2.6
G5	1.5	2.1	2.0	**1.9**
G6	1.4	1.8	2.1	**1.8**
G7	3.9	3.7	3.0	3.5
G8	0.6	0.9	1.0	**0.8**
G9	4.9	4.2	3.5	4.2
G10	6.5	5.4	4.7	5.5

3 Results and Discussion

The RT of the gyms was calculated using Odeon version 9.2 software [9]. The mean RT was calculated as the arithmetic mean of the respective reverberation times at frequencies of 500 Hz, 1 kHz and 2 kHz, according to Ananthaganeshan and Gastmeier [11]. These authors suggest that the mean RT of unoccupied gyms is between 1.5 and 2.0 seconds, at frequencies of 500 Hz, 1 kHz and 2 kHz. According to them, an RT value within this range would represent a compromise between an environment destined for sports practices and/or musical performances and speech intelligibility [11]. The literature consulted for this study does not report RT data for fitness gyms. Therefore, we used the data presented by Ananthaganeshan and Gastmeier [11] as a reference to evaluate the RT of the fitness gyms of this study.

Considering the average RT of 1.5 to 2.0 s suggested by Ananthaganeshan and Gastmeier [11] to provide an environment conducive to physical activity, with music as the main catalyst, it was found that, among the ten fitness gyms, only G3, G5 and G6 (see Table 3) were within this range, while the others exceeded the upper limit of the suggested range of RT values. The only exception was G8, whose RT was 0.8 s, i.e., below the range of suggested values [11]. Fitness gym G8 has a concrete ceiling with rockwool insulation and a rubberized floor (see section 2).

In the particular case of the academy A8, RT simulation was performed with the removal of Rock-wool layer that covered the ceiling, and the inclusion in one of the walls of a plasterboard perforated panel [12]. Figure 11 shows the changes made in the gym A8:

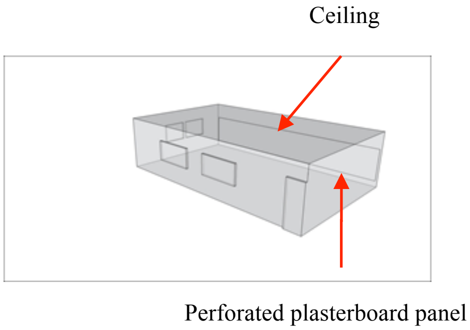

Figure 11: Fitness gym G8

Table 4 lists the sound absorption coefficients used to calculate the new RT for fitness gym G8.

Table 4: Sound absorption coefficients (α) as a function of frequency – Fitness gym G8.

Material	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Rock-wool [12]	0.09	0.29	0.55	0.61	0.82	0.91
Heavy rough concrete surfaces [12]	0.02	0.03	0.03	0.03	0.04	0.07
Plasterboard perforated panel [12]	0.33	0.79	1.03	0.83	0.65	0.54

With perforated plasterboard ceiling and wall paneling, the simulated RT of gym G8 was 1.3 s, 1.4 s and 1.7 s, respectively, at the frequencies of 500 Hz, 1 kHz and 2 kHz, and the mean RT was 1.5 s, i.e., within the 1.5 to 2.0 s limit proposed by Ananthaganeshan and Gastmeier [11].

Table 5 lists the equivalent sound pressure levels Leq measured in the 10 fitness gyms, and the daily noise dose. The calculated noise dose refers to the duration of a workout session, which is *Te* = 40 minutes. Brazil's aforementioned NR 15 standard considers that, for a normal 8-hour workday, the sound level of reference is Leq = 85 dB(A), and the noise dose of reference is 100%. In Table 5, note that the daily noise dose, D, did not exceed 100% in any of the workout sessions evaluated in the fitness gyms. Therefore, the gyms fall within with the D reference value of the NR 15 standard.

Table 5: Equivalent continuous sound level measured in each fitness gym, and daily noise dose for a 40-min workout session and for an average daily exposure time of 3 hours.

Fitness Gym	Equivalent Sound Level, L_{eq} dB(A)	Daily noise dose D (%) *Te* = 40 min (duration of a session)	Daily noise dose D (%) *Te* = 3 h (or 180 min) (mean daily exposure time)
G1	92	22	99
G2	87	11	50
G3	89	15	65
G4	86	10	43
G5	80	4	19
G6	82	6	25
G7	94	29	131
G8	99	58	261
G9	100	67	300
G10	88	13	57

However, in her master's dissertation, Anjelo [10] applied a questionnaire to assess the working conditions of the instructors of the fitness gyms under study. The group of instructors comprised 10 individuals (one for each fitness gym), 7 women and 3 men, with an average age of 28 years. The average time of professional activity is approximately 8 years. The average weekly workload at the evaluated gyms, from Monday to Friday, is 15 hours, corresponding to a average daily workload of 3 hours per instructor per gym. Thus, considering this average daily workload, Table 1 shows that the allowed limit noise level is 92 dB(A). Table 5 shows that the noise level measured in gym G1 was 92 dB(A), so an average exposure time of 3 hours/day corresponds to a noise dose of 99%. Although this value is high, it does not exceed the noise dose limit of 100%. However, an aggravating factor of this situation is that the RT in gym G1 is 4.7 s, the second highest RT among the ten gyms (see Table 3).

As can be seen in Table 5, considering the average daily exposure time of 3 hours at the other gyms, the daily noise dose of 100% was exceeded in gyms G7, G8 and G9. The calculated noise dose was 131% in G7, 261% in G8, and 300% in G9, significantly exceeding the 100% daily noise dose limit established by the NR 15 standard. A factor that aggravated this situation was that gyms G7 and G9 presented RTs of 3.5 and 4.2 s, respectively, i.e., well above the limit RT of 1.5 to 2 s suggested by Ananthaganeshan and Gastmeier [11].

4 Conclusions

This study documented the noise levels and daily noise dose in ten fitness gyms in Brazil, and also evaluated their RTs.

As Angelo [10] reported, the average daily workload per instructor at each of the evaluated fitness gyms is 3 hours. This means that the daily noise dose is 99% in gym G1, 131% in G7, 261% in G8, and 300% in G9. Only three fitness gyms, G3, G5 and G6, showed reverberation times within the 1.5 to 2 s limit suggested by Ananthaganeshan and Gastmeier [11]. It should be noted that the gym instructors work at other fitness gyms, thus extending their daily workload. Given these facts, therefore, it can be concluded that with the noise levels currently generated in the fitness gyms sampled in this study, there is certainly a possibility of workplace noise hazard.

Acknowledgments

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IMPACT OF AUDITORY ATTENTION ON THE EFFERENT AUDITORY SYSTEM IN THE ABSENCE OF REAL AUDITORY TARGETS

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Abstract

Previous studies have compared visual and auditory attention to no-task conditions and have demonstrated an attention-driven modulation of the efferent auditory system (De Boer & Thornton, 2007; Maison, Micheyl, & Collet, 2001). However, it is unclear whether these effects are modality-specific or a result of generalized attentional processes. In the present study, 16 young adults observed facial speech gestures related to productions of vowels /a/ and /u/ in the presence of contralateral broad band noise (BBN) under two instructions: (a) visual attention: visually count the number of /a/ productions and ignore BBN and (b) sham condition/ auditory attention: these trials did not have any vowels embedded in BBN, but participants were made to believe that there were sounds embedded and instructed to count the number of /a/ productions. These "sham" trials investigated the effect of auditory attention in the absence of real auditory targets. The influence of visual and auditory attention on the efferent auditory system was indirectly assessed by examining their effects on contralateral inhibition of click-evoked otoacoustic emissions (CS-CEOAE paradigm; Collet, Chanel, & Morgon, 1990). The mean inhibition from baseline for visual attention and auditory attention were 2.19 and 1.88 dB SPL, respectively. Cohen's *d* for the mean difference between the two conditions yielded a moderate positive effect size = 0.52. Twelve out of sixteen participants (75%; exact binomial test significant at one tailed $p = 0.03$) demonstrated a greater inhibition of CEOAEs amplitudes (mean difference = 0.31 dB SPL) in the visual attention condition relative to the auditory attention condition. Our results show that these effects are obtainable even in the absence of real auditory targets (i.e. without stimulus confound). Overall, finding a difference in inhibition of CEOAEs for visual and auditory attention conditions provide preliminary evidence for a modality-specific rather than a generalized attentional modulation in the efferent auditory system.

Keywords: Auditory attention, visual attention, contralateral inhibition, Transient-evoked otoacoustic emissions, efferent

Résumé

La comparaison de l'attention visuelle et auditive à des conditions sans-tâches a démontré une modulation du système efférent auditif dépendante de l'attention (De Boer & Thornton, 2007; Maison, Micheyl, & Collet, 2001). Cependant, il reste à déterminer si ces effets résultent de processus attentionnels généralisés ou de modalités. Dans cette étude, 16 jeunes adultes ont observé les mouvements du visage lors de la parole liés à la production des voyelles /a/ et /u/ en présence de bruit à bande large (BBN) controlatérale sous deux directives: (a) comptage visuel du nombre de production du /a/ en ignorant le BBN (attention visuelle) et (b) écoute soigneuse et comptage des sons cibles /a/ intégrés dans le BBN (condition feinte; attention auditive). Ces essais « feints » n'avaient pas de cibles acoustiques et reflètent l'effet de l'attention auditive en absence de véritables cibles auditives. L'influence de l'attention visuelle et auditive sur le système efférent auditif est mesurée par la inhibition controlatérale des otoémissions acoustiques provoquées (OEAP; Collet, Chanel, & Morgon, 1990). Les changements moyens du niveau de base pour l'attention visuelle et pour l'attention auditive sont respectivement de 2.19 et 1.88 dB SPL. La différence moyenne entre les deux conditions entraîne un effet positif modéré avec un d de Cohen de 0.52. Douze des seize participants (75%; valeur *p* du test binomial (unilatéral)= 0.03*) ont démontré une inhibition plus grande des amplitudes d'OEAPs (différence moyenne = 0.31 dB SPL) en condition d'attention visuelle qu'en condition d'attention auditive. Nos résultats démontrent que ces effets peuvent être obtenus même en absence de véritables cibles auditives. En résumé, l'observation d'une différence dans la inhibition de OEAPs entre les conditions d'attention visuelle et auditive fournit des preuves préliminaires soutenant une modulation attentionnelle spécifique plutôt qu'une modulation attentionnelle généralisée dans le système efférent auditif.

Mots clefs : attention auditive, attention visuelle, inhibition controlatérale, otoémissions acoustiques provoquées, efférent

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1 Introduction

In our day-to-day life, selective attention helps us tune in to relevant stimuli and ignore distractors as we try to make sense of the world around us. Research suggests that selective attention may be related to mechanisms that enhance relevant information or suppress irrelevant information [1]. Further, several studies have reported that attentional processes modulate the peripheral cochlear mechanisms [2,3,4], which are modulated by the efferent (descending) auditory pathway, specifically the medial olivocochlear (MOC) tracts. The MOC fibres are the only known descending connection between the corticofugal tracts originating from the auditory cortex and the cochlea, allowing top-down corticofugal modulation of the auditory system on a peripheral level [5,6]. Several animal studies have indicated that MOC tracts emerge from the superior olivary complex (SOC), and innervate the outer hair cells (OHCs) of the contralateral (75%) and ipsilateral (25%) cochlea [7,8]. The effects of corticofugal modulation of the peripheral auditory system can be indirectly assessed by examining their impact on the contralateral inhibition of evoked otoacoustic emission (OAE). OAEs are a byproduct of the cochlear amplifier and normal function of outer hair cells (OHC). In healthy ears, they can be recorded in the ear canal either spontaneously or in response to acoustic stimulation [9].

It has been reported that both visual and auditory attention leads to changes in OAEs, signifying a top-down modulation of the peripheral auditory system. For the visual system, attending to visual tasks (such as counting visual events) leads to an increase in contralateral inhibition (decrease OAE amplitude) relative to non-attending tasks [10, cf. 11]. In terms of auditory attention, attending to stimuli in the contralateral ear has also been shown to decrease contralateral inhibition compared to non-attending tasks [12]. However, given that both visual and auditory attention impact OAE amplitudes, it remains unclear whether these effects are modality-specific or a result of generalized attentional processes.

In the present study, we explored whether auditory attention, compared to visual attention, differentially modulates activity in the efferent auditory system. We investigated this using a well-reported procedure for assessing efferent auditory system modulation, which involves the presentation of broad band noise (BBN) in the contralateral ear and measuring OAE in the ipsilateral ear (CS-OAE paradigm; [13]). In this procedure, contralateral BBN is presumed to stimulate ipsilateral SOC via crossed efferent pathways; this in turn activates descending ipsilateral MOC fibres. Given that MOC fibres terminate at OHCs, it is assumed that they are in a position to modify the actions of OHCs and hence, modulate the gain of the cochlear amplifier and OAEs [7,14]. However, the resulting changes in OAEs may be a result of both active (OHC electromotility) and passive mechanisms (linear reflection along the cochlear partition) [15]. We hypothesize that cortically mediated release from MOC activity (i.e. level of contralateral OAE inhibition) at the level of cochlea would differ between tasks involving visual attention vs. auditory attention even when physical stimuli are identical. Such a differential response, if found, will support the influence of a modality-specific attentional process, as opposed to a more generalized attentional mechanism.

2 Method

2.1 Subjects

Sixteen young healthy adults (Mean age (S.D.) = 22.0 (3.16) years; Males= 4, Females= 12) participated in the study. All participants were right-handed, native English speakers, with no history of speech, language, learning, neurological, or otological issues, or noise exposure in the last 24 hours prior to the experiment. All participants met the following otological criteria: (a) normal tympanic membrane/ ear canal appearance on otoscopic examination, (b) bilateral audiometric thresholds between 500 Hz to 4000 Hz at 20 dB HL or lower, (c) normal middle ear function, exhibiting ear canal pressure values between -100 and +50 daPa, middle-ear compliance values between 0.3 and 1.6mL, and acoustic reflex thresholds ≥ 65 dB SPL. All participants were reimbursed at a standard fee of $10 CDN/hour. The study was approved by the University of Toronto's Health Sciences Research Ethics Board and participants provided informed consent prior to the start of the study.

2.2 Stimuli and Procedures

We used click-evoked OAEs (CEOAEs) elicited with clicks presented in a linear mode (same polarity) with the amplitude of 60 dB peak SPL (click duration of 80µs, click interval of 21.12 ms.) The responses were collected by averaging among 260 stimuli trains (1040 clicks), which was stored in two buffers (A and B) for a total of 2080 clicks. Whole wave reproducibility (WWR) was calculated as the Pearson correlation coefficient between the two obtained waveforms (A and B) and multiplied by 100. WWR is considered a quality index of the recorded OAEs; in the present study, WWR was set at > 70% as suggested by previous research [16,17]. The responses elicited were high and low pass filtered between 750 and 6000 Hz, respectively, with a recording window between 2.5 to 20.0 ms. CEOAEs at 2kHz centre frequency were recorded via the Vivosonic Integrity 4.5.3 system, with artifact rejection threshold of 45 dB SPL. A Signal-to-Noise Ratio (SNR) of > 6 dB was used as a criterion of CEOAE detection [18]. In the current study, we only analyzed CEOAEs centred around 2 kHz for three reasons: (1) this frequency yielded the largest SNR ratios across all participants, (2) contralateral inhibition effects are not strong above 3 kHz [19] and (3) most typical frequencies related to speech perception are < 3 kHz [20].

The study was conducted in a standard sound attenuated booth with a two-way observation window separating the control room and test room. The experimenter in the control room provided all instructions, presented different task conditions and controlled the stimuli presentation via a

Microsoft PowerPoint presentation on a laptop computer. The second experimenter sat next to the participant and carried out all CEOAE recordings, including probe fit monitoring on a trial-by-trial basis.

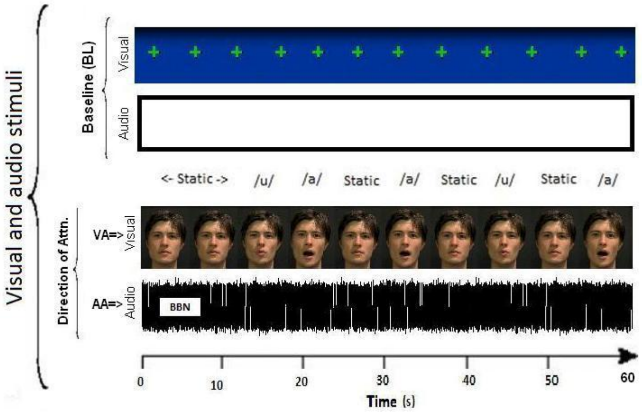

Figure 1. Task conditions: (a) Baseline (BL) condition: no contralateral BBN, (b) VA condition: contralateral BBN + attention (attn.) directed to visually observing speech gestures related to productions of vowels /a/ and /u/ (c) AA condition: contralateral BBN + attention directed to auditory stimuli (sham-condition). X-axis represents time in seconds.

CEOAEs were recorded from the right ear under 3 task conditions (Figure 1). The first condition was the baseline (BL) condition, in which participants focused their attention on a "+" symbol displayed on a computer monitor without any contralateral BBN. In the other two conditions, the participants were presented with continuous contralateral BBN, generated by a Grason-Stadler 61 (GSI-61) audiometer and delivered in the left ear at 55 dB HL via an ER-3A insert earphone. Real-ear or "in-situ" responses were measured (using a probe microphone real-ear measurement system; Audioscan RM500) for such BBN levels at the eardrum, and were found to be equivalent to 63-73 dB SPL (for frequencies between 750 to 4000 Hz) with roll offs at the higher and lower frequencies [18]. This noise level is the highest level of BBN that could be presented without eliciting acoustic reflexes [11, 12, 21]. While BBN was delivered, participants were also presented with a video of a man producing facial speech gestures related to productions of vowels /a/ and /u/ in both task conditions. In the visual attention condition (VA), the participants were instructed to mentally count the number of times they saw the person's face produce an /a/ speech gesture and ignore BBN. Prior to the start of the VA condition, participants were given two practice trials to familiarize themselves with the task condition. In the auditory attention (sham) condition (AA), we presented the subjects with a "practice" trial in which /a/ and /u/ sounds were embedded in BBN in different SNR (i.e. +10, +5, 0, -5 and -10). The participants were instructed to listen carefully to detect and mentally count the number of target sound /a/ embedded in BBN Importantly, the "sham" trials differed from the "practice" trial in that they did not have any real acoustic stimuli embedded in BBN. Furthermore, the "practice" trials were also used as random catch trials throughout the study to convince participants that there were vowel targets embedded in the BBN in the sham trials; OAEs from these catch trials were not recorded. In fact, participants were presented with identical visual and auditory stimuli in both the VA and the AA trials, and the only difference between the conditions was the information channel (visual/ auditory) to which they were instructed to direct their attention. This controlled for stimulus confound and probed the effect of auditory attention even when there was no real acoustic target. Notably, all participants reported "hearing" at least one embedded target in the "sham" trials, indicating that they were indeed paying auditory attention. There were 5 trials per block: the first block was always BL trials, followed by VA or AA trials, with the order of the latter two counterbalanced across participants. Trials within each block were also randomized; each trial lasted approximately 60 seconds, and was matched for both number of productions and movement duration of each /a/ or /u/ production (as timed with a metronome). Interstimulus interval (ISI) between any two visual speech gestures ranged from 1s to 6s, wherein all speech gesture presentation began at about 15s after the onset of BBN.

3 Results

The means and standard deviations (in parenthesis) for CEOAE amplitude (in dB SPL) across the 2kHz frequency band are depicted in Table 1. The mean of the VA block (or AA block) was subtracted from the mean of the BL block within a participant to derive a score representing change from baseline (ΔVA and ΔAA).

Table 1. Means (standard deviation) in dB SPL across 16 participants for 2kHz CEOAE test frequency (see text for more details).

CEOAE Frequency Band	BL	VA	AA	ΔVA	ΔAA
2kHz	3.36 (6.66)	1.17 (6.27)	1.48 (6.34)	2.19 (1.98)	1.88 (1.82)

The mean difference between the two conditions yielded a moderate positive effect size (Cohen's *d* adjusted for repeated measures = 0.52) [22, 23]. 75% of the participants tested (12 out of 16 participants; exact binomial test significant at one-tailed $p = 0.03$) exhibited an increase in inhibition of 0.31 dB SPL in the visual attention (VA) task relative to the auditory attention (AA) task.

4 Discussion

The current study investigated whether visual and auditory attention differentially modulates the peripheral auditory system. Overall, the presence of contralateral BBN inhibited CEOAE amplitude responses in the test ear across both attentional conditions, relative to baseline. The amounts of inhibition (see Table 1), as indicated as change from baseline, in the attentional conditions were 2.19 dB SPL (for

VA) and 1.88 dB SPL (for AA). Notably, our results show that auditory attentional effects are obtainable even in the absence of real auditory targets (i.e. without stimulus confound). Further, despite the identical physical stimuli presentation of the two conditions, a significant increase in inhibition of about .31 dB SPL was observed for the VA task, relative to the AA task (Table 1).

Such small differences (~0.35dB) found across attentional task conditions are not unusual and have been reported in other studies [2, 18]. Small changes in the amount of inhibition between conditions have larger implications if one takes into account the presumed role of MOC fibres and the efferent pathway. MOC fibre activity is assumed to have an inhibitory effect on OHC's electromotility, which is reflected in OAE inhibition. Evidence in the literature suggests that even small changes in the cochlear mechanics are able to alter target-specific input gain in the peripheral auditory system, resulting in increased signal amplitudes in the ascending auditory nerve fibres [21, 24].

Previous studies have also reported an increase in OAE inhibition from baseline during visual attention tasks [2, 3]; however, since the methodologies of these studies involved different stimuli during auditory attention and visual attention tasks, it was unclear whether selective attention was the only variable manipulated. In the current study's paradigm, given that VA and AA conditions employed the same stimuli and only differed in instructions of directing either visual or auditory attention, the differences observed between the conditions suggest a modality-specific rather than a generalized attentional modulation in the efferent auditory system. Alternatively, these effects may also be explained in terms of differences in neuronal bandwidths, wherein BBN and auditory attention may share the same neuronal bandwidth while visual attention may have access to additional bandwidth, either anatomically or functionally (e.g. [25]).

A potential limitation in the study is that the instrument we utilized (Vivosonic Integrity 4.5.3) does not allow for the time-locked recording of OAE with stimuli presentation. Thus, artifact rejection was not synchronized with the presentation of stimuli (and hence our blocked presentation approach). However, to ensure that there were no systematic differences in artifact rejection that could have biased the data towards a specific condition, we carried out a within participant post-hoc analysis on artifact rejection ratio (AAR%) across conditions. The results of this analysis did not reveal any systematic differences in AAR% across conditions within a participant. Thus, the condition effects in the present study are less likely due to differences in artifact rejection.

Another potential limitation is that, given the study's design, it is not possible to separate the sole influence of BBN from the effects of attention. However, since the aim of the study was to explore differences in modulation of OAE as a function of the direction of attention, the test conditions (VA and AA) have BBN as a common factor for we do not expect the influence of BBN across test conditions to be different.

Building on previous findings of both visual and auditory attention having an impact on OAE amplitude, the current results seem to indicate that the channel through which attention is directed may have the potential to differentially modulate efferent cochlear mechanisms.

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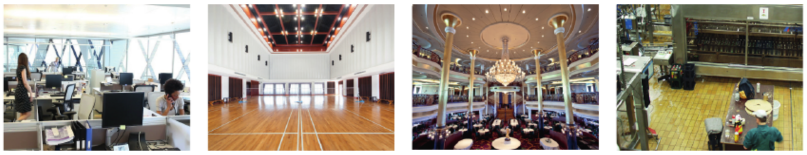

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STRATEGIES TO ENHANCE WHISPERED SPEECH SPEAKER VERIFICATION: A COMPARATIVE ANALYSIS

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Abstract

Today, automated speech–enabled tools are increasingly being used in everyday environments. This mobility has created new challenges for developers, who are now faced with input speech of varying styles (e.g. whispered) and corrupted by different noise sources. In this paper, special emphasis is placed on whispered speech, an underexplored yet burgeoning area due to the rapid proliferation of smartphones around the world. More specifically, this paper explores the performance boundaries achievable with whispered speech for a speaker verification task, both in matched and mismatched *train/test* conditions. Several strategies are investigated to improve the performance in the mismatched scenario, as well as in situations involving ambient noise. Our results agree with previously reported studies in adjacent areas, that significant gains could be obtained by training speaker models with both naturally voiced and whispered speech data. Moreover, additional gains could be achieved with speaking style and gender dependent systems. Overall, speaker verification performance inline with that obtained with naturally-voiced speech could be attained for whispered speech once specific strategies were put in place. Particularly, feature fusion showed to be an important strategy for practical applications in both clean and noisy conditions.

Keywords: Whispered speech, gender detection, speaker verification, instantaneous frequency, vocal effort classification, modulation spectrum.

Résumé

De nos jours, les outils tirant profit de l'analyse automatique de la parole sont de plus en plus utilisés au quotidien. Cette mobilité engendre de nouveaux défis pour les développeurs, qui doivent composer avec différents types de parole (par exemple, des chuchotements) et de sources de bruit. Dans cet article, une attention spéciale est accordée à la parole chuchotée, qui malgré son importance particulière dans le contexte d'une augmentation fulgurante de l'utilisation de téléphones intelligents dans le monde, demeure un champ inexploré. Plus spécifiquement, cet article explore les niveaux de performance atteignables lorsque la parole chuchotée est utilisée pour la vérification de locuteurs, à la fois dans des conditions correspondant et non-correspondant d'entraînement et de test. Plusieurs stratégies sont explorées afin d'améliorer la performance dans le cas non-correspondant, de même que dans des situations impliquant un bruit ambiant. Nos résultats confirment ceux obtenus dans des domaines connexes : des gains de performance significatifs peuvent être obtenus en développant des modèles de locuteurs basés sur la parole voisée et chuchotée. De plus, des gains additionnels peuvent être obtenus en considérant des modèles spécifiques à un style de parole et au sexe. Globalement, un niveau de performance semblable à celui obtenu avec la parole voisée a été atteint lors d'une tâche de vérification de locuteurs basée sur la parole chuchotée. En particulier, la fusion au niveau des traits caractéristiques (≪ feature fusion≫) s'est avérée une stratégie importante pour le succès d'applications pratiques dans des conditions de parole propre et bruitée.

Mots clefs: Parole chuchotée, détection de genre, vérification du locuteur, fréquence instantanée, classement de l'effort vocal, spectre de modulation

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1 Introduction

Human speech is a natural and flexible mode of communication that not only conveys a message, but also traits such as identity, age, gender, social and region of origin, emotional, and health states, to name a few [1]. Under controlled conditions, speech processing systems have become useful across a number of domains. As examples, a number of applications have emerged that allow people to use their voices to interact with their devices (e.g., Apple's Siri), login to secure services (e.g., Bell Canada's Voice Identification Service), or even unlock their mobile devices (e.g., Baidu-I^{2}R Research Centre's Speaker Verification Service). Many such applications have thrived due to the recent proliferation of mobile devices. Notwithstanding, while the ubiquity of smartphones has opened a pathway for new speech applications, user mobility has created several challenges that still need to be addressed, such as the robustness to ambient noise or varying vocal efforts (e.g., whispering). While robustness to noise has been addressed numerous times in the past (e.g. [2–4]), little attention has been given to varying vocal efforts.

Here, special emphasis is given to whispered speech as, with the burgeoning of mobile speech applications, users have become more cautious about protecting the content of their spoken words, (e.g., during mobile telephone banking) specially when providing their credit card number, bank account number, or other personal information. One limiting factor in the widespread development of whispered speech applications lie on the lack of large amounts of training data [5–7], as is the case with normally-voiced speech. Notwithstanding, the increasing interest in this speaking style has led to the development of a few publicly-available databases, such as the CHAINS corpus [8]. Such initiatives open doors for speaking-style dependent models to be used and accurate whispered speech applications to emerge.

Existing automatic speech and speaker recognition systems do not perform well under whispered speech conditions, particularly if normal speech was used during training (i.e., training/testing mismatch conditions) [6, 9–11]. Despite this drop in performance of automated systems, subjective studies have suggested that whispered speech still conveys a significant amount of speaker identity information and degree of understanding [12, 13]. As such, recent studies looking at speaker identification have shown that the best solution is to include small portions of whispered speech during training to adapt the speaker models [6, 14]. Alternately, other studies have explored the benefits of developing automated sys-

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tems with dedicated speaker models for different vocal efforts (e.g., [9, 14, 15]), thus taking into account the particular characteristics of each vocal effort.

When a person whispers, several changes occur in the vocal tract configuration, thus altering not only the excitation source, but also the syllabic rate and the general temporal dynamics characteristics of the generated speech signal [10, 16]. Therefore, classical methods designed for normal speech characterization tend to fail for whispered speech, as commonly used features (e.g. Mel frequency cepstral coefficients - MFCC) are sensitive to such changes [6, 11]. The aim of this paper is to explore the performance envelope achievable with whispered speech, particularly within the scope of a small scale speaker verification (SV) task. To this end, we explore the benefits of different existing preprocessing methods, frequency warping strategies, feature representations, and SV strategies. The main goal of this paper is to comprehensively investigate which system configurations result in the best performance for whispered and normally-voiced speech, both in clean and noisy conditions. Ultimately, it is hoped that the insights reported herein will help the development of large scale applications in more realistic scenarios, and for future development of practical systems that can be used in everyday settings.

The remainder of this paper is organized as follows. Section 2 provides the background on whispered speech, emphasizing the main differences with normal speech. Section 3 describes the speaker verification problem, the corpus employed for speaker verification, the feature extraction approaches, as well as the baseline settings and results. Section 4 discusses different approaches and strategies to reduce the error rate in whispered speech speaker verification. Section 5 discusses the robustness of the best feature representations and system design to different levels of babble noise. Section 6 presents further discussion and analysis of the main results and describes future research directions. Lastly, Section 7 presents the conclusions.

2 Whispered speech

In the past, perceptual studies have been conducted to characterize major acoustic differences between whispered and normal-voiced speech. For example, topics such as pitch perception and the correlation between perceived pitch and formant location have been studied, as well as the measurement of the formant shifts towards higher frequencies [17, 18]. Moreover, perceptual studies have suggested that whispered speech still conveys a significant amount of speaker identity and gender information [12, 13, 19, 20].

Using signal processing tools, acoustical studies have found that whispered speech has a lower and flatter power spectral density [10]. In [16], it was found that the duration of consonants in whispered speech is prolonged by about 10% relative to normally-voiced speech. In addition to the duration increase, the intensity of the whispered consonants is lower by about 12 dB. These significant changes have been documented only in voiced consonants. A recent study has also corroborated the perceptual findings regarding the formant shifts in whispered mode [21]. The above-mentioned insights have been used by the research community to tackle different challenges, such as reconstruction of normal speech from whispers [22–24], speech recognition [9, 10], and speaker identification [6–8, 14] with whispered speech.

To illustrate some of the significant differences between normal and whispered speech, their waveforms and spectrograms are depicted by Figure 1(a) and 1(b) respectively, for the utterance "*Here I was in Miami and Illinois*". From Figure 1(b), it can be observed that whispered speech is mostly turbulent noise modulated by the vocal tract with no clear structure. With normal speech (Figure1(a)), on the other hand, the glottal excitation is clear. Moreover, the time waveform for whispered speech is significantly lower in amplitude ; in this particular case about 15 dB lower. Figure 2(a) in turn, illustrates the average power spectrum for the same utterance, using 32 ms windows and a 12 order linear predictive model to estimate the spectral envelope. From Figure 2(a), it is evident that the differences lie mostly in the low frequencies. For normal speech, most of the energy is concentrated below 1 kHz, whereas for whispered speech it is concentrated below 500 Hz, with frequency shifts in the spectral peaks and valleys. Between 1 kHz and 4 kHz the two spectral envelopes follow a similar trend, where spectral peaks and valleys are located in approximately the same frequency values, however the differences in magnitude are not constant. Regarding frame energy distribution, the histogram in Figure 2(b) was computed using male and female speech and utterances of about 55 s from 36 speakers and shows that the concentration of high-energy frames is higher for normal speech, with 60% of the frames having energy between -10 dB and 10 dB. For whispered speech, on the other hand, 70% of the frames have energy between -35 dB and -10 dB. Combined, these findings show that significant differences exist between whispered and normal-voiced speech in terms of temporal, spectral and energy dynamics. As such, it is expected that any speech-based technology trained on normal speech will fail when tested on whispered speech. Clearly, strategies need to be devised to improve system performance. As mentioned previously, the focus of the present paper is to explore such strategies for a speaker verification task.

3 Baseline SV system characterization

3.1 Automatic speaker verification system

In automatic speaker recognition (SR) there are two classical tasks that can be performed : speaker identification (SI) and speaker verification (SV). Identification is the task of deciding, given a speech sample, who among a set of speakers said it. This is an N–Class problem (given N speakers), and the performance measure is usually the classification rate or accuracy. Verification, in turn, is the task of deciding, given a speech sample, whether the specified speaker really said it or not. The SV problem is a two class problem of deciding if it is the same speaker or an impostor requesting verification. Commonly, SV exhibits greater practical applications

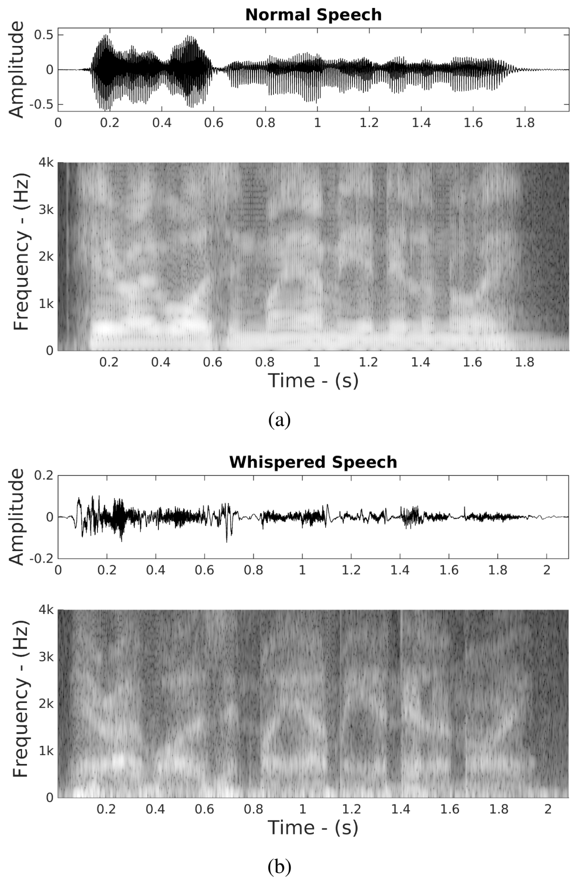


Figure 1: Comparison of waveform and spectrogram of the speech signal "*Here I was in Miami and Illinois*" from the same speaker in (a) normal and (b) whispered speech mode.

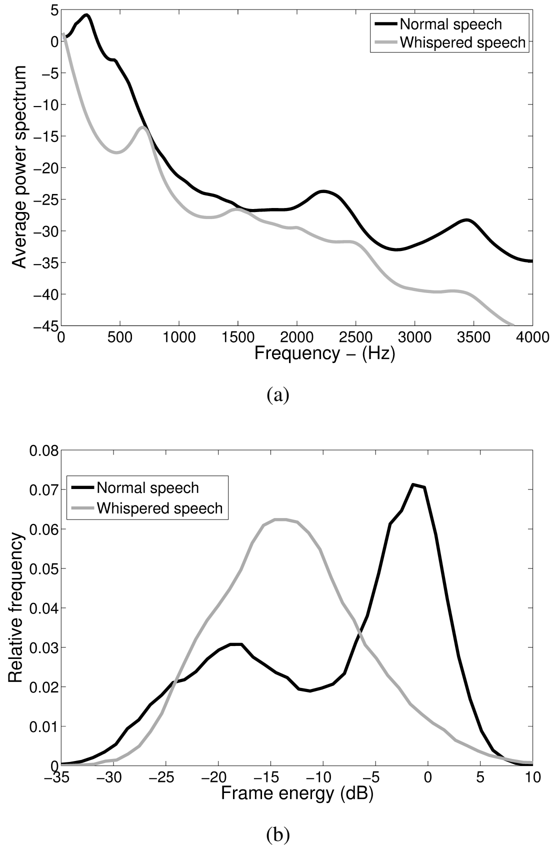


Figure 2: Plots of average power spectrum and frame energy distribution. (a) average power spectrum comparison of the utterance "*Here I was in Miami and Illinois*" spoken by same speaker and (b) frame energy distribution for normal and whispered speech using combined male and female data across 36 speakers.

related to SI, specially in access control and identity management applications. In the past, whispered speech has only been explored within the SI problem [5–8, 14, 25], where the use of the accuracy metric does not give a clear picture of the actual impact of mismatch conditions between training and testing [26]. In addition, it is not clear whether the strategies proposed for SI systems can also be useful for SV systems.

Currently, state-of-the-art SV systems based on normal speech use highly elaborate techniques, such as the so-called i-vectors [27]. However, to properly train such systems, large amounts of training data are required [2, 28]. Unfortunately these amounts of data are hard to collect for whispered mode, which can affect the training and limit the advantages of these techniques over other strategies. Furthermore, these methods are heavily dependent of the data, i.e., the nature of the testing data should be the same with the one the i-vector extractor was trained on [29]. According to our experiments, a classification system based on Gaussian mixture models (GMM) and maximum a posteriori (MAP) adaptation, as depicted by Figure 3, was more suitable for dealing with mismatched scenarios. For the described system, the widely-used mel-frequency cepstral coefficients (MFCC) are used to implement a text–independent SV system [2, 30]. First an M-Component GMM is trained as an universal background model (UBM) using the Expectation – Maximization (EM) algorithm and the training data available from all speakers. Then, a GMM for each speaker is obtained using MAP adaptation, as depicted by top half diagram in Figure 3. During the recognition phase (bottom half of Figure 3), the hypothesized speaker model is scored against the UBM and a decision is made based on thresholding. More details can be found in [30].

3.2 Speech stimuli

In our experiments, the CHAINS (Characterizing Individual Speakers) speech corpus was used [8]. The corpus contains the recordings of 36 speakers obtained in two different sessions with a time separation of about two months, there are three different accents : 28 speakers from Ireland (16 male), 5 speakers from the USA (2 male) and 3 speakers from the United Kingdom (2 male). Additional details about the database can be found in [8]. Speech stimuli was generated under six speaking conditions, namely solo (natural rate reading), retelling without time constraints, two-person synchronous reading, repetitive synchronous imitation, accelerated-rate reading, and whispered.

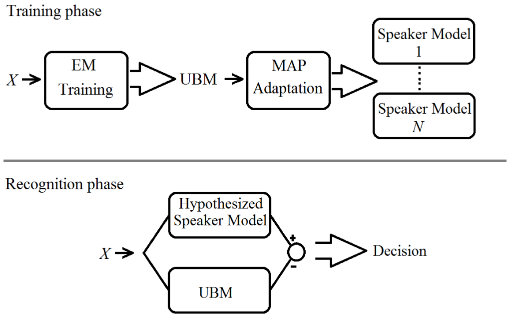


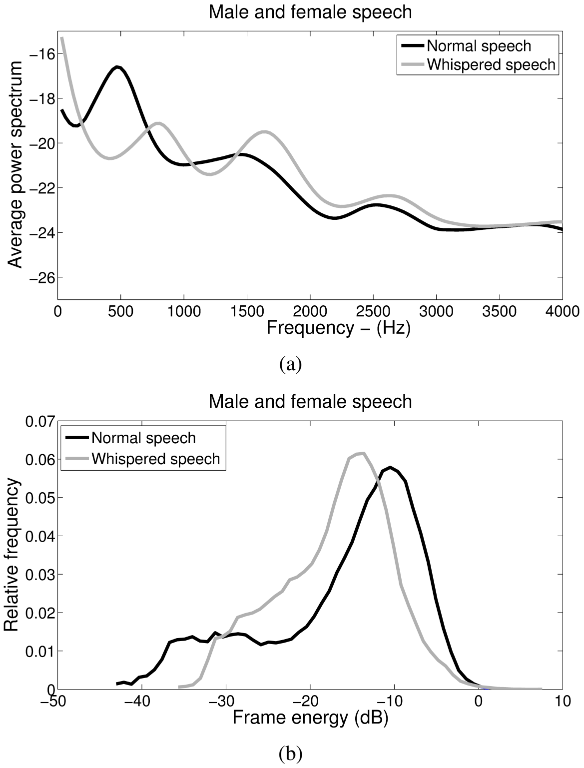
Figure 3: Block diagram of a general SV system. Top and bottom diagrams represent the training and testing stages, respectively, for a GMM-UBM SV based system

For our experiments, two speaking styles were used - solo and whispered - where the same text was read in both conditions. We used the speech stimuli generated from reading the paragraph of the *Cinderella story* (average duration : 55 seconds, minimum duration : 48 seconds) for training, and kept the stimuli generated from reading the *Rainbow Text* (average duration : 30 seconds ; minimum duration : 23 seconds) segmented in short sentences of 3 seconds, plus 32 individual sentences (nine selected from the CSLU Speaker Identification corpus and 23 from the TIMIT corpus) for testing. Data was originally recorded at 44.1 kHz sample rate but downsampled to 8 kHz, as motivated by [31].

3.3 Baseline performance in matched and mismatched conditions

Prior to feature extraction, in our experiments we normalized the speech data to -26 dBov (dB overload) using the ITU-T P.56 speech voltmeter [32], and pre-emphasized using a first order FIR filter with constant $a = 0.97$. Then 19 MFCC were computed on a per-window basis excluding the 0–th order cepstral coefficient, using a 32 ms window with 50% overlap and 24 triangular bandpass filters. Delta coefficients were also included to convey temporal dynamics information. Delta coefficients were computed by means of an anti-symmetric Finite Impulse Response (FIR) filter of length nine to avoid phase distortion of the temporal sequence. For all experiments herein, the training data was fixed to 35 seconds per speaker, and the number of Gaussian components per model was fixed to $M = 32$, showing a tradeoff between performance and computational burden.

Before presenting the results, we want to illustrate the effects of pre-emphasizing and normalizing the speech recording. Figure 4(a) and 4(b) depict the average spectrum and frame energy distribution, respectively, of amplitude-normalized and pre-emphasized recordings using male and female speech. As can be seen, the gap between the two speaking styles seen in Figure 2 has been greatly diminished, although most of the differences remain below 1.2 kHz.



(a)

(b)

Figure 4: Plots of (a) average power spectrum and (b) frame energy distribution after preprocessing for normal and whispered speech (averaged over 36 speakers).

Table 1 reports the Equal Error Rate (EER) obtained with the baseline system under different *train/test* conditions. In the table, 'c' stands for cepstral coefficients and 'Δ' for delta coefficients. As can be seen, for normal speech in the *normal/normal* (train/test) matched condition inclusion of delta coefficients did not provide any advantage over using only MFCCs. In fact, in the *normal/whisper* and *whisper/whisper* scenarios, inclusion of delta parameters had a negative impact on system performance, as previously reported by [6]. Only in the mismatch *whisper/normal* condition, was an improvement in EER with the inclusion of Δ parameters observed ; the gains, however, were modest and we can not considerate this as a significant advantage. In the Table, the values in bold represent the baseline performances with which improvements will be gauged against.

Table 1: EER(%) comparison for different *training/testing* conditions after power normalization and pre-emphasis. Results in bold represent the baseline systems with which the tested improvements will be gauged against.

		EER(%)	
Training	**Testing**	c	$c + \Delta$
Normal	Normal	**2.13**	2.33
Normal	Whisper	**35.75**	38.62
Whisper	Normal	29.81	28.18
Whisper	Whisper	2.90	3.12

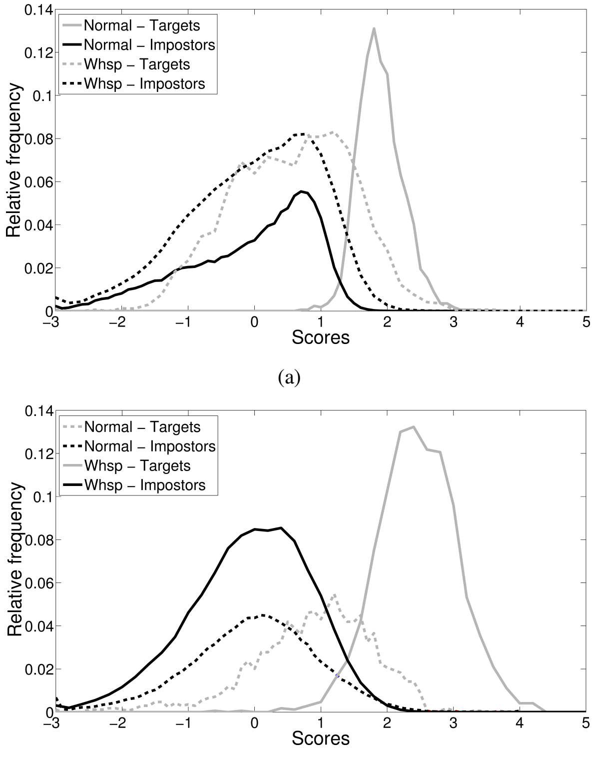
Overall, it can be seen that significant performance degradation occurs in the mismatch conditions. When testing with whispered speech, the obtained EER for the mismatch condition was more than 10 times greater than in the matched condition. Moreover, a gap of approximately 6 – 9% can be seen in mismatched cases, depending on what speaking style is used for training. As can be seen, lower EER is achieved when training with whispered speech and testing with normal. This was expected, as in our dataset, approximately 70/30% of the normal-speech training data was comprised of voiced/unvoiced speech segments. When training with normal speech, it is likely the GMMs became biased towards voiced characteristics which are not present in whispered speech. On the other hand, when training with whispered speech, the GMMs could more accurately represent unvoiced normal-speech segments, as only small differences have been observed between unvoiced consonants in whispered and normal speech modes [16]. To better illustrate this point, Figure 5 shows the plots of the scores distribution for target speakers and impostors under the two training conditions. Continuous lines represent the speaking style used for training (i.e., normal speech in subplot (a) and whispered speech in subplot (b)).

Figure 5(a) shows that by using normal speech for training the scores of normal speech are less scattered than those for whispered speech, which, in turn, show a high degree of overlap. Figure 5(b), on the other hand, shows the scores obtained when training only with whispered speech. As can be seen, scores from whispered speech testing recordings are still more scattered than those for normal speech, but the overlap has been reduced. Overall, as expected the matched *normal/normal* scenario resulted in the lowest EER. Together these findings suggest that alternate strategies are needed to improve the performance of SV systems based on whispered speech, particularly in mismatched cases. This is the focus of the sections to follow.

4 Strategies to improve system performance in mismatched train/test scenarios

4.1 Frequency and feature warping

Different frequency warping strategies have been proposed and can be used in lieu of the classical mel scale. These frequency warpings allow greater resolution to be placed at certain frequency ranges. Commonly used scales include : linear, exponential and the whisper sensitive scale (WSS) [33], in addition to the widely used mel scale. Previous studies using the exponential and linear scales showed that relative improvements of around 20% could be achieved ; however, for further improvements some knowledge about the speaking style was needed for testing [5, 25]. Furthermore, the improvements were shown only for the whispered speech speaker identification task, thus there is no evidence about the effects of this front-end in the speaker verification task. Table 2 shows the mappings between the original (f) and warped ($\hat{f}$) frequencies used in our experiments. The linear scale is omitted from the Table, as $\hat{f} = f$.



(a)

(b)

Figure 5: Plots of score distributions for target and impostor speakers using normal and whispered speech files. The scores were computed using two different systems, the system in (a) was trained only with normal speech and the system in (b) was trained only with whispered speech. Continuous lines are representative of the speaking style used for training.

Table 2: List of frequency warping strategies used in the experiments. Cepstral coefficients derived are MFCC (mel), EFCC (exponential - Exp. in the table) and WSSCC (WSS).

Scale	Frequency warping
Mel	$\hat{f} = 2595 \times \log_{10}(1 + \frac{f}{700})$
Exp.	$\hat{f} = 10610 \times (10^{f/50000} - 1)$
WSS	$\hat{f} = \begin{cases} \frac{2475 f^4}{1220^4 + f^4}, & 0 < f < 2000 \\ 4100 - \frac{2000}{1+e^{(f-300)/310}}, & 2000 \leq f < 4000 \end{cases}$

Using the same settings as before, 19 cepstral coefficients were computed using the above described frequency warping strategies, along with the delta coefficients. Cepstral coefficients derived are MFCC (mel), EFCC (exponential), WSSCC (WSS), and LFCC (linear). This experiment allows us to determine which frequency warping strategy can better reduce the negative impact of train/test mismatch. Additionally, to mitigate the effects of linear channel mismatch, a widely accepted method is called *feature warping*, which maps the distribution of the cepstral features to a normal distribution ($\mathcal{N}(0,1)$) by using a 3-second sliding window, also known as short-time Gaussianization (STG) [34]. For the sake of comparison, the different feature sets are evaluated in the two possible scenarios : with and without STG.

Results are shown in Table 3 where two *training/testing* conditions are evaluated, namely *normal/normal* and *normal/whisper* (represented in the table as N/N and N/W, respectively). Whilst the negative impact of mismatch is still evident, all frequency warping strategies have improved the MFCC performance. As an example, by using the whisper sensitive scale and appending delta coefficients it is possible to reduce the EER by approximately 13% relative to the baseline in mismatch condition without using feature warping. Furthermore, STG can result in additional improvements in the mismatch condition, leading to improvements up to 31% relative to the baseline. Notwithstanding, one disadvantage of frequency and feature warping is the drop in performance obtained in the matched N/N condition. For example, with MFCCs the EER doubles after STG. The other frequency warping strategies, on the other hand, resulted in more stable results after STG. As before, no significant advantages were observed by appending the delta coefficients.

4.2 Frequency sub-band analysis

Results presented in Tables 1 and 3 suggest that whispered speech conveys information highly related to each speaker, but significant differences are still present between the two speaking styles. Motivated by the results in Figure 4(a), we also explore the use of only a sub-band of the speech signal in which their difference is minimized. According to Figure 4(a), this sub-band ranges from approximately 1.2 kHz to 4 kHz. As such, the frequency-warpings are calculated between 1.2 and 4 kHz. This frequency band comprises mostly information from the second and third formants (F2 and F3). EER performance results are shown in Table 4. As observed, further gains are obtained in the mismatch condition, but at the cost of reduced performance in the matched scenario. Notwithstanding, these findings corroborate previously-reported cues showing a significant amount of speaker-specific information in the second and third formants [35, 36]. An additional advantage of focusing within this sub-band is that for whispered speech, shifts in F2 of 2 - 24% and in F3 of 1 - 10% have been observed relative to normal-voiced speech [21]. This is a rather low variation when compared with the shift for F1 that can be 50% or higher [21]. The most relevant improvement in mismatch condition is achieved using MFCC ; when comparing with the results in Table 3, a relative reduction in the error rate of approximately 38% is achieved using STG and without appending delta coefficients. It is important to emphasize that in the matched condition the error rate is three times higher than that reported in Table 3. Together, these results show the high relevance of speaker identity information contained below 1.2 kHz, particularly for normal speech.

4.3 Alternate feature representations

Some authors have proposed to use features completely different in nature to cepstral coefficients. As an example, features derived from the AM-FM signal representation have proven to be more robust in noisy conditions and perform at the same level as cepstral coefficients [8, 37]. The main difference is that cepstral coefficients are based on power spectrum estimation (i.e., frequency domain) whilst features derived from the AM-FM signal representation are computed in the time domain. More specifically, the AM-FM model decomposes the speech signal into bandpass channels and characterizes each channel in terms of its envelope and phase (instantaneous frequency) [8, 38]. The speech signal $s(n)$ is filtered through a bank of N_K filters, resulting in the bandpass signal $y_k(n) = s(n) * h_k(n)$, where $h_k(n)$ corresponds to the impulse response of the k-th filter. There are different approaches for filter design that have been used in speech applications. In this study, two approaches were tested : a gammatone filterbank [39], and the Gabor filterbank [8], each with 23 channels. Filter center frequencies range from 50 Hz to 3528 Hz and their bandwidths are characterized by the mel frequency scale. After filtering, each analytic sub-band signal $s_k(n)$ is uniquely related to a real–valued bandpass signal $y_k(n)$ by the relation :

$$s_k(n) = y_k(n) + j \cdot \hat{y}_k(n) \tag{1}$$

where $\hat{y}_k(n)$ stands for Hilbert transform of $y_k(n)$. There are two approaches to decompose each analytic signal in terms of its envelope and phase : *i*) the Hilbert envelope approach (non–coherent demodulation) and *ii*) coherent demodulation [38]. The main difference between these two approaches is in the allocation of phase between the envelope and carrier. Whereas the Hilbert envelope places all of the sub-band phase in the carrier, coherent demodulation makes the important distinction between carrier and modulator phase. In our previous work, it was found that the Hilbert envelope approach resulted in improved performance relative to the coherent demodulation approach [40], hence in this work only the Hilbert envelope approach is used. For the sake of notation, let $m_k(n)$ denote the low–frequency modulator and $f_k(n)$ the instantaneous frequency for each bandpass signal. Figure 6 depicts the general process to decompose the speech signal into bandpass channels and their respective modulator and instantaneous frequencies.

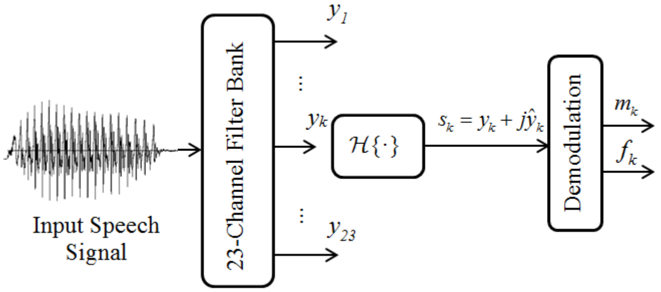


Figure 6: AM-FM signal representation. Block diagram to decompose the speech signal in bandpass channels and compute the low frequency modulator and the instantaneous frequency per channel.

Table 3: EER(%) comparison for matched and mismatched *training/testing* condition, using different frequency warping strategies and comparing the effects of using STG as feature warping. N/N and N/W correspond to training with normal speech and testing with normal or whispered speech, respectively. All feature representations where computed from the full 0 to 4 kHz band. EER values in bold highlight the best performance achieved in matched and mismatched conditions.

	without STG				**with STG**			
Cepstral	c		$c+\Delta$		c		$c+\Delta$	
Coefficients	**N/N**	**N/W**	**N/N**	**N/W**	**N/N**	**N/W**	**N/N**	**N/W**
MFCC	**2.13**	35.75	2.33	38.62	5.08	32.23	4.78	35.23
LFCC	4.88	31.04	4.60	30.20	4.17	**24.33**	5.20	25.82
EFCC	5.09	31.36	5.21	30.10	4.18	24.57	5.26	25.64
WSSCC	6.01	31.02	6.21	29.08	6.17	25.70	7.50	27.26

Table 4: EER(%) comparison for matched and mismatched *training/testing* condition using the sub-band from 1.2 kHz to 4 kHz to compute the different feature sets with different frequency warping strategies and comparing the effects of using STG as feature warping. N/N and N/W correspond to training with normal speech and testing with normal or whispered speech, respectively. EER values in bold highlight the best performance achieved in matched and mismatched conditions.

	without STG				**with STG**			
Cepstral	c		$c+\Delta$		c		$c+\Delta$	
Coefficients	**N/N**	**N/W**	**N/N**	**N/W**	**N/N**	**N/W**	**N/N**	**N/W**
MFCC	8.64	26.50	9.02	26.82	**7.14**	**21.81**	9.20	24.51
LFCC	9.58	27.54	9.53	25.96	7.44	21.81	9.62	22.89
EFCC	9.39	27.18	9.45	26.24	7.74	22.47	9.38	23.43
WSSCC	8.36	27.75	8.85	26.93	8.89	24.87	11.62	25.58

Here, two features are explored based on the AM-FM signal decomposition. The first is the so called Weighted Instantaneous Frequencies (WIF). These features are computed by combining the values of $m_k(n)$ and $f_k(n)$ using a short-time approach :

$$F_k = \frac{\sum_{i=n_0}^{n_0+\tau} f_k(i)\cdot m_k^2(i)}{\sum_{i=n_0}^{n_0+\tau} m_k^2(i)}, \quad k = 1, \ldots, 23, \tag{2}$$

where τ is the length of the time frame. F_k is calculated over the full length of each $m_k(n)$ with increments of $\tau/2$.

The second feature set is the mean Hilbert envelope coefficients (MHEC) proposed in [37] and shown to perform better than traditional MFCC features under noisy conditions for normal speech for speaker verification. In this case, the envelope $m_k(n)$ is blocked into frames and the mean Hilbert envelope for a specific frame in channel k is calculated as :

$$E_k = \frac{\log\left(\frac{1}{\tau}\sum_{i=n_0}^{n_0+\tau} w(i-n_0+1)\cdot m_k(i)\right)}{\bar{E}_k}, \quad k = 1, \ldots, 23 \tag{3}$$

where $w(n)$ is a Hamming window of length τ, and the term $\bar{E}_k$ represents the long-term average in each channel which normalizes the values of E_k. Finally, for a specific frame and using all 23 E_k values, a discrete cosine transform (DCT) is applied to produce the MHEC features [37].

Table 5 reports the EER obtained with the different filterbank characterizations, considering both the full band and the limited sub-band (1.2–4 kHz) components. In the matched condition, MHEC and WIF perform better than cepstral coefficients without STG and at the same level using STG. However, in mismatched condition both WIF and MHEC achieve error rates similar to the ones achieved with cepstral coefficients. These results suggest that the information present in the slowly varying envelope of the bandpass signals is highly discriminative, but extremely sensitive to changes in the vocal effort. By limiting the analysis frequency band to 1.2–4 kHz, a significant reduction of approximately 36% could be achieved relative to the baseline system in mismatched condition (see Table 1). This, however came at a severe penalty for the matched scenario, as was similarly observed with the cepstral coefficients (see Table 4).

4.4 Feature combination

Since cepstral coefficients, WIF, and MHEC extract complementary information, we explored feature combination as an alternate strategy to improve SV performance in mismatched scenarios. For this experiment, and based on the results presented in Table 4, the mel and linear scales were selected to

Table 5: EER(%) comparison for matched and mismatched *training/testing* conditions, using features derived from the AM-FM signal representation. Limited band corresponds to 1.2–4 kHz. Norm/Norm and Norm/Whsp correspond to training with normal speech and testing with normal or whispered speech, respectively. For each feature representation (WIF and MHEC) EER values in bold highlight the best performance per train/test condition.

	Filter Bank	**EER–Full band**		**EER–limited band**	
		N/N	**N/W**	**N/N**	**N/W**
WIF	Gammatone	**1.63**	33.73	5.87	24.63
	Gammatone + STG	4.48	29.48	7.86	23.19
	Gabor	2.18	35.65	6.53	24.27
	Gabor + STG	4.17	30.92	7.99	**22.77**
MHEC	Gammatone	2.06	42.24	9.80	26.72
	Gammatone + STG	5.51	41.34	10.71	28.78
	Gabor	**1.57**	36.73	9.13	**26.24**
	Gabor + STG	4.23	34.09	11.62	26.78

compute the cepstral coefficients in the 1.2–4kHz sub-band with STG. Moreover, motivated by results in Table 5, the WIF features using the Gammatone filter bank and the MHEC features using the Gabor filter bank were selected as they showed to be more effective in the matched condition without STG.

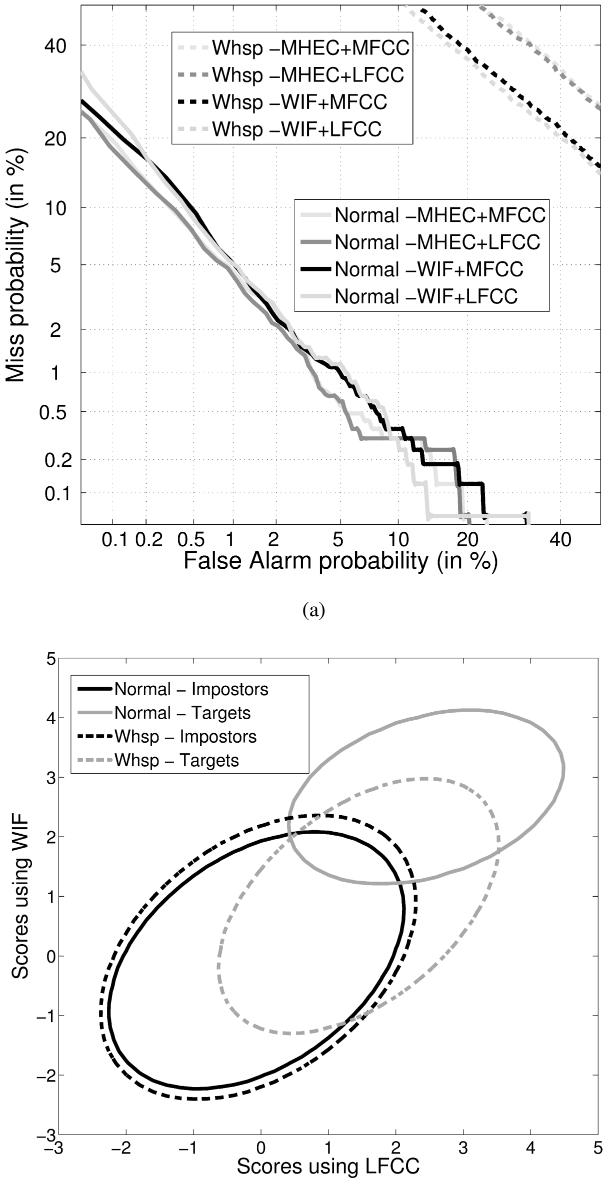
Results for feature combination are shown in Figure 7(a) and Table 6. In the table, the features labelled in the columns are combined with the features labelled in the rows to produce a new feature space and the EER corresponding to each testing condition is presented in the respective intersection. According to these results, feature combination does not help to obtain further reductions of the EER in mismatch condition (N/W). Notwithstanding, combining WIF and LFCC and comparing the results with the baseline system, this combination can help to maintain the performance inline with the baseline system for the match condition, whilst achieving relative reduction of the EER in the mismatch condition by approximately 21% . To extend the analysis, the scores of target speakers and impostors were calculated separately using WIF and LFCC. These scores were used to estimate the parameters of a 2 dimensional full covariance Normal distribution. The contours of the distributions are depicted in Figure 7(b) with continuous lines for normal speech and dashed lines for whispered speech. As can be seen, the overlap between target speakers and impostors for normal speech is minimum, however for whispered speech the scores are more scattered and higher overlap exists. As such, any decision boundary minimizing the error rate for normal speech will not necessarily be optimal for whispered speech. Such findings suggest the need for speaking-style dependent models, as will be described in Section 4.7.

4.5 Gender dependency analysis

Male and female voices are different from each other in terms of physical characteristics (pitch and vocal track length), linguistics and style. As such, some authors recommend to train separate systems per gender [41, 42]. To test if this trend also

Table 6: EER(%) comparison with different feature combination, where the best features from Tables 4 and 5 were selected. EER values in bold represent the best performance per train/test condition.

Cepstral Coefficients	**WIF**		**MHEC**	
	N/N	**N/W**	**N/N**	**N/W**
MFCC	2.17	29.35	2.29	36.96
LFCC	2.29	**28.16**	**2.05**	36.60



(a)

(b)

Figure 7: Plots of (a) DET curves for feature combination and (b) contours of an estimated Gaussian distribution for the scores of testing utterances. These Plots were obtained by using only normal speech for training and normal and whispered speech for testing.

occurs with whispered speech, we tested a gender-dependent system as well. This is possible, as systems have been shown to accurately discriminate genders from whispered speech in clean conditions [12,40]. Results are presented in Table 7 for individual features and Table 8 for feature combination. In the latter case, the combined feature sets used are the same as in Section 4.4. As can be seen, in the matched condition there are some differences relative to Table 6. First, for normal speech the feature representations that performed best for male speech did not perform at the same level for female speech, thus corroborating previous findings [41, 42]. Next, feature combination (Table 8) in gender dependent models does not help to reduce the impact in the mismatch condition relative to the results shown Table 6. This is also corroborated when comparing the results from Table 6 and the overall error rates presented in Table 8, thus suggesting that feature combination is more effective in the mismatched train/test condition for gender independent systems. It is possible that the models can learn some specific structures about whispered speech when both genders are involved into the parameter estimation. Together, these findings suggest that speaking style and gender dependencies are present in the whispered speech SV task. Such scenario will be further explored in Section 4.8.

4.6 Training with combined *normal/whisper* data

Results presented so far have shown that reliable performance can be achieved in matched conditions, but significant drop in performance occurs in mismatched conditions. As an alternate solution, here we explore the use of both normal and whispered speech during training and model adaptation as has been done in previous studies for speaker ID [6, 14]. This allows speaker-specific information represented in whispered speech features to be properly modeled. Since whispered speech training data can be sparse, it is not clear how much whispered speech material is necessary to achieve acceptable performance levels for practical applications. In order to be able to perform a comparison with the baseline system, we investigate the effects of adding small amounts of whispered speech to the training set, using a MFCC–GMM system (without delta coefficients). Experiments were conducted using a fixed duration length of normal speech (35 seconds per speaker) and different duration lengths of whispered speech for training.

Results of these experiments are illustrated in Figure 8 and Table 9. As can be seen, there is significant improvement by adding as little as 5 seconds of whispered speech per speaker relative to the mismatch performance reported in Table 1. By gradually increasing the duration length of whispered speech, the performance of the system also gradually improves, thus corroborating previous speaker identification findings [6, 14]. Nevertheless, using the same amount of data (35 s) for both vocal efforts shows that improved performance is still achieved with normal speech with respect to whispered speech (11% lower EER). In addition, it is necessary to pay attention to the slight losses induced by the addition of whispered speech, which slightly increases the EER for normal speech. For example, using only normal speech for training, an EER of 2.13 % was reported in Table 1. Here, in the case of using the same amount of data for both vocal efforts, an EER of 3.05 % (i.e., 43% higher) was found. According to these results, for a practical SV verification task improved performance can be achieved for whispered test speech, but at the cost of lower performance for normal test speech.

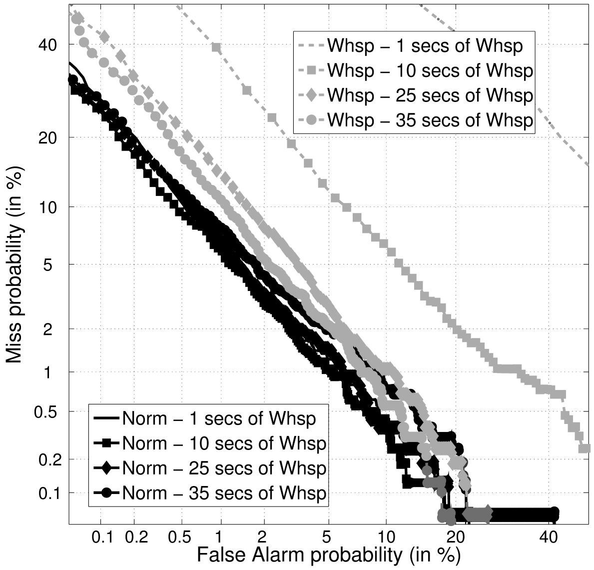


Figure 8: DET curves exploring the effects of adding different amounts of whispered speech to the 35 s of normal speech during the training phase.

4.7 Speaking–style dependent SV systems

Up to now speaking-style *independent* SV systems have been described to handle both vocal efforts. Recent literature on SI and speech recognition, on the other hand, has recommended the use of speaking-style dependent models [9, 10, 14], as depicted by Figure 9. The method builds on the previously described MFCC-GMM algorithm and takes into account the different subclasses that can be modelled in order to build a complete speaker verification system. In this section, two classes are investigated : normal and whispered modes. In order to develop a speaking-style dependent SV system, a classification stage is needed in order to detect specific speaking styles. For example, a recently proposed *normal/whispered* speech classifier can be used, as it was shown to perform accurately even in noisy conditions [43].

With speaking style dependent systems, the concept of "mismatch" shifts from one of *train/test* mismatch to one of errors in speaking style classification. In order to analyse the benefits of having dedicated speaker models for each speaking style, this first set of experiments will assume an "oracle" system in which perfect *normal/whisper* classification is achieved. For clean conditions, this is not an unrealistic assumption [43]. Within this scenario, we are particularly in-

Table 7: EER(%) comparison with different feature representation using gender dependent models and the best features from Tables 4 and 5. Best results are highlighted per gender and per training/testing condition.

	WIF		MHEC		MFCC		LFCC	
Gender	**N/N**	**N/W**	**N/N**	**N/W**	**N/N**	**N/W**	**N/N**	**N/W**
Female	**2.15**	38.52	2.72	40.79	7.60	28.18	8.46	**25.07**
Male	2.19	40.91	**1.04**	38.94	7.42	**25.85**	6.90	26.16
Overall	2.17	39.84	1.78	39.76	7.50	26.88	7.59	25.67

Table 8: EER(%) comparison with different feature combination using gender dependent models and combining the best features from Tables 4 and 5. Best results are highlighted per gender and per train/test condition.

	Female				Male				Overall			
Cepstral	**WIF**		**MHEC**		**WIF**		**MHEC**		**WIF**		**MHEC**	
Coefficients	**N/N**	**N/W**	**N/N**	**N/W**	**N/N**	**N/W**	**N/N**	**N/W**	**N/N**	**N/W**	**N/N**	**N/W**
MFCC	3.15	32.71	3.44	41.64	2.40	36.44	**1.25**	39.66	2.73	34.78	2.22	40.54
LFCC	**2.86**	**32.43**	3.29	41.35	2.40	**35.51**	1.35	39.77	2.60	34.14	2.21	40.47

Table 9: Effects of adding different amounts of whispered speech to the normal speech training set.

Amount of whispered training data (s)	EER(%) Normal	EER(%) Whispered
1	2.54	30.97
5	2.53	13.25
10	2.49	7.91
15	2.60	5.47
20	2.62	4.24
25	2.66	3.94
30	2.63	3.52
35	3.05	3.45

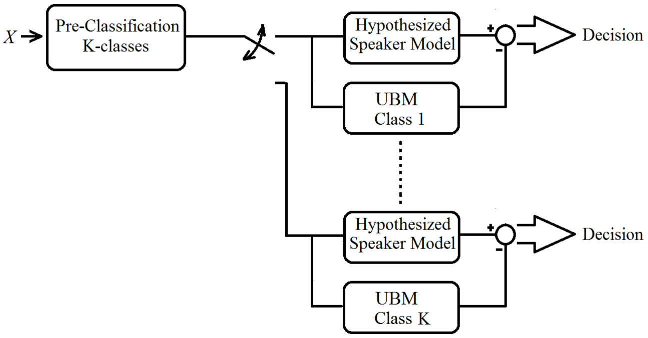


Figure 9: Multimodel framework for SV. Block diagram for a K-class speaking style dependent SV system

terested in the performance obtained with the whispered test speech files. Tables 10 and 11 show the EER comparison for different frequency warpings and AM-FM feature representations, respectively. As can be seen from Table 10, inclusion of delta coefficients degrades performance of the system. Overall, the Linear-Frequency Cepstral Coefficients (LFCC) and MFCC showed to be the two sets of feature vectors that can achieve the lowest error rates, outperforming the WSS scale, which was developed specifically for whispered speech [33]. From Table 11, in turn, it can be seen that the AM-FM based features provide a modest improvement over the cepstral-based features. When using the gammatone filterbank, WIF features outperformed the MHEC ones. The opposite behaviour was observed with the Gabor filter bank. In both cases (cepstral and AM-FM based features), the EER results obtained with whispered test speech files are slightly higher than those obtained with the normal-voiced files in Table 3, where an EER of 2.13% was reported with MFCCs.

Table 10: EER(%) comparison in W/W condition using speaking style dependent models. Results are for whispered test files and using different warping strategies to compute cepstral coefficients.

Cepstral coefficients	EER(%) c	EER(%) $c+\Delta$
MFCC	2.90	3.12
LFCC	2.90	3.08
EFCC	3.12	4.15
WSSCC	4.22	6.02

Subsequently, feature combination was explored. Motivated by the results presented in Tables 10 and 11, the mel and linear scales were chosen to compute the MFCC and LFCC features, respectively. The gammatone filterbank was used to compute the WIF features and the Gabor filterbank to compute the MHEC features. Since the inclusion of delta coefficients did not present any advantage for the considered feature sets, they were not included in this feature combina-

Table 11: EER(%) comparison in W/W condition using speaking style dependent models. Results are for whispered test files and using AM-FM based features. Highlighted results are the best EER values per feature representation.

	AM-FM features	
Filter Bank	**WIF**	**MHEC**
Gammatone	**2.55**	3.10
Gabor	2.62	**2.60**

tion analysis. Results are shown in the Table 12. According to these results, significant improvements can be achieved by combining features, thus corroborating their complementarity. A relative reduction of the EER of approximately 33% can be seen when comparing the best results from Tables 10 and 11, and outperforming those for normal speech reported in Table 1.

Table 12: EER(%) comparison in W/W condition with different feature combination, where the best features from Tables 10 and 11 were selected.

Cepstral	AM-FM features	
Coefficients	**WIF**	**MHEC**
MFCC	1.79	2.03
LFCC	1.91	1.85

4.8 Gender and speaking–style dependent SV systems

For these experiments, recordings were separated by gender in the training phase. Following the scheme presented in Figure 9, besides the speaking style detection, it would be necessary to detect two additional classes, i.e., male and female speech. For these experiments, two UBMs were obtained (one for each gender) as well as their respective speaker-specific models from MAP adaptation. Mel and linear scales were chosen to compute the cepstral coefficients, and from the AM-FM features the WIF using the Gammatone filter bank and the MHEC using the Gabor filter bank were selected. EER results are reported in Table 13. As can be seen, gender dependent systems provide advantages only for female speakers. Feature combination, on the other hand, did not provide further advantages as can be observed by Table 14. Interestingly, in the matched N/N scenario shown in Tables 7 and 8, male speech was shown to result in improved performance related to female speech. With the matched W/W scenario shown in Tables 13 and 14, the inverse is seen and female speech results in better performance, with AM-FM based features resulting in optimal performance.

Table 13: EER(%) comparison in W/W condition for gender and speaking style dependent models. Results are for whispered speech test files, and best EER values are highlighted per gender.

Gender	WIF	MHEC	MFCC	LFCC
Female	1.27	**0.99**	1.41	1.55
Male	**1.86**	2.18	3.73	3.21
Overall	1.59	1.65	2.69	2.47

As illustrated by Figure 9, when using class-specific models, gender classification needs to be performed prior to the verification stage. For this purpose, an M-component GMM was trained. Initially, different amounts of training data and different values of M were evaluated to analyse how these values affect gender detection error rates. Figure 10 shows that while the amount of training data does not have a significant effect on EER, the number of Gaussian components does. From Figure 10 it can be seen that there is a settling point using M=30 and 40 seconds of training data per speaker. Table 15 summarizes the gender detection error rates for different feature sets and Gaussian components M. As can be seen, for gender detection WIF and MHEC features, both using the Gabor filter bank, outperform MFCC features. Moreover, MHEC and WIF features achieve close to perfect accuracy even with only 10 Gaussian components. With MFCC, on the other hand, this performance is only achieved using $M = 30$. This suggests that there is gender-specific information in the phase of the acoustic signal and that an approach based on Hilbert envelopes can be used to characterize such information. This corroborates previously-reported subjective findings that whispers not only carry information about speaker identity but also about the gender [12, 19]. Hence, even without glottal excitation, gender discrimination has been shown to be a feasible task using whispered speech. Note that cepstral coefficients using other frequency scales or feature combination did not show any advantage for gender detection, hence they were not included in Table 15.

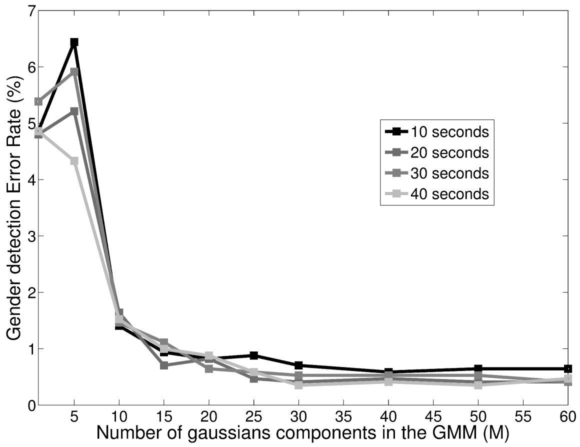


Figure 10: Gender detection error rate using MFCC as a function of of Gaussian components (M) and amount of training data per speaker.

Table 14: EER(%) comparison in W/W condition for gender and speaking style dependent models and feature combination. Results are for whispered speech test files, and best EER values are highlighted by gender.

Cepstral	**Female**		**Male**		**Overall**	
Coefficients	**WIF**	**MHEC**	**WIF**	**MHEC**	**WIF**	**MHEC**
MFCC	1.41	**1.13**	2.59	2.90	2.06	2.11
LFCC	1.27	**1.13**	**2.28**	2.69	1.83	1.99

5 Robustness to noise

As mentioned previously, whispered speech based SV is burgeoning due to the popularity of smartphones. But user mobility has also created several challenges that need to be addressed, one of them is robustness to ambient noise. Hence, it is important to analyse the robustness of the investigated features to noise. For these experiments, speaker models were trained with clean whispered speech and testing data was contaminated with three different signal-to-noise ratios (SNR) of babble noise : 5, 10 and 15 dB. Babble noise was chosen due to its challenging speech-like nature, as well as its likely presence in places where whispered speech SV is bound to be used. Using the speaking-style dependent system proposed in Section 4.7, experimental results are shown for both normal and whispered speech in Table 16. As can be seen for whispered speech, EER in noisy conditions increased for all feature representations as the SNR decreased, thus suggesting the sensitivity of the features to ambient noise. The benchmark feature MFCC is the feature set with worse performance at all SNR levels. LFCC and exponential frequency cepstral coefficients (EFCC), on the other hand, have better performance when tested alone, thus suggesting that a proper selection of frequency warping can improve robustness against noise. Interestingly, while in clean conditions the cepstral coefficients extracted from the WSS-warped spectra (i.e., WSSCC) did not result in optimal results, they outperformed all other cepstral-based features with noisy speech. A similar dependency on noise levels was observed with the MHEC features, which were outperformed by the WIF features. Regarding these latter features, the use of the gammatone filter bank showed improved robustness against noise relative to Gabor filter bank. Overall, our results suggest that WSSCC combined with WIF are the most appropriate setup for whispered speech SV under noisy environments.

Table 15: Gender detection error rates (%) for different feature sets and number of Gaussian components (M). Best results are highlighted by number of Gaussians.

Feature	**M Gaussians**						
Set	**1**	**5**	**10**	**20**	**30**	**40**	**50**
MFCC	4.85	4.33	1.52	0.99	0.58	0.40	0.38
WIF	3.45	1.22	**0.52**	**0.46**	0.46	0.39	0.35
MHEC	**3.04**	**1.11**	0.70	0.60	**0.38**	**0.35**	**0.30**

Similar noise sensitivity of the various features was also observed for normal speech. As seen previously, the MFCC features were most affected by noise. Interestingly, the WSSCC features also showed to be optimal in the very noisy scenario (SNR=5dB) for normal speech, thus showing the importance of frequency warping strategies for improved robustness against babble noise. Overall, AM-FM based features, as well as their combination with different cepstral features, were not as beneficial for normal-speech speaker verification in noisy settings as they were with whispered speech.

Note that results presented in Table 16 were obtained by assuming perfect *normal/whispered* speech classification in the speaking-style dependent system (i.e., an oracle system). However, different levels of noise can also affect this stage prior to speaker verification. In order to be able to quantify the total effect on system performance by the inclusion of noise, a second experiment was performed. Here, the speaking-style classifier described in [43] was used. EER comparison is shown in Table 17. The last row in the table shows the speaking style classifier error rates for different noise level scenarios. As can be seen, *normal/whisper* classification errors result in 20%, 16% and 10% relative increases in EER for SNR of 15, 10 and 5 dB, respectively. Despite this drop in performance, the speaking-style dependent system exhibits reliable performance even in noisy conditions. It is important to emphasize that results are not reported for the gender and speaking style dependent systems from Section 4.8 as the gender detection classifier was shown to be very sensitive to babble noise.

6 Discussion

There is evidence based on subjective studies suggesting that invariant speaker identity across different vocal efforts exists [13], i.e., a listener can recognize a speaker without training, using only the experience with normally voiced speech of the same speaker. Despite different strategies, such as frequency warping, preprocessing, and alternate feature representations, our results suggest that the invariant information between normal and whispered speech is not sufficient to achieve reliable performance in an SV task for *both* speaking styles. A compromise must be kept in order to guarantee system performance in normal and whispered speech. Notwithstanding, for most of the cases evaluated herein, improvements in the mismatched condition were accompanied with reduced performance in the matched scenario. Moreover, the strategies that performed better for normal speech did not exhibit the same

Table 16: EER(%) comparison for different feature representations under different ambient noise levels. Best EER values are highlighted in bold per feature group for the tested SNR levels and the two train/test conditions.

	W/W			**N/N**		
	SNR level			**SNR level**		
Feature set	**15 dB**	**10 dB**	**5 dB**	**15 dB**	**10 dB**	**5 dB**
MFCC	13.42	22.53	31.82	12.34	19.18	26.98
LFCC	7.13	13.42	21.27	7.20	9.13	13.67
EFCC	7.25	13.30	21.21	**6.96**	**9.07**	13.43
WSSCC	**6.35**	**9.59**	**15.78**	7.20	9.38	**12.95**
WIF (Gamma.)	**5.33**	**8.87**	**14.80**	16.33	22.14	28.80
WIF (Gabor)	7.43	12.22	20.61	**11.07**	**16.27**	**23.65**
MHEC (Gamma.)	16.48	27.44	36.49	18.81	27.47	35.33
MHEC (Gabor)	13.24	23.37	32.59	12.76	18.63	26.74
LFCC+WIF (Gamma.)	5.51	10.19	18.45	**7.86**	**10.95**	16.70
EFCC+WIF (Gamma.)	5.21	10.07	18.15	8.17	11.07	16.27
WSSCC+WIF (Gamma.)	**5.03**	**8.09**	**13.78**	8.23	11.07	**15.91**

benefits for whispered speech. This makes it difficult to find a speaker feature representation that stores speaker identity information invariant across both vocal efforts. More research is needed to find vocal effort invariant features.

Table 17: EER(%) comparison in W/W condition using the two feature representations more robust to noise (see Table 16) and *normal/whispered* speech detector in [43]. Last row reports detection error rate for the *normal/whispered* speech detector

	SNR level		
Feature set	**15 dB**	**10 dB**	**5 dB**
WIF (Gammatone)	6.90	10.12	16.40
WSSCC+WIF (Gammatone)	6.09	9.43	15.23
N/W detection error (%)	1.03	2.01	5.54

Frequency warping strategies, in the matched condition for whispered speech showed interesting results. Simple approaches such as mel and linear scales showed to outperform the WSS scale, which was designed specifically for whispered speech. This WSS scale divides the frequencies into several critical bands from 0 Hz to 4 kHz giving more emphasis to the frequencies where the resonance peaks of F1 and F3 are located. We found that the only advantage given by this strategy is an error rate reduction in the mismatched condition. While the mel scale places emphasis on lower frequencies around F1 and F2, WSS can better handle the mismatch condition due to the lower variation of the third formant between normal and whispered speech relative to F1 and F2 [21]. Notwithstanding, the WSS scale showed useful in scenarios involving babble noise for both whispered and normally-voiced speech.

In addition, we found that whispered speech speaker verification performance was higher for female speakers. This suggests that female whispered speech carries more speaker-specific information that is captured by the investigated features. In fact, most of the recent published research in the field has been done only with females [6, 7], thus making the improvements seem more noticeable. This gender-dependency may be due to the fact that formant shifts are more noticeable in male speech than in female. As seen in Figure 4, and as previously reported in the literature [21], F1 shifts can be up to 71% for men and 52% for women ; F2 shifts can be up to 24% for men and 20% for women ; and F3 shifts can be of 10% and 4.8%, respectively [21]. Further investigation into this gender dependency is still needed.

Regarding robustness to noise, we can observe that LFCC and EFCC outperform MFCC features. One explanation can be that babble noise highly affects low frequencies, mostly between 0 Hz and 1 kHz. As a consequence, frequency warping strategies placing more emphasis in such band (such as the mel scale) will suffer higher degradation. The linear scale, in turn, gives equal relevance to all frequencies. Moreover, linear and exponential scales are not very different in the range between 0 and 4 kHz, as shown in [6]. The fact that WSSCC does not emphasize lower frequencies but place more emphasis in certain bands where there is highly discriminative information, helps to explain why WSSCC achieved the best performance amongst the tested cepstral based features in a noisy environment. Additionally, WIF features also showed high performance in noisy environments thus suggesting that phase information assists with noise robustness for whispered speech.

7 Conclusions

In this paper, the speaker verification (SV) task based on whispered speech recordings was addressed. More specifically, the performance bounds of a standard GMM–UBM SV system were obtained using several strategies, such as frequency warping, sub-band analysis, alternate feature representations, feature combination, as well as class-dependent modeling (i.e., speaking-style and gender-specific). Our experimental evaluation shows that mismatch *train/test* conditions can highly affect the performance of a SV system, independent of the feature representation used. As in previous studies in adjacent areas, it was shown that in order for a SV system to handle both normal and whispered speech for practical applications, speaker model training had to involve data of both vocal efforts. Such approach, however, resulted in poorer verification performance for normal speech. To overcome this limitation, speaking–style dependent models and gender-specific models where used. In the latter scenario, female speakers were seen to benefit the most. Overall, feature representations evaluated here have been mainly proposed for normal-voiced speech applications, thus suggesting that alternate feature representations, tuned for whispered speech speaker verification, are still needed.

Lastly, regarding noise robustness, alternative frequency warping techniques to extract cepstral coefficients and AM-FM based features showed to offer more advantages in noisy environments than conventional MFCC features.

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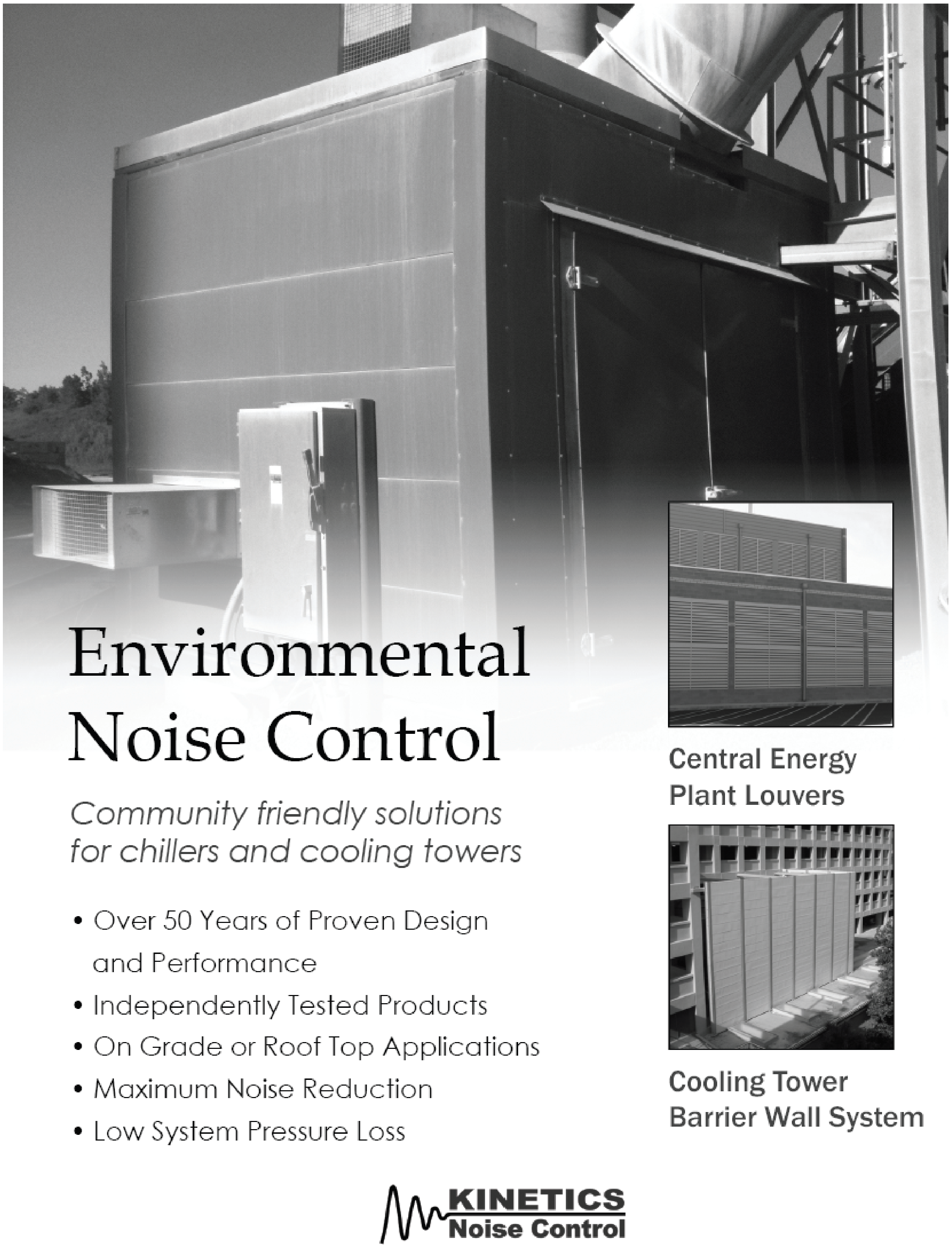

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Yearly Reviewer List / Liste annuelle des évaluateurs

The high scientific standards maintained by Canadian Acoustics in its papers owe much to the continuing dedication of the journal's reviewers, who give freely of their time and expertise. JCAA is pleased to pay tribute to this contribution by recognizing those who have participated in the review process. Thus, the Editorial Team of Canadian Acoustics acknowledge with particular gratitude the following reviewers who have reviewed papers during the last 12 months.

Les normes scientifiques élevées maintenues par la revue Acoustique canadienne doivent beaucoup au dévouement constant des réviseurs de la revue, qui donnent généreusement de leur temps et de leur expertise. JCAA est heureux de rendre hommage à cette contribution en reconnaissant ceux qui ont participé au processus d'examen. Ainsi, l'équipe de rédaction de l'Acoustique Canadienne reconnaît avec une gratitude particulière les réviseurs suivants qui ont examiné des articles au cours de la période des 12 derniers mois.

Omar Afifi
University of Ontario Institute of Technology
CANADA

Dr. Umberto Berardi
Ryerson University
CANADA

Professor Sumit Dhar
Northwestern University
UNITED STATES

Dale D. Ellis
CANADA

Pauline Fortier
CANADA

M. Jeff L. Fullerton
Acentech
UNITED STATES

Prof. Christian Giguère
University of Ottawa
CANADA

Mr Jeffrey Michael Goldberg
Custom Protect Ear, Inc.
CANADA

Dr. Gary S. Madaras
Rockfon
UNITED STATES

Prof. Frank A. Russo
Ryerson University
CANADA

Professor Jacek Smurzynski
East Tennessee State University
UNITED STATES

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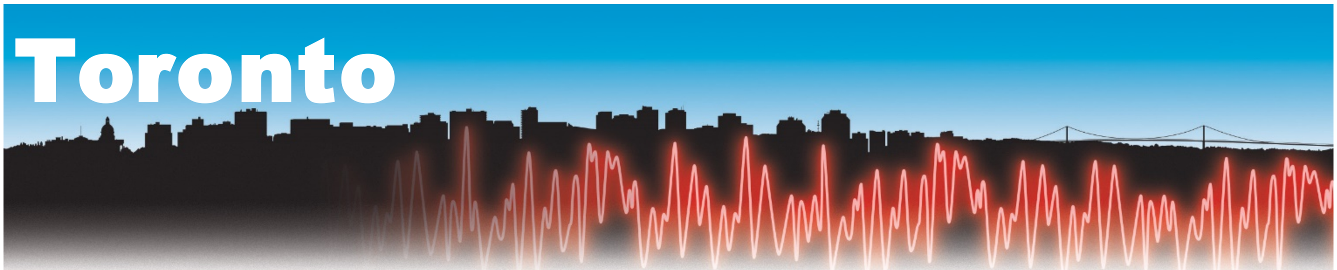


Call for Papers

Special issues with regional topics and articles

Acoustics is a broad subject matter, as you know, that currently employs hundreds of us across the country in fields as different as teaching, research, consulting and others. To reflect such diversity and to -maybe- help each of us discover a new professional in the neighborhood, the Canadian Acoustics journal is currently inviting submissions for a series of special “regional” journal issues from individuals, groups and companies located within the greater-areas of major cities in Canada.

After the successful Special issues that the Canadian Acoustics journal has published in June 2015, with several contributions from Montreal, the next special issue is tentatively programmed for June 2016, and will mainly include contributions from the **Greater Toronto Area.**

How to be part of it?

To contribute to these special “regional” journal issues, author are invited to submit their manuscript (2 pages minimum) under “Special Issue” section through the online system at http://jcaa.caa-aca.ca **before February 15th 2016**

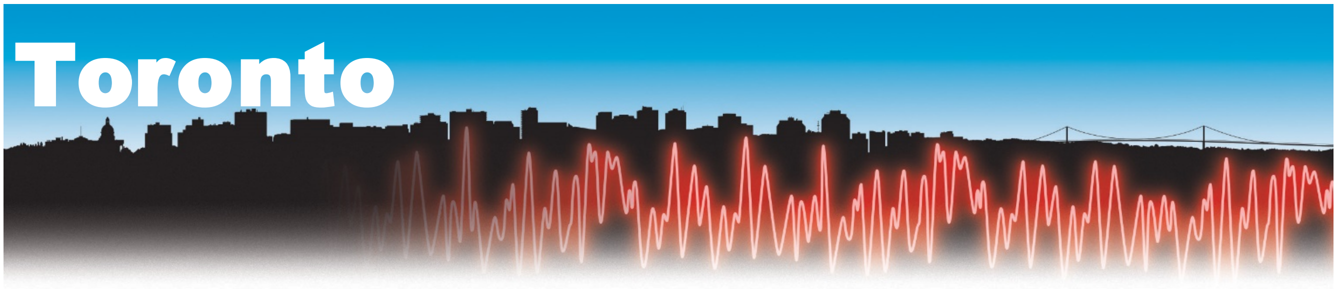
Each manuscript will be reviewed by the Canadian Acoustics Editorial Board that will enforce the journal publication policies (original content, non-commercialism, etc., refer to Journal Policies section online for further details) while welcoming promotion of authors expertise, companies services, and consultants' success stories and the like.

A true “regional directory” you want to appear in!

Each of these regional local issues of the journal can be considered as a local directory book for acoustics. They will be published in hardcopies, sent to all CAA national and international members, while electronic copies will be made available in open-access on the journal website. The content of these issues will be entirely searchable and comprehensively indexed by scholar engines as well as by major internet search engines (Google, Bing, etc.). Authors are invited to carefully select their keywords to maximize the visibility of their articles, while ad-hoc advertisement opportunities will be given to pair each article with a one-page full advertisement.

For any question, please contact Prof. Umberto Berardi (deputy-editor@caa-aca.ca) or Prof. Ramani Ramakrishnan (rramakri@ryerson.ca). To secure an advertisement for this special issue, please contact Mr. Bernard Feder (advertisement@caa-aca.ca).

Such an offer will only appear every 7-9 years, make sure to be in!



Appel à soumissions

Numéros spéciaux portant sur des sujets régionaux

Comme vous savez, l’acoustique donne matière à plusieurs sujets d’ordre général et créer des centaines d’emplois au pays, et ce, dans différents secteurs tels que l’éducation, la recherche, la consultation professionnelle et autres. Afin de bien refléter cette diversité et peut-être même à faire connaître davantage les professionnels de notre voisinage qui œuvrent dans le domaine, l’Acoustique canadienne fait un appel à soumettre une série d’articles provenant de personnes, groupes ou compagnies qui font partie d’une même grande région du Canada.

Suite au succès du premier numéro spécial régional de l’Acoustique canadienne, en juin 2015 pour Montréal, le prochain numéro est planifié pour juin 2016 et inclura des articles provenant uniquement de la grande région de **Toronto**.

Comment en faire partie?

Pour contribuer à un de ces numéros « régionaux », les auteurs sont invités à soumettre un article (de 2 pages maximum), sous la rubrique « Numéro spécial » dans notre système en ligne au http://jcaa.caa-aca.ca avant le **15 février 2016**. Il est possible de soumettre un même article dans les 2 langues officielles.

Chaque article sera révisé par le comité éditorial de l’Acoustique canadienne qui veillera à ce que les politiques de publications de la revue soient respectées (contenu original, contenu non commercial, etc. – voir les politiques de la revue pour de plus amples détails) tout en accueillant les articles qui font la promotion de l’expertise des auteurs, des services offerts par les compagnies, les réussites de consultants et autres sujets du même ordre.

Un vrai « répertoire régional » dans lequel vous voulez paraître!

Chacun de ces numéros spéciaux régionaux pourra être considéré comme un répertoire des noms et services locaux liés à l’acoustique. Ils seront publiés en format papier et envoyés à tous les membres nationaux et internationaux de l’ACA. Une version électronique sera aussi disponible en ligne sur le site internet de la revue. Le contenu de ces numéros sera indexé, donc facilement trouvable au moyen de moteurs de recherche majeurs, tels Google, Bing, etc.). Les auteurs sont invités à bien choisir les mots clefs pour maximiser la visibilité de leur article. Des opportunités de publicité ad hoc seront offertes pour jumeler chaque article avec une page complète de publicité.

Pour toutes questions, vous pouvez communiquer avec Umberto Berardi (deputy-editor@caa-aca.ca) et ou Ramani Ramakrishnan (rramakri@ryerson.ca). Pour réserver un espace de publicité dans un de ces numéros spéciaux, veuillez communiquer avec notre coordonnateur Bernard Feder (advertisement@caa-aca.ca).

Une telle offre ne se reproduira pas avec 7 ou 9 ans, assurez-vous d’en profiter maintenant!

PRIZE ANNOUNCEMENT • ANNONCE DE PRIX

CANADIAN ACOUSTICAL ASSOCIATION
ASSOCIATION CANADIENNE D'ACOUSTIQUE

Prize

Edgar and Millicent Shaw Postdoctoral Prize in Acoustics
Alexander G. Bell Graduate Student Prize in Speech Communication and Hearing
Eckel Graduate Student Prize in Noise Control
Fessenden Graduate Student Prize in Underwater Acoustics
Raymond Hetu Undergraduate Student Prize in Acoustics
Thomas D. Northwood Graduate Student Prize in Architectural and Room Acoustics
Albert S. Bregman Graduate Student Prize in Psychological Acoustics

Prix

Prix Post-doctoral Edgar et Millicent Shaw en Acoustique
Prix etudiant Alexander G. Bell en Communication orale et audition (2e ou 3e cycle)
Prix etudiant Eckel en Controle du bruit (2e ou 3e cycle)
Prix etudiant Fessenden en Acoustique sous-marine (2e ou 3e cycle)
Prix etudiant Raymond Hetu en Acoustique (1er cycle)
Prix etudiant Thomas D. Northwood en Acoustique Architecturale et Acoustique des Salles (2e ou 3e cycle)
Prix etudiant Albert S. Bregman en Psychoacoustique (2e ou 3e cycle)

Deadline for Applications:
April 30th 2016

Date limite de soumission des demandes:
30 Avril 2016

Consult CAA website for more information
Consultez le site Internet de l'ACA pour de plus amples renseignements
(http://www.caa-aca.ca)

Canadian Acoustical Association
Association canadienne d'acoustique

2015 PRIZE WINNERS / RÉCIPIENDAIRES DES PRIX 2015

FESSENDEN GRADUATE STUDENT PRIZE IN UNDERWATER ACOUSTICS /
PRIX ÉTUDIANT FESSENDEN EN ACOUSTIQUE SOUS-MARINE

Caitlin O'Neill (University of Victoria)

BELL GRADUATE STUDENT PRIZE IN SPEECH COMMUNICATION AND HEARING /
PRIX ÉTUDIANT BELL EN COMMUNICATION VERBALE ET AUDITION

Jonathan Vaisberg (University of Western Ontario)

ECKEL GRADUATE STUDENT PRIZE IN NOISE CONTROL /
PRIX ÉTUDIANT ECKEL EN CONTRÔLE DU BRUIT

Zahra Nili Ahmadabadi (École de Technologie Supérieure)

BREGMAN GRADUATE STUDENT PRIZE IN PSYCHOLOGICAL ACOUSTICS /
PRIX ÉTUDIANT ALBERT S. BREGMAN EN PSYCHOACOUSTIQUE

Jessica Arsenault (University of Toronto)

RAYMOND HÉTU PRIZE IN ACOUSTICS /
PRIX ÉTUDIANT RAYMOND HÉTU EN ACOUSTIQUE

Sylvia Mancini (University of Toronto in Mississauga)

CANADA-WIDE SCIENCE FAIR AWARD / PRIX EXPO-SCIENCES PANCANADIENNE

Samantha Peets and Jeremy Mallete (St. Joseph's S.S., Cornwall, Ontario)

UNDERWATER ACOUSTICS AND SIGNAL PROCESSING STUDENT TRAVEL AWARD /
SUBVENTIONS POUR FRAIS DE DÉPLACEMENT POUR ÉTUDIANTS EN ACOUSTIQUE SOUS-MARINE ET TRAITEMENT DU SIGNAL

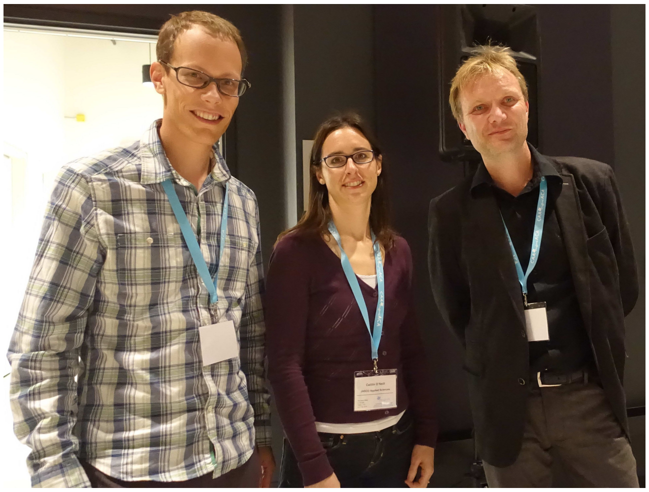
Caitlin O'Neill (University of Victoria)
Graham Warner (University of Victoria)

STUDENT PRESENTATION AWARDS / PRIX POUR COMMUNICATIONS ÉTUDIANTES
HALIFAX (NS), OCTOBER 6-9, 2015

Fabien Bonnet (École de Technologie Supérieure)

Graham Warner (University of Victoria)

Jessica McKellar (University of Prince Edward Island)



Left - Awards winner Caitlin O'Neill (Fessenden graduate student prize in underwater acoustics)
Right – Awards winners Graham Warner and Caitlin O'Neill (Underwater acoustics and signal processing student travel award),
with Awards Coordinator Hugues Nélisse, at the Awards Ceremony during the Acoustics Week in Canada 2015 in Halifax

Gauche – Récipiendaire de prix, Caitlin O'Neill (Prix étudiant fessenden en acoustique sous-marine)
Droite – Récipiendaires de prix Graham Warner et Caitlin O'Neill (Subventions pour frais de déplacement pour étudiants en acoustique sous-marine et traitement du signal),
en compagnie du Coordonnateur des Prix Hugues Nélisse, à la cérémonie de remise des prix lors de la Semaine de l'Acoustique Canadienne 2015 à Halifax

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Student presentation awards winners Graham Warner (left) and Fabien Bonnet (right), with Awards Coordinator Hugues Nélisse, at the Acoustics Week in Canada 2015 in Halifax

Récipiendaires des prix des communications étudiantes Graham Warner (gauche) et Fabien Bonnet (droite), en compagnie du Coordonnateur des Prix Hugues Nélisse, lors de la Semaine de l'Acoustique Canadienne 2015 à Halifax

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CONGRATULATIONS / FÉLICITATIONS

Canadian Acoustical Association

MINUTES OF THE BOARD OF DIRECTORS MEETING

Maritime Room at Westin Nova Scotian, Halifax, Nova Scotia
6 October 2015

Present: Frank Russo (chair), Alberto Behar, Bill Gastmeier, Bryan Gick, Dalila Giusti, Michael Kiefte, Hugues Nélisse, Roberto Racca, Mehrzad Salkhordeh, Jérémie Voix; [by conference call] Christian Giguère, Kathy Pichora-Fuller.

Minutes taken by Roberto Racca.

The meeting was called to order at 15:10 local time (ADT).

Minutes of the previous Board of Directors meeting held by teleconference on 8 May 2015 were approved by participants without correction. (*Approval moved by Jérémie Voix, seconded by Dalila Giusti, carried*)

President's report (Frank Russo)

a. Frank notified the Board that as of 12 May Guelph had been approved for hosting Acoustics Week in Canada 2017 (*additional information later in these minutes*).
b. On 29 May CRA acknowledged continuance of the Association under the new Canada Not-for-profit Corporations Act and the official name change to "Canadian Acoustical Association / Association canadienne d'acoustique" (former name contained superfluous articles); Frank noted that a form still needed to be filed in Ontario as province of registration, and he would take care of that.
c. In September a brief history of the Association was featured in an INCE newsletter; Frank had provided copy for that feature in August by revamping an older text. Jérémie will ask our webmaster to reproduce the piece on the CAA-ACA website (no need to obtain permission since it came from the Association in the first place).
d. In the wake of the recent changes to the Association's articles and bylaws, Frank called for a review and discussion of how the nomination and selection process for the Board should be conducted henceforth. The premise at the outset was that the Board would put forward at the AGM a slate of designate directors and officers; the membership could propose new candidates, but the Board would retain final decision on the appointment to executive roles. It was also noted that the new bylaws place no restrictions on how many directors may serve (as long as there are a minimum of three) and for how long. Following debate, the following protocol was agreed upon:
    i. Board will continue having 12 Directors (in regular circumstances) who in common practice are asked to stay in office for four years, including four officers – President, Secretary, Editor and Treasurer – who may serve for an indeterminate period.
    ii. After choosing a slate of candidates ahead of time and announcing them at the AGM, nominations will be accepted from the floor and subjected to a final internal decision by the Board post-meeting.

    Note: Although the above was the effective position reached by the Board at the meeting and is thus entered in the record, follow-up discussion among Board members prior to the AGM led to the adoption of a revised protocol that fully involves the membership in the ratification of Board members. The adopted selection procedure is included as a footnote at the end of these minutes.
e. Frank informed the Board that Karen Turner did not intend to continue serving as a Director, but Joana Rocha (Carleton University) had expressed interest in the role. The Board agreed to accept Joana's candidacy. Since all the other Directors were willing to continue serving for another term, this gave a full slate of 12 candidates to propose at the AGM.
f. As an initiative to ensure smooth flow of information and support in matters regarding the annual conference, Frank proposed that a member at large of the Board (ideally with experience in chairing an earlier edition) be tasked to act as liaison with the conference organizers on a recurrent basis. Michael Kiefte agreed to be the first to fill this position and received unanimous support from the Board.

Treasurer’s report (Dalila Giusti)

The report presented a summary of the assets, a summary of the awards, a comparison of the proposed and actual budgets for 2015, and a proposed budget for 2016. The following points were presented and discussed by Dalila:

a. Association’s finances are generally in good shape. The corporate tax return was filed in May 2015. The review Engagement Report has been received from the Association’s accountant and has been accepted.
b. Advertising revenue collected was $11,400, with an additional $9,000 in outstanding receivables. A loss of $8,135 was incurred from the Winnipeg conference, but on the positive side the CAA-ACA received a 3-year GST rebate of $21,950 because of the organization’s not for profit status.
c. The CAA-ACA’s Capital Fund is invested in three GICs that are maturing this year; two of them are secure accounts yielding a fixed 1.55% whilst the third is a potentially high-yield account (up to 40% of invested value). The principal is guaranteed.
d. Awards totalling $6,650 are to be distributed at the 2015 Halifax conference. Interest earnings have not been sufficient to cover awards but successful past conferences have generated sufficient funds to pay out the award prizes.
e. The Board is requested to approve transfer of $3,000 from the Operating Account to the Capital Account to cover the student prizes.
f. The 2014 journal expenses were $29,000. The journal costs for the current year presented in the statements are incomplete because the costs from the suppliers for the September and December issues are not yet known. Commencing with the next spring meeting of the Board a summary of the full previous year’s journal expenses will be provided.
g. Advertising revenue is beginning to pick up thanks to efforts by Bernard Feder, the Association’s advertising editor, to approach advertisers for new business and to ensure payment on existing accounts. An improved system to collect outstanding amounts and to coordinate payments received is being implemented.
h. For individual membership payments, PayPal has provided easy access to on-line transactions and automatic issuing of receipts. On-line payment also being used in some corporate transactions (purchase of advertising), but still a long way from being adopted by institutions and organizations that largely still require PO’s and pay by cheque.
i. The Hugh Jones award for physical acoustics is moving ahead after prolonged discussions with the benefactor and his agents on the structuring of the gift; issues of control of investment have been addressed and final papers are being signed.

Approval of the Treasurer’s report and, by reference therein, the transfer of funds to the capital account (point e. above) was moved by Alberto Behar and seconded by Roberto Racca; carried unanimously.

- ACTION: Mehrzad suggested in discussion to optimize sponsorship opportunities for future conferences by better structuring the support levels (e.g., Gold plan, platinum plan, etc.). The Board is to take this on over the coming months to better assist the next meeting.
- ACTION: Frank proposed in discussion that the Association increase allocation for student travel funding to increase involvement in the annual meetings, and ultimately membership. This is to be considered by the Board in coming months.

Ad-hoc report about the 2015 conference

Michael Kiefte (busy with preparations for the imminent start of the event and thus not available for the full meeting) gave a brief status update. Conference is on the lean side financially but will run a positive budget. Fewer full registrations than expected (about 77 by latest count); peak of single-day registrations for the Thursday, making the total around 100 for that day. Tally is still incomplete as not everyone has registered yet; many registrations surprisingly came in post early discount deadline.

Secretary's report (Roberto Racca)

a. Roberto provided and discussed a summary of categorized information about the 2015 membership and subscriptions based on the CAA database, with comparison to the previous year's numbers.

Category	Paid-up 2015 As of 5.10. 2015	Reported 2014
Regular member	165	158
Emeritus	1	1
Student	22	16
Sustaining subscriber	28	27
Indirect subscribers		
- Canada	3	3
- USA	6	3
- International	5	3
Direct subscribers	4	4
Total	**234**	215

b. There has been a slight increase in numbers for almost every category, although in the case of the indirect subscribers the change is due at least in part to a recent adjustment in the status of institutions managed by subscription agencies that had been overlooked in the handling of paper based renewals. Roberto suggested that coalescing the secretarial correspondence to a single point of contact would prevent delays and occasional oversights in responding to renewal instructions provided by post.
c. In the longer term, better tracking of the status of corporate and institutional subscriptions handled through agencies would be achieved by having the latter sign on to an electronic renewal process similar to that used by individual members and direct subscribers. Such a change, however, seems not to be compatible with their established practices. Roberto proposed to make some updates to the database entries for indirect subscribers that will result in prompter notification of their lapsing or need for renewal.
d. The on-line enrolment and renewal process has been embraced by the majority of the membership, with very few cases of paper-based applications. There have been a few requests for conventional invoices to be issued, and a few requests for formal receipts from the Association. Roberto indicated that whilst the present volume of requests can still be handled manually, it would be worth looking into the possibility of having formal receipts in PDF format sent out automatically by e-mail as part of the on-line process; it would appear that the current PayPal payment receipt is not generally seen as formal documentation of the payment of professional dues.
e. The Board agreed in principle to Roberto's suggestion to discontinue the Ottawa PO box mailing destination (currently handled by Chantal as a courtesy) and update all mailing address references in print and web to his office address at JASCO Applied Sciences in Victoria except for cheques mailing instructions that should point directly to Dalila. Practical issues about the timeline for this transition will have to be considered in terms of outstanding mailing instructions, return labels information etc.
f. In discussion of membership matters Frank raised the issue that some registrants at the annual conference assume that if their company has a corporate subscription they can register at member rates. The misperception that corporate subscriptions (including sustaining ones) entitle individuals in that organization to membership rights requires better clarity in communications from the Association, and firmness in applying the rules.

Editor's report (Jérémie Voix)

a. Last year there was a request from members during the AGM to have access to stats of the online journal use; site has been equipped to provide that information. Roughly 8,000 articles are downloaded each month, most of them are by indexing robots (Google, Yahoo, Microsoft, etc.) as we have an open-source access.

b. Membership database tallying code has been updated online so that it provides to both the Treasurer and Secretary the correct statistics for paid-up members.
c. Better coordination of advertiser records has been implemented between journal editorial office and advertisement coordinator through the use of a Google Spreadsheet.
d. Migration is underway to consolidate conference proceedings and journal articles databases through an XML journal importation script.
e. Instant open access is still available as a 300$ fee based service, but no longer easily selectable as a form checkmark because it generated confusion with authors. Consensus among Board members in discussion is that Association should advertise more proactively (e-mail blast) the open access feature of the Journal as a benefit of publishing in JCAA, specifically as Canadian academics now have to make most of their work openly available 12-months after publication.
f. JCAA still undergoing review for inclusion into the Web of Science. Process can take upward of a year, and in the process it is especially important that authors adhere strictly to publication guidelines to facilitate a positive outcome.
g. Prof. Josée Lagacée resigned earlier in the year from her Deputy Editor position and the role has been filled by Prof. Umberto Berardi as of September 2015.
h. JCAA is being indexed by SCOPUS but process has stopped for technical reasons and needs to be reinstated; editor is following up.
i. JCAA could support Digital Object Identifier to allow instant electronic referral. Annual fee is $275/year, as well as cost for identification of the +2600 articles. Editor to provide a cost estimate; budget approval by the Board will then be required.
j. JCAA on-line system has been migrated in spring 2015 to a virtual private server on OVH.net. Budget for the hosting had been approved previously for a multi-year term. AWC on-line system and CAA website should soon follow, and no later than March 2016, as the old web hosting will be expired.
k. October 2015 issue with post-conference articles is due to be sent; June 2016 issue will be Toronto edition of “Canadian Cities Acoustics” curated by Ramani Ramakrishnan and edited by newly appointed Deputy Editor, Umberto Berardi.

Present / Future Meetings

a. 2015 Halifax – See intervention by Michael Kiefte above.
b. 2016 ICA will be held in Buenos Aires (for information)
c. 2016 Vancouver (Sept 22-24, to follow World Congress of Audiology Sept. 18-22). Kathy Pichora-Fuller gave an update about candidate venues. She raised the option to have the event in the suburb of Richmond as opposed to downtown Vancouver / North Vancouver which would be about twice the cost per room. Richmond has a very reasonable offer for room nights to be achieved in order not to pay for meeting rooms, plus free audio, free internet and other benefits. If price is an issue this would be a clear choice, but location would not be the most appealing. Frank noted that a downtown venue would generate more excitement and lead to greater participation. Kathy has received some good offers for rates and meeting packages at prime hotels and will be pursuing a choice in the near future. She indicated that she was seeking ideas for plenary speakers and put forth the question of whether a budget should be allocated for an honorarium and/or travel and lodging costs; other members of the Board generally opposed the idea of paid speakers. Kathy is also pursuing a still vague concept of a pre- or post-conference workshop aimed at young acousticians just starting in or about to enter the consulting world.
d. 2017 Guelph. Frank gave a brief follow-up to his announcement in the President’s report. Event is now confirmed at that locale. The organizing process is moving along under the leadership of Peter vanDelden.
e. 2018 Expression of interest from Kingston but no actual proposal. Frank informed the Board that he has received a communication from Stan Dosso with the potential idea of combining the 2018 CAA conference with the ASA autumn meeting in Victoria, BC that Stan will be chairing. Purely conceptual at the moment; no formal outreach from one society to the other has taken place. Members of the Board expressed concerns about the financial risks of tying the CAA conference fortunes to the ASA budgeting. Generally, however, it was felt that Victoria would be an excellent venue and provide geographic diversity after Guelph instead of another Ontario locale.

Award Coordinator's Report (Hugues Nélisse)

a. The 2015 awards are as follows:

Award	Coordinator	Winner
Shaw postdoctoral	Stan Dosso	No entry in 2015
Bell Student Prize in Speech Communication and Speech	Kathy Pichora-Fuller	2 entries in 2015 Winner: Jonathan Vaisberg, U. Western Ontario
Fessenden Student Prize in Underwater Acoustics	Sean Pecknold	1 entry in 2015 Winner: Caitlin O'Neill, U. of Victoria.
Eckel Student Prize in Noise Control	Clair Wakefield	1 entry in 2015 Winner: Zahra Nili Ahmadabadi, ÉTS, Montréal
Bregman Student Prize in Psychological Acoustics	Frank Russo	1 entry in 2015 Winner: Jessica Arsenault, U. of Toronto
Northwood Student Prize in Architectural and Room Acoustics	Ramani Ramakrishnan	No entry in 2015
Raymond Hétu Prize in Acoustics	Meg Cheesman	1 entry in 2015 Winner: Sylvia Mancini, U. of Toronto in Mississauga
Canada-Wide Science Fair Award in Acoustics	Annabel Cohen	Samantha Peets, Jeremy Mallette St. Joseph's S.S., Ontario
Directors' Awards • Non-student • Student		• To be evaluated • To be evaluated

b. Hugues noted that almost all awards are being presented this year with the exception of the Shaw Postdoctoral Prize and the Northwood Student Prize in Architectural and Room Acoustics. There was discussion among Board members of why it is so difficult to find candidates for the latter award, and suggestion that more reaching out should be done to promote participation. Still, also for the other awards there were very few entries, and just one entry for most of them (that does not guarantee winning, if the entry is deemed weak).

c. Papers to be evaluated for Directors' Awards are to be circulated soon.

d. The Board discussed how the CAA-ACA awards cold be made more meaningful. Even with small bases of candidates, medals and awards remain valuable as a means to recognize a highlight in someone's career and they contribute to a person being considered for later recognitions based on life achievements. The consensus was that there is no need to endanger the well-run system currently in place by overhauling the awards structure, but the Board and other members of the Association should be bolder in reminding the community about the awards and encouraging potential candidates to apply.

Standards Committee Report

Tim Kelsall was not available to present his report. His continuing position as chair of the committee had to be ratified by the Board. (*Moved by Frank Russo, seconded by Dalila Giusti, carried unanimously with abstention of Alberto Behar and Bill Gastmeier because of their involvement in the committee's activities*).

- ACTION: Board has been asked to comment on a number of aspects of the Standard Committee's activities; need to follow up.

Other Business

There being no further items raised for discussion, meeting was adjourned at 19:35 (*moved by Frank Russo, seconded by Dalila Giusti*)

Footnote

After the BoD meeting and prior to the AGM, the Directors had a follow-up deliberation that led to the adoption of a revised protocol for filling positions on the Board.

Protocol is as follows:

A slate of twelve nominees is pre-selected by the Board. Their names are presented to the members at the AGM (projected on overhead screen).

The President calls for any additional nominations from the floor.

- a. If there are no new nominees, all board-nominated members are elected by acclamation.
- b. If there are new nominees, then the existing and new names are projected on the overhead screen and voting proceeds by secret ballot;
  - i. Membership at the meeting is asked to list on paper slips 12 of the names from the overhead
  - ii. Past president (or delegate) and a volunteer from the membership counts up the votes
  - iii. The 12 candidates with most votes are elected.

Board proceeds after the meeting to appoint officers.

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Canadian Acoustical Association • Association canadienne d'acoustique

ANNUAL GENERAL MEETING
ASSEMBLÉE GÉNÉRALE ANNUELLE

Westin Nova Scotian Hotel, Halifax, Nova Scotia
Thursday, 8 October 2015
17:00-18:00

1. Call to Order: 17:10 – about 25 members

2. Approval of previous minutes:

MOTION to approve the previous minutes by Alberto Behar, seconded by Ramani Ramakrishnan, carried.

3. President's Report (Frank Russo)

a. The Association's transition process with CRA under the new Canada Not-for-profit Corporations Act, which required an updating of bylaws, is complete; we filed as a registered charity as well; a formal name change to correct grammatical issues (superfluous articles) still needs to be filed in Ontario.

b. Frank congratulated organizers on a very well planned and run meeting, but noted that numbers are still in a dip compared to several years ago. No full tally is available yet, but attendance stands at roughly 80 people for full registration and several more single day participants.

c. Next year's conference in Vancouver will be at a different period of the year, 21-24 September, to dovetail with the World Congress of Audiology providing a cross-over between the two events. Congress chair Cathy Pichora-Fuller intends to incorporate audiology relevant content in the CAA-ACA congress. She is now assisted by Claire Wakefield who has agreed to co-chair the event.

d. Guelph is confirmed as host city for the 2017 conference and is well underway with preparations. Organizing committee is chaired by Peter VanDelden. Christian Giguère is to be technical chair.

4. Treasurer's Report (Dalila Giusti)

a. Finances are in good shape, in particular thanks to previous congresses (pre 2014) that did well financially. Also received substantial GST refund that offset losses incurred in the 2014 event.

b. Not enough money is available in the capital account to pay for student prizes, so the Board has authorized the transfer of $3,000 from the operating account. A total of $6,650 [*updated number*] is being paid out in awards this year. Dalila noted that the Youth Science Fair (YSF) Award exacts a $1,000 annual fee to manage the $1,000 bursary.

c. Investments (GICs) are maturing this year; one of them, a high-interest fund, is hoped to yield over 5%.

d. Journal costs are the largest operating expense at $29,000.

e. Dalila reviewed the 2015 operating budget report. Revenues are about $2,000 above expenses. Proposed budget for next year not very different, but sustaining subscriptions revenue appears to have dipped somewhat.

f. Advertising revenue is higher after some slump, thanks to better management of the account and collections.

g. PayPal fees expense is well justified by significantly improved collection of membership dues.

MOTION to accept the Treasurer's report by Mehrzad Salkhordeh, seconded by Peter VanDelden, carried unanimously.

5. Secretary's Report (Roberto Racca)

a. Roberto gave a summary of membership (total 234 between members and subscribers of all types) and pointed out the good status of renewals.
b. Ramani Ramakrishnan asked why membership is not nearly as high as appeared in previous reports; Roberto noted an error in the database, corrected last year, which caused inclusion of lapsed accounts in the totals.
c. Annabel Cohen reminded that back in the mid 1980's, when she managed membership, the Association had up to 600 members by her account. She pointed out that likely there are more Canadian members in the Acoustical Society of America (ASA) than there are members overall in the CAA-ACA.
d. Frank Russo pointed out the value to the acoustics community of what the Association provides, such as its strong outreach to students, and encouraged members to canvas for more people to join.
e. Annabel noted that having a member of the executive focused on membership was an important feature in the past, and perhaps should be recommended for reinstatement.
f. There was some discussion of the cost of attending the annual conference, which by comparison to other events of its nature is modest but, Annabel noted, is still high for academics when travel costs for themselves and their students are factored in. Frank noted that the Association is actively seeking increased industry sponsorship for student travel.
g. Annabel suggested that a public lecture at each conference, well-advertised, could lead to greater participation and indirectly stimulate greater levels of membership.
h. Frank asked whether anyone in attendance would volunteer to coordinate a drive toward greater exposure and increased membership, possibly serving in an adjunct role in the executive. There was no immediate expression of interest, so Frank asked all participants to keep considering the idea and perhaps offer recommendations; he reiterated that the quality of the Association is very high despite the small numbers.
i. Gary Madaras, a member from Chicago, pointed out that the ASA has had a major drive for student membership and continues to hold events such as socials and mentoring designed to attract young people. Peter VanDelden suggested that the CAA-ACA put effort into targeted recruiting in specific areas of acoustics. Frank reminded that ASA has paid staff in such roles, but we will try to do better in encouraging volunteers.

Motion to accept the Secretary's report by Stan Dosso, seconded by Annabel Cohen, carried.

6. Editor's Report (Jérémie Voix)

a. Last year there was a request from members during the AGM to be shown usage stats of the online journal; the site has been equipped to provide that information, and Jérémie presented some metrics for downloads of content from the JCAA. Visits to the JCAA site are now around 10,000 to 25,000 a month, and roughly 8,000 articles are downloaded each month. A number of downloads are performed by indexing robots (Google, Yahoo, Microsoft, etc.) as the JCAA site has an open access policy except for the most recent content.
b. The membership database tallying code has been updated online so that it provides to both the Treasurer and Secretary the current statistics for paid-up members.
c. Migration is underway to consolidate conference proceedings and journal articles into a unified database.
d. Instant open access is still available as a $300 fee based service, but no longer easily selectable as a form checkmark because it generated confusion with authors as it was perceived as a mandatory fee.
e. The JCAA is still undergoing review for inclusion into the Web of Science. The process can take upward of a year, and in the meantime it is especially important that authors adhere strictly to publication guidelines to facilitate a positive outcome.
f. Prof. Josée Lagacée resigned earlier in the year from her Deputy Editor position and the role has been filled by Prof. Umberto Berardi as of September 2015.
g. Digital Object Identifier (DOI) is in the process of being implemented to allow instant electronic referral. The Journal will have to pay an annual fee and initial setup costs for the identification of over 2600 articles.
h. The JCAA on-line system has been migrated in spring 2015 to a virtual private server on OVH.net. The conference on-line system and CAA-ACA website will soon follow, and the old web hosting will be discontinued no later than March 2016.

i. The October 2015 conference proceedings issue is due to be printed and sent out after the congress to ensure that only papers actually presented are included. In the future, proceedings issues will be printed before the conference but contain only the full articles for participants who did register ahead of time. The electronic version will be updated with articles from late registrants.

7. Other Business

Annabel Cohen provided an update on the YSF Award that she coordinates. It has been in place for about 20 years, and is meant to make acoustics a household word for science fairs. Prize is $1000 and includes a student membership in CAA. This year the prize was won by two students who designed an acoustical aid for visually impaired people. They also won many other prizes for their work. Annabel suggested that such role models could be invited to give a keynote address at conferences. She thanked the CAA for their continued support of this award.

8. Elections

a. The Past President normally coordinates the elections, but Christian Giguère was not present so Stan Dosso (prior Past President) agreed to serve in that role.
b. Frank Russo gave a preamble explaining changes in bylaws under new status of the Association.
    - Each member is only elected for a one year term, so all Board members have to be re-elected (or replaced) at every AGM.
    - Officers are not elected, but appointed from the group of elected directors.
    - There is no stated maximum term for directors, but a guideline term of four years is encouraged.
c. Frank requested approval from the membership that a slate of twelve (12) directors be maintained. *Motion to approve by Ramani Ramakrishnan, seconded by Stan Dosso; carried with none opposed*.
d. Frank listed the proposed members of the slate: Alberto Behar, Bill Gastmeier, Bryan Gick, Dalila Giusti, Michael Kiefte, Hugues Nélisse, Kathy Pichora-Fuller, Roberto Racca, Joana Rocha, Frank Russo, Mehrzad Salkhordeh, and Jérémie Voix. He pointed out that former director Karen Turner did not intend to continue serving, but Joana Rocha (Carleton University) was willing to stand for the role.
e. Stan Dosso took over to run the election. He asked whether there were any nominations from the floor, in which case an election would be held. Three calls for nominations were made with no response, so the slate was approved by acclamation.

Motion to adjourn by Dalila Giusti, seconded by Benjamin Tucker, carried.

Meeting adjourned at 18:15.

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May 28th 2015

Michael R. Stinson was elected President-Elect of the Acoustical Society of America (ASA)

The Acoustical Society of America (ASA) has elected officers and Executive Council members in 2015 including President-Elect Michael R. Stinson, an old time member of the Canadian Acoustical Association.

Michael R. Stinson was elected President-Elect. His term began on 22 May 2015 and he will automatically assum the office of President on 27 May 2016. Mike Stinson served as Principal Research Officer at the National Research Council of Canada, in Ottawa where he is now Researcher Emeritus. Mike was awarded a Ph.D. in Physics from Queen’s University in Kingston, Ontario, Canada. His research activities have spanned a broadrange of technical activities including studies of the acoustics of the human ear canal and middle ear which have led to advances in hearing aid design. His recent work has looked at propagation of infrasonic noise from wind turbines.

August 5th 2015

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