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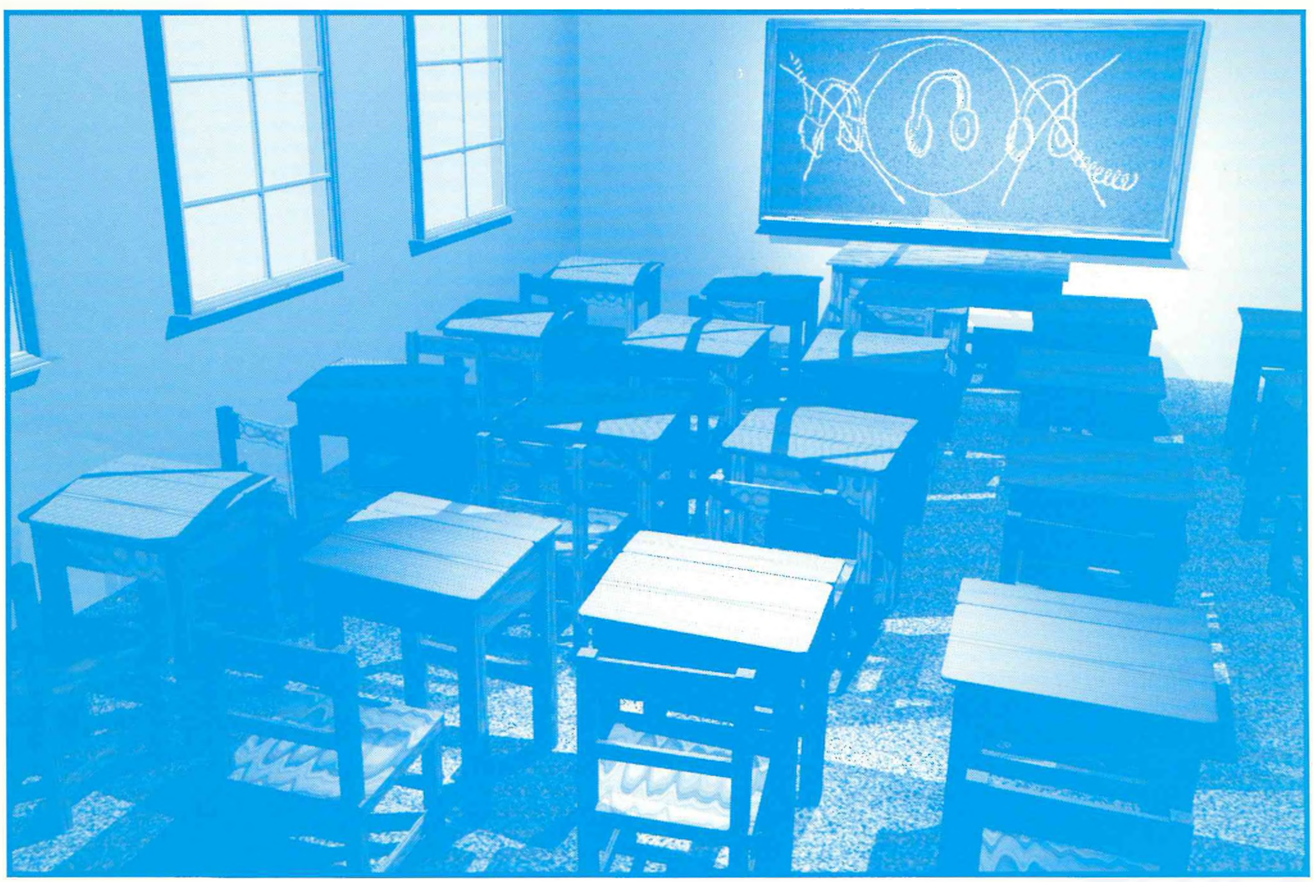

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EDITORIAL

Acoustics Week in Canada 1994 has come and gone. It was a great success and set record attendance levels - congratulations to the organizers. Also a great success - despite the absence of the press - was the special session on Hearing Accessiblility, and the associated Round Table. A review of these events is included in this issue; summaries of the Round Table presentations will appear in the March issue.

Speaking of the press, am I dreaming or has noise suddenly become a big topic in newpapers. There have recently been two major articles on the subject in the Globe and Mail, and a number in my local Vancouver papers. What's going on?

I promised some time ago to dedicate this issue to comments on the article by Raymond Hétu which appeared in the March 1994 issue. Regrettably, I am forced now to put this off until next issue. The positive side of the delay is that there is still have time to comment (for or against).

Continuing on the subject of past promises, I'm pleased to report that I am in the final stages of forming a *Canadian Acoustics* Editorial Board to increase the number of papers submitted to, and the visibility of, your journal. Full details will be provided in the March issue.

Best wishes to everyone for a Merry Christmas and a Happy New Year.

La Semaine Canadienne d'Acoustique est maintenant chose du passé. Cet événement a connu un grand succès et on y a enrégistré un record de participation. Félicitations aux organisateurs. La session spéciale et la table ronde sur l'accessibilité auditive a elle aussi connu un franc succès, malgré l'absense des médias. Une rétrospective de ces événements est présentées dans ce numéro; les résumé des communications présentées lors de la table ronde seront publiés dans le numéro de mars.

En parlant des médias, est-ce je rêve ou le thème du bruit est-il devenu un sujet d'intérêt dans les journaux? Le Globe and Mail a récemment publié deux articles importants sur le sujet et un certain nombre l'ont été dans les journaux locaux de Vancouver. Que se passe-t-il?

Je vous promettais, il y a quelques mois, de consacrer ce numéro aux commentaires reçus suite à la publication de l'article de Raymond Hétu dans le numéro de mars 1994. Malheureusement, je suis dans l'obligation de retarder la publication de ces commentaires jusqu'au prochain numéro. L'aspect positif de ce retard est qu'il est toujours temps de réagir (pour ou contre).

Toujours en ce qui a trait des promesses faites dans le passé, je suis heureux d'annoncer que je finalise la composition d'un comité de rédaction pour l'*Acoustique Canadienne* qui aura pour mandat d'augmenter le nombre de papiers soumis et la visibilité de notre journal. Tous les détails vous seront transmis dans le numéro de mars.

Meilleurs voeux pour un Joyeux Noël ainsi qu'une Bonne Année.

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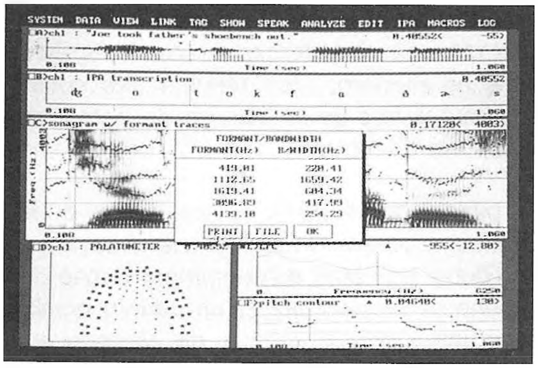
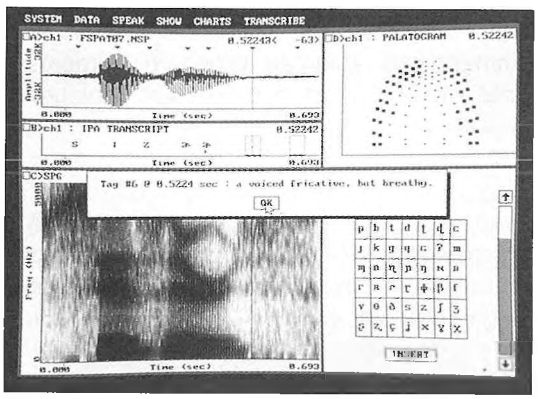


Multiple windows of analysis including speech waveform, phonetic transcription (time-linked to waveform), spectrogram with formant trace, LPC slice, pitch contour and linguapalatal contact in lower left is linked to cursor in spectrogram. Numerical window shows formants' center frequencies and bandwidths.



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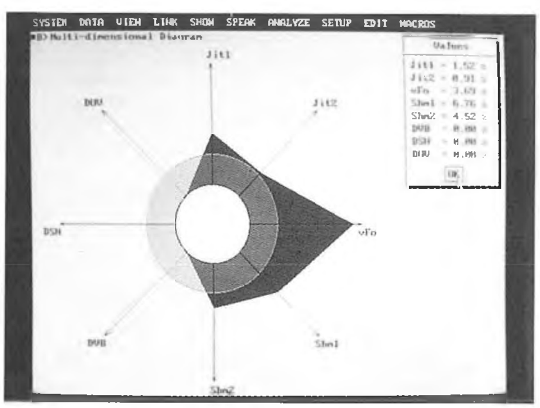

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Canadian Acoustics / Acoustique Canadienne 22(4) 3-10 (1994) **Research article / Article de recherche**

UBC-CLASSROOM ACOUSTICAL SURVEY

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SUMMARY

Acoustical measurements were made in 46 randomly-chosen, unoccupied University of British Columbia (UBC) classrooms. Further tests were done in 10 UBC classrooms when both unoccupied and occupied by students, in order to determine the effect of people and to correct the 'unoccupied' results. The objective of the work was to determine the acoustical quality of the UBC classroom stock and how this depends on the classroom design. The results showed that the UBC classroom stock is of far from optimum acoustical quality. This was found to be because many classrooms have excessive reverberation and result in low speech levels, especially at the back of the rooms; in addition, some have noisy ventilation systems. Further work is in progress to determine user reaction to the acoustical conditions, typical student-generated noise levels and the effect of speech-reinforcement systems.

SOMMAIRE

Des mesures acoustiques ont été réalisées à l'intérieur de 46 salles de classe inoccupées de l'Université de la Colombie Britannique (UBC), sélectionnées au hasard. Des relevés supplémentaires ont été faits dans 10 autres classes de l'UBC alors qu'elles étaient inoccupées ou occupées par des étudiants, dans le but de déterminer la contribution des gens et de corriger les résultats "inoccupés". L'objectif de l'étude était de déterminer la qualité acoustique de l'inventaire de classes de l'UBC et comment celle-ci dépend du design de la classe. Les résultats démontrent que l'inventaire de classes est loin d'atteindre des qualités acoustiques optimales. Ceci serait attribuable au fait que plusieurs salles de classe ont une durée de réverbération excessive, ce qui engendre des niveaux faibles de parole, surtout à l'arrière des salles de classe; de plus, quelques unes des salles sont équipées de systèmes de ventilation bruyants. D'autres projets sont en cours afin de déterminer la réaction des usagers aux conditions acoustiques, aux niveaux de bruit typiques générés par les étudiants et à l'effet de systèmes de renforcement de la parole.

1. INTRODUCTION

During summer 1993 an acoustical survey of the classrooms on the University of British Columbia (UBC) campus was undertaken. The general objective was to determine the acoustical quality of the UBC classroom stock and how this depends on the classroom design. This work was carried out under the auspices of the UBC Ad Hoc Committee on Hearing Accessibility.

This paper summarizes work accomplished to date. That work did not allow a final conclusion regarding all aspects of classroom quality to be determined. Further work, aimed at resolving these questions, is in progress.

2. SPEECH INTELLIGIBILITY

In university classrooms, the major acoustical concern is that of verbal communication. Inadequate acoustical conditions, resulting in poor verbal communication, cause two main problems. First, they lead to reduced learning efficiency. Second, they can lead to fatigue, stress and health problems (headaches, sore throats) amongst lecturers, who are forced to compensate for poor acoustical conditions by raising their voices, for example.

The quality of verbal communication can be quantified by the "speech intelligibility". This quantity is the percentage of speech material which is correctly understood by the average listener. It has been suggested that, in the case of normal-hearing adults working in their first language, the speech intelligibility should exceed 97% [1]. In the case of acoustically-challenged people, such as hard-of-hearing students, students working in a second language and children, the requirements are undoubtedly more stringent; Bradley suggests aiming for 100% [2].

In the present study, speech intelligibility was assumed only to be due to the following two factors:

1. Signal-to-noise ratio, S/N - this is equal to the level of speech, SL, in dBA minus the level of background noise, BGN, in dBA, both at the listener position. The speech level depends on the speaker's voice level, the distance between the speaker and the listener, and on the acoustical conditions in the classroom. The background-noise level results from noise from the ventilation system, projectors, in-class student activity and sources outside the classroom. The levels of these depend on the acoustical conditions in the classroom;

2. Reverberation time - the reverberation time in a room generally increases with room size, and decreases with the amount of sound absorption in the room.

The higher is the speech level and the lower is the background noise level, the higher is the signal to noise ratio and, thus, the speech intelligibility. Too much reverberation is bad, since it results in an effective increase in the background-noise level.

Research has shown that to obtain a speech intelligibility of 100% for normal-hearing people the reverberation time must not exceed 0.7 s; with this reverberation time, the signal to noise ratio must exceed 15 dBA [2]. Given typical speech levels [3], this implies that the background-noise level must not exceed about 35 dBA. As mentioned, the requirements are even more stringent in the case of more acoustically-challenged persons; an optimum reverberation time of 0.4-0.5 s, a minimum signal-to-noise ratio of 20 dBA and a maximum background-noise level of 30 dBA have been suggested [2].

The acoustical conditions in a classroom depends on three main factors: room geometry (size and shape); the sound-absorptive properties of the internal room surfaces; the number of people in the room. All three factors affect speech and background-noise levels, as well as reverberation time.

3. CLASSROOMS TESTED

Measurements were done in two categories of classroom:

a. Randomly-selected, unoccupied classrooms - in order to evaluate the quality of the UBC classroom stock and determine how room design affects it, tests were done in 46 unoccupied classrooms, chosen randomly from the UBC classroom list. Note that this represents about 10% of the UBC classrooms. Of course, the results of tests in unoccupied classrooms are not typical of the acoustical conditions in a classroom when in use for lectures, since they do not account for the presence of students. However, tests in unoccupied classrooms are much easier to do than in occupied classrooms. The classrooms varied from small seminar rooms with volumes under 100 m^3 and less than 10 seats, to large auditoria with volumes over 3000 m^3 and over 400 seats; the volume-to-surface-area ratios varied from 0.6-2.4 m. The largest proportion of rooms had 40-60 seats, volumes from 250-500 m^3 and volume-to-surface-area ratios of about 1.0 m;

b. Unoccupied / occupied classrooms - in order to determine the effect of the presence of students on speech intelligibility and, thus, to correct the results from the unoccupied classrooms for the presence of students, tests were done in 10 classrooms when both unoccupied and occupied by a number of students.

In all tests the ventilation systems were in operation. However, overhead or slide projectors, common sources of background noise in a classroom, were not in operation. Since the tests were done during the summer, noise from outside the classrooms was not a factor as it can be during term. Speech-reinforcement systems, installed in some larger classrooms, were also not in operation. In the case of the occupied classroom tests, the students were asked to remain quiet; thus the effect of background noise due to in-class student activity was not measured.

4. EXPERIMENTATION AND ANALYSIS

In each classroom, measurements were made of the impulse responses between a source and each of 4 to 10 microphone positions, distributed throughout the room, using the Maximum Length Sequence System Analyzer (MLSSA). The source was an onmidirectional loudspeaker array located at a typical lecturing position and at 1.5 m high. It radiated white noise filtered according to the spectrum of typical speech. The output level was adjusted to one standard deviation below that typical of average male and female speakers, speaking at between normal and raised voice level (ie 56 dBA at 1 m in a free field [3]). From each of the impulse responses the following quantities were calculated:

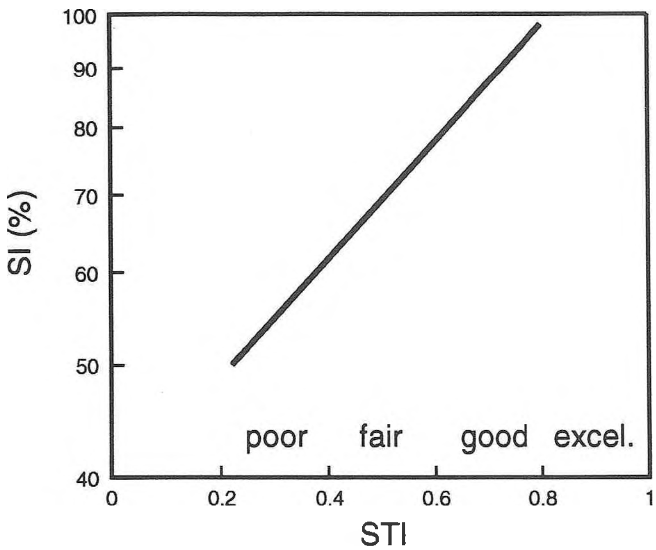

Figure 1. Assumed relationship between STI and SI (derived from Figure 2 of [4] under the assumption that SI=1-AL_{cons}).

a. Speech Transmission Index (STI) [4] - the relation between this measure, which varies between 0 and 1, and speech intelligibility (SI) is shown in Figure 1 (derived from Figure 2 of [4] under the assumption that SI=1-AL_{cons}). Note that ranges of STI values can also be associated with subjective acoustical-quality descriptors as follows [4]:

STI range	Quality descriptor
0.2-0.4	Poor
0.4-0.6	Fair
0.6-0.8	Good
0.8-1.0	Excellent

b. Early decay time (EDT) - this is a measure of reverberation time based on the initial sound decay.

The STI and EDT results were averaged over all of the measurement positions in each room. All quantities were determined in octave bands from 125-4000 Hz. Single-number ('Global') values were, for want of a better method, then determined by weighting the octave-band values according to their relative importance to speech intelligibility [4].

c. Sound propagation (SP) - this is the variation of level with distance from the source (expressed in terms of level minus the source power level, resulting in a negative value in decibels). All quantities were determined in octave bands from 125-4000 Hz.

In addition, measurements were made of background-noise levels in dBA at a number of positions in each classroom using a sound-level meter.

It is important from a design point of view to determine to what extent typical classroom surfaces absorb sound. Therefore, diffuse-field theory and the octave-band EDTs measured in the 46 unoccupied classrooms were used to determine the average octave-band and Global absorption coefficients of the classroom surfaces.

It was also important to determine to what extent people absorb sound. Therefore, diffuse-field theory and the octave-band EDTs measured in the 10 unoccupied/occupied classrooms were used to determine the average absorption per person, in m^2.

In order to get an estimate of the background-noise levels generated by student activity while attending a lecture, a further test was performed. Noise levels generated by 51 students during a final exam in Classroom A (see below) were measured in octave bands and in dBA.

5. RESULTS AND DISCUSSION

Test results will be illustrated using those from three classrooms, whose main characteristics are shown in Table 1. Note that Classroom A was regularly shaped, moderately sized and had low absorption. Classroom B was regularly shaped, moderately sized and had high absorption; in terms of average Global STI it was the best classroom measured. Classroom C was a large, irregularly shaped auditorium with moderate absorption; it was the worst room measured.

5.1 Unoccupied classrooms

Figure 2 shows the variation of octave-band STI with source / receiver distance in Classrooms B and C. This figure

Table 1. Details of three classrooms for which results are presented.

Room	Seating Type	No. of seats	Length (m)	Width (m)	Height (m)	Global avg. absn. coeff.	# students (occupied)
A	Raked	113	9.0	12.1	3.7	0.09	51
B	Flat	120	10.6	11.6	3.1	0.27	14
C	Raked	451	25.2	21.5	6.1	0.16	350

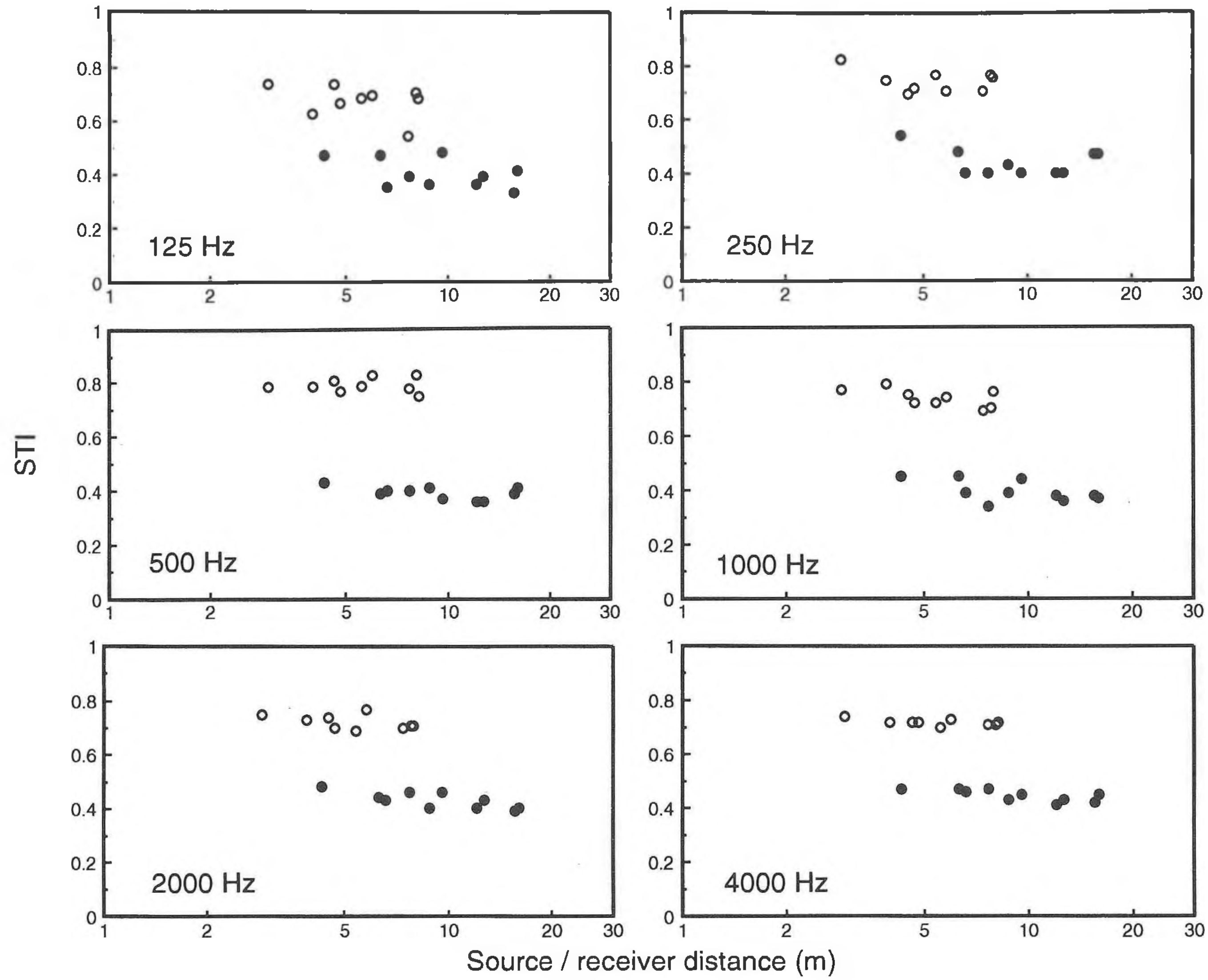

Figure 2. Measured octave-band STI's in unoccupied (o) Classroom B and (●) Classroom C.

shows the range of STI values measured. Though STI's tended to decrease with source/receiver distance as expected, surprizingly the variation was never strong. Figure 3 shows the frequency distribution of the average Global STIs measured. None of the classrooms had average Global STIs above 0.8 (excellent) or below 0.4 (poor). However, some individual positions at the front of smaller classrooms has excellent ratings; similarly, some positions at the back of the largest and 'worst' rooms had Global STI values under 0.4 (see Figure 2). The classrooms were divided more-or-less equally between fair (0.4 < Global STI < 0.6) and good (0.6 < Global STI < 0.8). It appears that the acoustical quality of the UBC classroom stock when unoccupied is very mediocre. We will return later to the question of the quality when occupied.

By way of explanation of the STI results, Figures 4 and 5 show the frequency distributions of the measured Global EDT and BGN values, respectively. Measured EDTs exceeded 0.7 s in most classrooms, and exceeded 2 s in some cases. Background-noise levels exceeded 35 dBA in most classrooms and 50 dBA in some.

Figure 6 shows the 1000-Hz octave-band sound propagation in Classrooms A, B and C. In the small, low-absorption Classroom A, the speech level varies little with position. In small but absorbent rooms (eg Classroom B), and in large rooms (eg Classroom C), the speech level decreases with distance from the source, leading to low speech levels at the back of the room.

Note also that the shape of these curves indicates that prediction by diffuse-field theory is often inaccurate. Levels generally decrease with distance, only showing constant reverberant levels in small, low-absorption rooms.

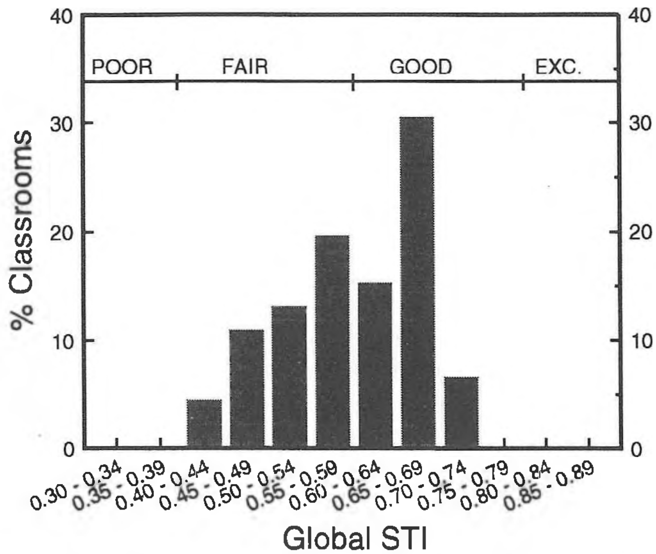

Figure 3. Frequency distribution of the room-averaged Global STI's measured in 46 unoccupied classrooms.

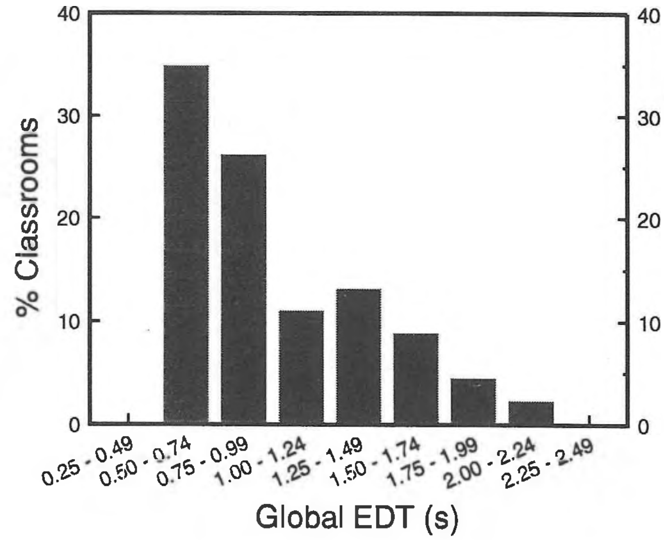

Figure 4. Frequency distribution of the room-averaged Global EDT in 46 unoccupied classrooms.

In the absence of special acoustical treatment, the main features found to significantly increase the amount of sound absorption above and beyond the ambient absorption in 'basic' rooms which did not have these features, were carpets, acoustical ceiling tiles (suspended or not) and upholstered seating. In order to determine the absorptive properties of typical classroom surfaces, the classrooms were divided into categories according to whether or not they had these features. Figure 7 shows the average octave-band and Global surface absorption coefficients which can thus be attributed to each type of surface in these classrooms. For example, classrooms without carpets, ceiling tiles and upholstered seating had, on average, a Global absorption coefficient of 0.09. The presence of a carpet, ceiling tiles or upholstered seating increased the Global coefficient by 0.05, 0.08 or 0.04, respectively.

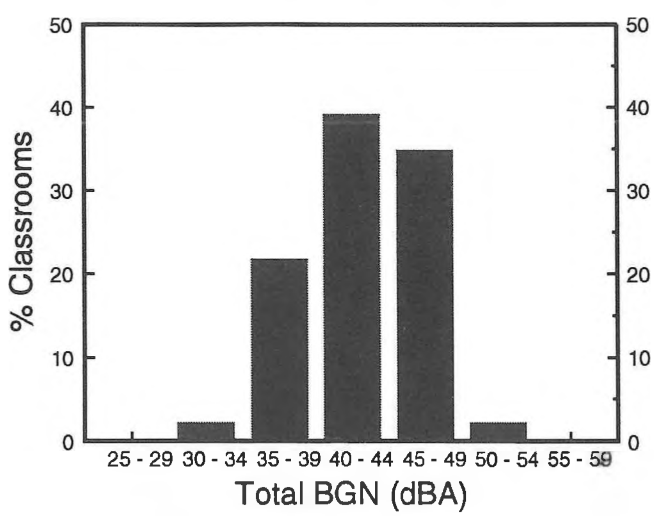

Figure 5. Frequency distribution of the room-averaged A-weighted BGN in 46 unoccupied classrooms.

5.2 Occupied classrooms

Figure 8 shows the variation with distance of the change due to people in 1000-Hz octave-band STI in Classrooms B and C. The results show that the presence of students generally had little effect on STI in smaller classrooms (eg Classroom B), and increased the STI in larger rooms (eg Classroom C). As illustrated in Figure 9, this result is partly

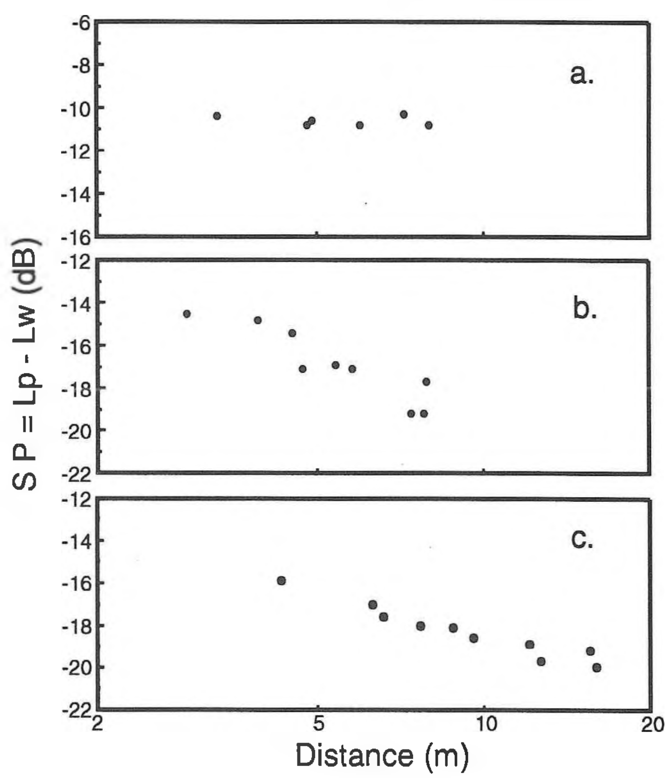

Figure 6. 1000-Hz octave-band SP measured in Classrooms a) A, b) B, and c) C when unoccupied.

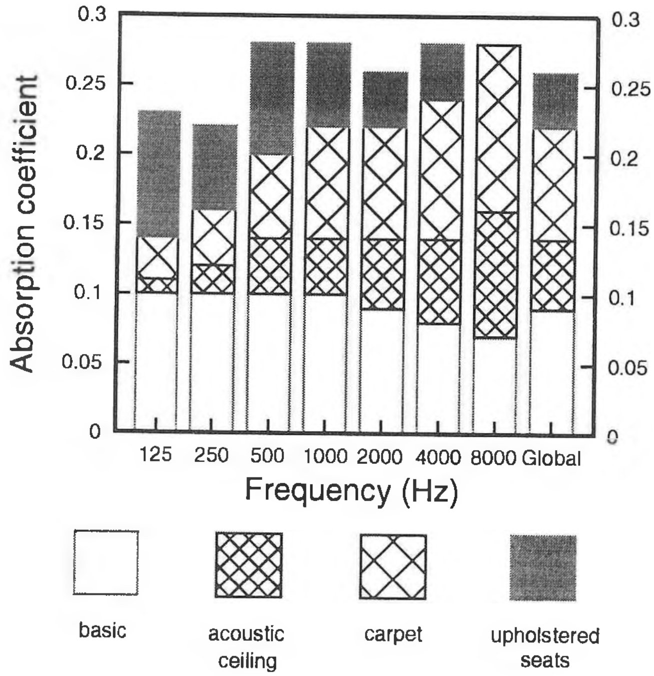

Figure 7. Average surface-absorption coefficients in classrooms with various classroom features.

explained by the fact that in small rooms - especially when absorbent - people had little effect on EDT (in Classroom B the Global EDT decreased by 8%), whereas in large rooms they reduced the EDT significantly (in Classroom C the Global EDT decreased by 44%). Unfortunately, the positive effect of decreased reverberation is counterbalanced by the negative effect of a reduction in speech level resulting from the presence of people in large rooms. This is illustrated in Figure 10 showing the change due to people in the 1000-Hz octave-band SP in Classrooms B and C, respectively. Recall that the effect of noise due to in-class student activity is not included here.

Figure 11 shows the average and standard deviations of the octave-band and Global absorption-per-person results. The absorption introduced by a person in a classroom increases with frequency from about 0.4 to 1.1 m^2 (Global increase of 0.74 m^2).

5.3 Background-noise test

Figure 12 shows the octave-band and A-weighted BGN levels in Classroom A when unoccupied (ventilation system only) and when occupied by 51 students writing a final exam. In this case noise is due to movement of chairs, papers etc., but not to voices. Background-noise levels increased by 21 dBA to 56 dBA due to the presence of the students. This result suggests that student-generated background noise is a significant factor negatively affecting speech intelligibility in classrooms.

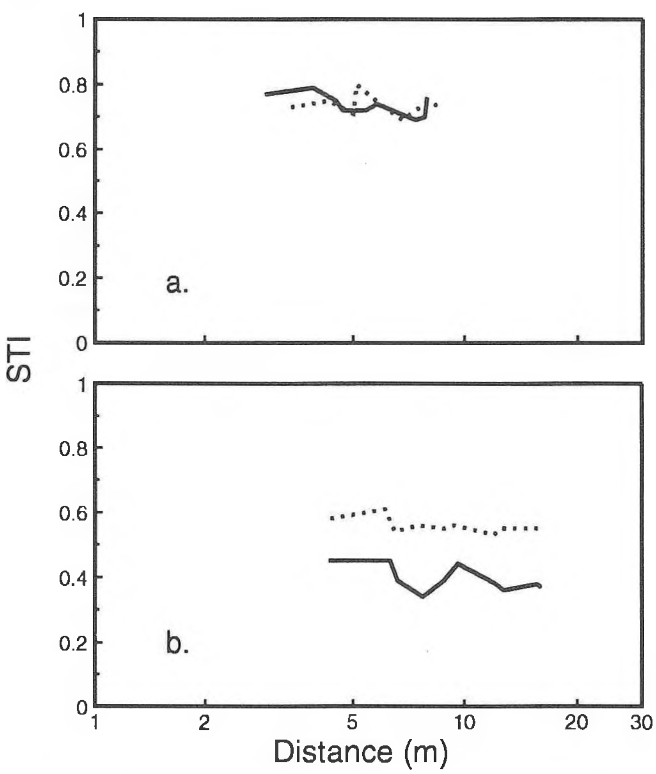

Figure 8. Measured 1000-Hz octave-band STI's in Classrooms a) B and b) C when (———) unoccupied and (······) occupied.

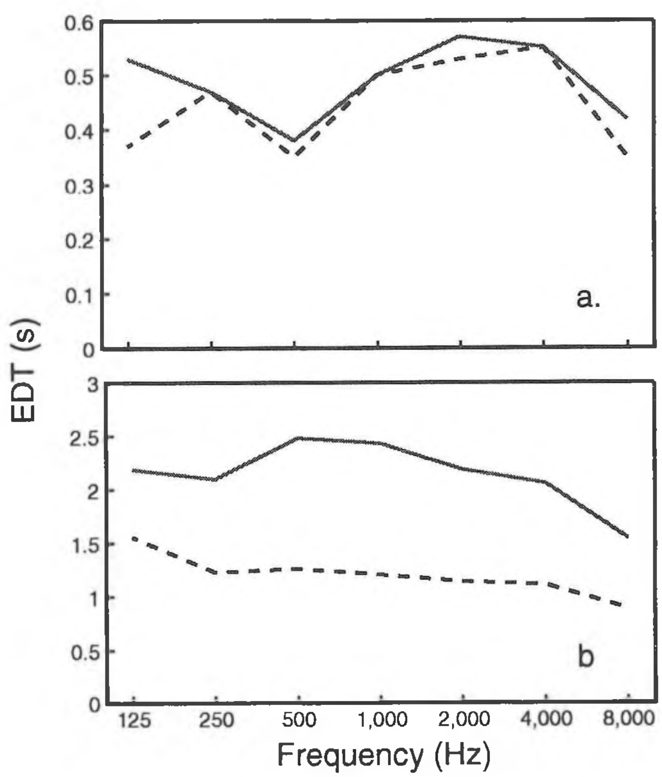

Figure 9. Measured octave-band EDT's in Classrooms a) B and b) C when (———) unoccupied and (– – –) occupied.

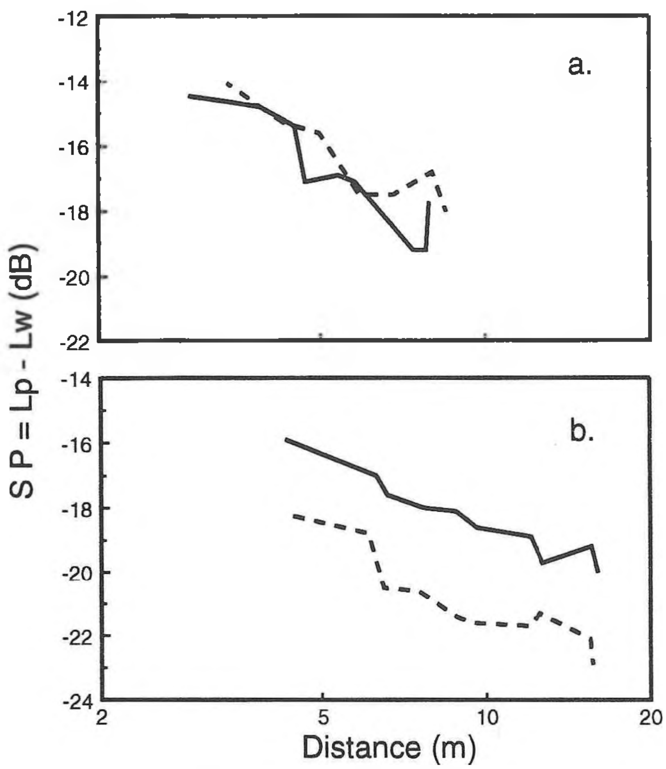

Figure 10. Measured 1000-Hz octave-band SP's in Classrooms a) B and b) C when (——) unoccupied and (- - -) occupied.

6. STI IN OCCUPIED CLASSROOMS

In order to estimate the acoustical quality in occupied UBC classrooms, the following procedure was followed for each of the 46 classrooms, assumed half and fully occupied, using the above results:

- using diffuse-field theory and the average absorption per person, the 1000-Hz unoccupied EDTs, and the SPs (ie signal levels) at the centre of the classroom, were corrected for the presence of students;
- based on the results of the background-noise test in Classroom A, the background-noise levels in the occupied classrooms were assumed to be 53 dBA (half occupied) and 56 dBA (fully occupied);
- the average Global STIs measured in the unoccupied classrooms were corrected.

Figure 13 compares the frequency distributions of the STI values for the 46 classrooms when unoccupied and half and fully occupied, respectively. In general, the presence of students decreased speech intelligibility (average Global STI decreased by as much as 0.3). Only in the case of 'basic' classrooms with low-absorption surfaces and, therefore, high EDTs when unoccupied, did the presence of students increase speech intelligibility (average Global STI increased by up to 0.1).

7. CONCLUSIONS

The results of the UBC-classroom acoustical survey show that the classrooms - even when fully occupied - have far from optimum acoustical quality. Most classrooms have excessive reverberation and provide inadequate speech

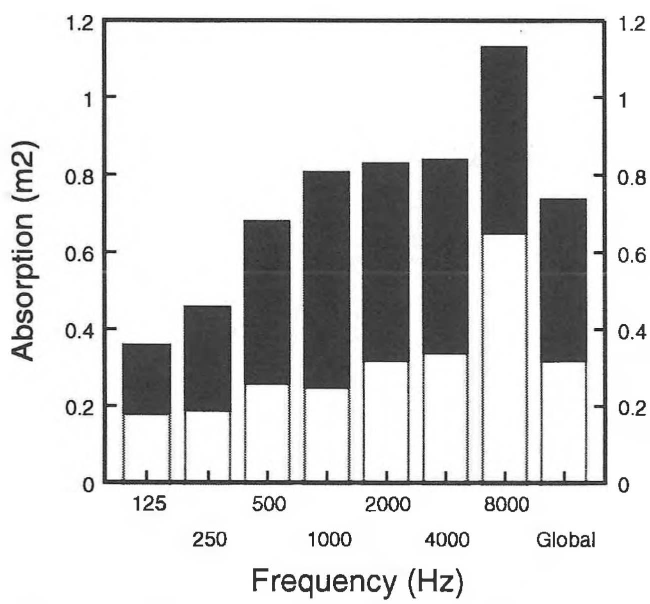

Figure 11. Average (complete bar) and standard deviations (white bar) of the average absorption per person measured in 10 classrooms

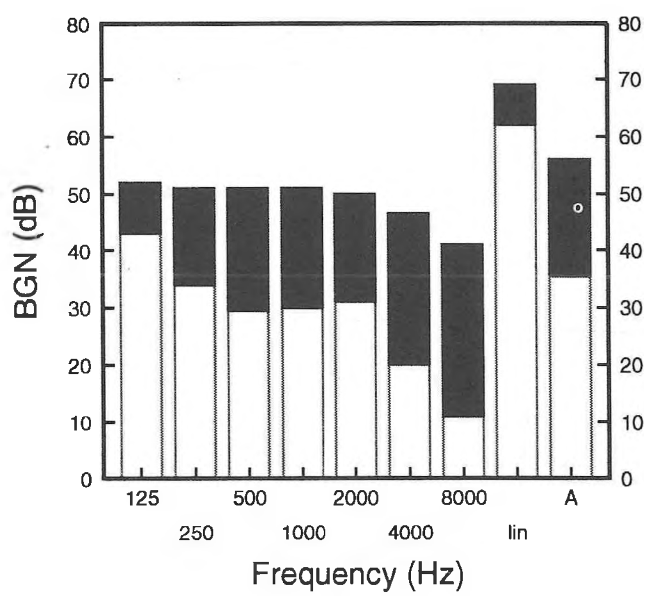

Figure 12. Measured room-averaged background noise levels in Classroom A when unoccupied (white bar) and occupied (complete bar) by students writing an exam.

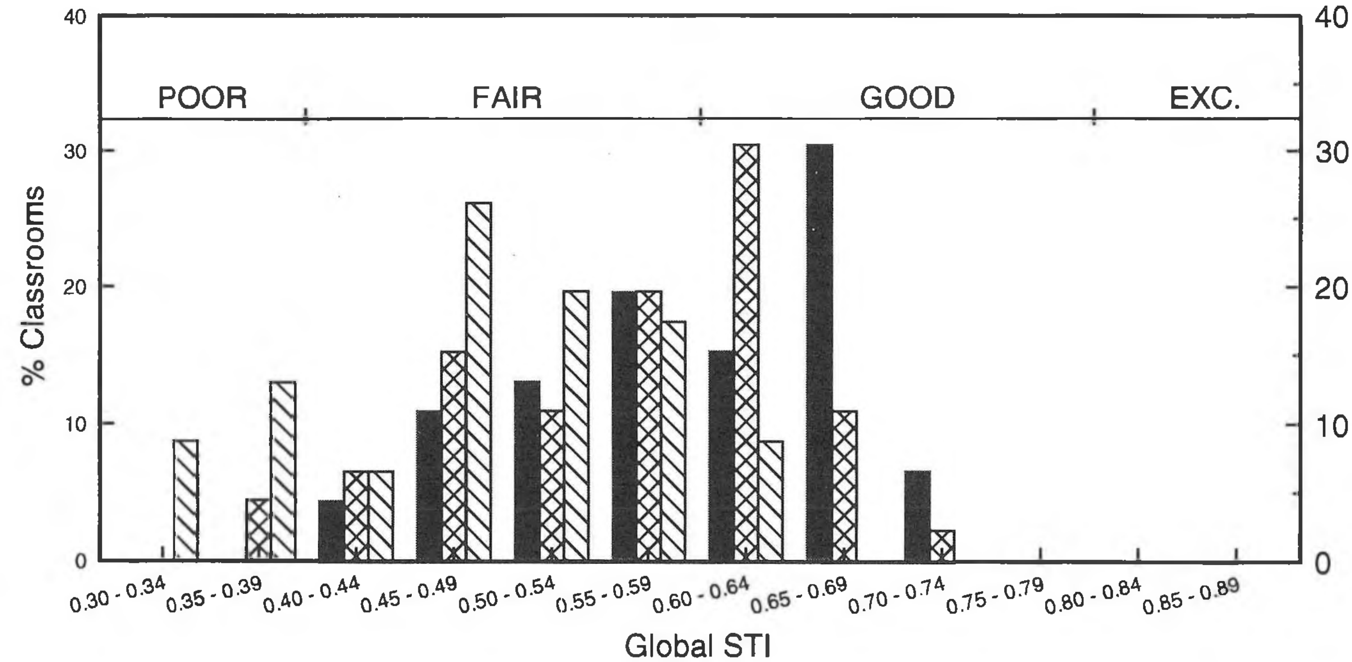

Figure 13. Frequency distributions of the Global STI in 46 classrooms: ■ unoccupied (measured); ⊠ half occupied (predicted); ⧅ fully occupied (predicted).

levels; some have high background-noise levels due to the ventilation system and other sources.

Several associated studies are on going at this time, involving further tests in UBC classrooms. They are as follows:

- a questionnaire has been developed to determine student and instructor reactions to the acoustical conditions in UBC classrooms. It has been administered to over 6000 people; the results are being analyzed;

- initial measurements of the effect of speech-reinforcement systems on classroom quality have been done. They suggest that such systems may improve or worsen quality;

- STI measurements for source positions in the audience, and for receiver positions in the audience and at the instructor position are planned. This is relevant to speech intelligibility when students ask questions;

- detailed measurements of speech levels, and of student-generated background noise levels are in progress.

ACKNOWLEDGEMENTS

The author would like to thank the professors who allowed us time during their classes to make measurements in the occupied classrooms. Thanks also to the students involved for putting up with the 'noise' and remaining quiet. Thanks also to the Disability Resource Centre which provided partial funding for project. Finally, thanks to Physics students John Kim and Tony Skrjanec for their hard work in completing the survey and associated analysis.

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Announcement and Call for Papers

INTER–NOISE 95 TO BE HELD IN NEWPORT BEACH, CALIFORNIA, USA

INTER–NOISE 95, the 1995 International Congress on Noise Control Engineering, will be held in Newport Beach, California, USA. Newport Beach is a business center and resort community on the Pacific Coast south of Los Angeles. The congress will be held at the Newport Beach Marriott hotel from 1995 July 10 to 12.

INTER–NOISE 95 will be the twenty–fourth in a series of international congresses on noise control engineering that have been held in the United States and in other countries since 1972. The theme of INTER–NOISE 95 is *Applications for Noise Control Engineering*. The congress is sponsored by the International Institute of Noise Control Engineering, and is being organized by the Institute of Noise Control Engineering of the USA (INCE/USA).

Alan H. Marsh, President of DyTec Engineering and Editor–in–Chief of *Noise Control Engineering Journal,* is the General Chairman. Robert J. Bernhard, Director of the Ray W. Herrick Laboratories at Purdue University, and J. Stuart Bolton, Professor of Mechanical Engineering at Purdue University, are co–chairmen of the Technical Program and will edit the congress proceedings.

Technical papers in all areas of noise control engineering will be considered for presentation at the congress.

CONTRIBUTIONS INVITED

Abstracts of papers proposed for presentation at INTER–NOISE 95 must be received by the Technical Program Chairmen no later than **1994 November 29.** The abstract should be approximately 250 words in length, and must be submitted in the format reproduced on the third page of this announcement.

If the paper is accepted for presentation at INTER–NOISE 95, it must be typed on the special manuscript paper which will be supplied by the Congress Secretariat. The completed manuscript will be printed in the Congress Proceedings, and must be received by the Technical Program Chairmen no later than **1995 April 04.**

EQUIPMENT EXHIBITION

A major acoustical equipment, materials and instrument exhibition will be held in conjunction with INTER–NOISE 95. The Exhibition will include materials and devices for noise control as well as instruments such as sound level meters, noise monitoring equipment, sound intensity measurement systems, acoustical signal processing systems, and equipment for active noise control.

OTHER MEETINGS IN NEWPORT BEACH

A noise control seminar and an international symposium will be held at the Newport Beach Marriott immediately before INTER–NOISE 95. The seminar will be held on 1995 July 07–08. The 1995 International Symposium on Active Control of Sound and Vibration will be held on July 06–08. This symposium is a continuation of the conferences on active control of sound and vibration which were held at Virginia Polytechnic Institute in Blacksburg, Virginia, USA in 1991 and 1993, and a continuation of an active noise symposium held in Japan in 1991.

Technical Papers in all areas of noise control engineering will be considered for presentation at the Congress. The following technical areas are of particular interest.

Aircraft Noise Control: Interior and Exterior

Airport Noise Control: Planning and Modeling

Applications of Active Noise Control

Construction Equipment Noise and Vibration Control

Corporate Programs for Noise Control

Highway Noise Prediction Models

Industrial Fan and HVAC Noise

Industrial Noise Control: Planning and Implementation

Measurement and Rating of Impulsive Noise

Noise Prediction Methods: BEM, FEM, etc.

Outdoor Sound Propagation Models

Prediction of Noise Effects in Communities

Sound Quality and its Industrial Applications

Vehicle Noise Control: Engine and Tire Noise

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CONGRESS VENUE

The site of the congress, the Newport Beach Marriott Hotel, is approximately 1 km from the Pacific Ocean on a hill with a view to the southwest of Newport Beach Harbor, Balboa Island and, on the horizion, Catalina Island about 40 km offshore. Newport Beach is located in Orange County, California, south of Los Angeles. Orange County Airport (John Wayne Airport [SNA]) is about 15 minutes to the north of the hotel by automobile. The airport was completely rebuilt in 1990–1991, and is an excellent final destination for delegates to INTER–NOISE 95. The Newport Beach Marriott hotel provides complimentary transportation to and from the Orange County Airport. Los Angeles International Airport (LAX) is about 60 km to the northwest. Scheduled air transportation service, scheduled bus service and frequent van service are also available from LAX to Orange County Airport.

The location of the hotel is very attractive; opportunities for recreational activities include sightseeing at *Disneyland* in Anaheim, a boat trip to Catalina Island, and the harbor and beaches in the Newport Beach and Laguna Beach areas (readily accessible by public transportation). The hotel is adjacent to one of Southern California's major shopping centers, Fashion Island, in the Newport Center, and is about 20 minutes by automobile from the well–known South Coast Plaza shopping center and the Orange County Center for the Performing Arts in Costa Mesa. Some of the best restaurants in California are within a 30–minute drive from the hotel.

The hotel has excellent meeting room and exhibition facilities for INTER–NOISE 95. It was the venue for INTER–NOISE 89. Attendees at that congress will recall the excellent meeting, living and dining facilities at the Newport Beach Marriott.

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Canadian Acoustics / Acoustique Canadienne 22(4) 13-18 (1994) **Review article / Article de revue**

REVIEW OF THE LITERATURE ON SOUND SOURCE LOCALIZATION AND APPLICATIONS TO NOISY WORKPLACES

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ABSTRACT

In noisy workplaces, workers have to detect and localize significant sound sources. If they fail in these auditory tasks, serious accidents can occur. The present paper deals with a review of the different aspects of localization in free field and in closed spaces. Different factors such as hearing loss, hearing protectors and hearing aids have been statistically proven to worsen the ability to localize sounds in both horizontal and vertical planes. In order to emphasize the need for research in understanding the complex mechanisms involved in real life sound localization, a simulated case is presented. Arguments are given for the necessity in developing clinically relevant tests that will enable audiologists to quantify an individual's ability to localize sounds in different situations. It is important that the rationale for these tests be to improve safety in noisy workplaces and not to discriminate among job candidates.

SOMMAIRE

Dans les milieux de travail bruyants, les travailleurs doivent détecter et localiser des sources sonores importantes. S'ils échouent dans ces tâches auditives, des accidents graves peuvent survenir. Cet article porte sur une revue de la littérature des différents aspects de la localisation auditive en champ libre et en milieu réverbérant. Différents facteurs tels que les pertes auditives, les protecteurs auditifs et les aides auditives diminuent statistiquement les performances de localisation dans le plan horizontal et vertical. Un cas simulé est présenté afin de démontrer la nécessité de poursuivre la recherche d'outils cliniques qui permettront aux audiologistes de mieux quantifier les abilités d'un individu à localiser des sources sonores dans différentes situations. Ces tests devraient être faits avec l'intention d'améliorer les conditions de travail et non pas de discriminer parmi les individus qui posent leur candidature pour un emploi.

1. INTRODUCTION

Each year, serious work related accidents occur because workers claim not having identified or localized an alerting sound signal (Moll van Charente and Mulder, 1990). Much is known about sound source localization in quiet free field or closed spaces (Canévet, 1988) but very little attention has been given to sound source localization in noisy workplaces. To the author's knowledge, no detailed review of the literature or specific field studies have dealt with sound source localization in noisy workplaces where noise-induced hearing loss, the wearing of hearing aids and hearing protectors are common. This situation is particularly troublesome since existing studies do not address situations where sound sources and workers are continually in motion.

Before conducting a specific study in the field of localization in noisy workplaces, a review of the literature (Laroche, 1992) was done on localization in quiet free field and in closed spaces. Many factors such as hearing loss, hearing protectors and hearing aids have been shown to be important considerations. The present paper will summarize the effects of these factors. One simulated case will be reviewed to illustrate the application of the theoretical aspects of localization. This case will deal with the localization of a travelling crane in a closed field environment.

2. SOUND LOCALIZATION IN FREE FIELD

2.1 Horizontal plane

Canévet (1988) has summarized the actual knowledge on localization in the horizontal plane. In the free field, localization in the horizontal plane is made possible through the use of two cues: the interaural phase (or time) difference and the interaural level difference. The phase difference is valid for the low frequencies up to 1500 Hz and the level difference takes over for the high frequencies. However, between 1500 and 3000 Hz, neither cue fully helps for localization, explaining why most of the pure tone errors made by humans are centered between 1500 and 3000 Hz. Front/rear confusions are also common to all pure tones. Continuous large spectrum noises are then easier to localize than pure tones. Most of the studies have been made with no head motion allowed. Head movements seem to improve the localization of sustained sounds but the contribution of head motion to localize brief sounds is less clear. .Middlebrooks and Green (1991) propose that, for brief sounds, the duration must be long enough to allow head movements in the direction of the sound source.

2.2 Vertical plane

According to Blauert (1983), wide spectrum noises are preferred for localization in the vertical plane. In fact, the noise spectrum is the key factor. For example, 8 kHz signals will always be localized above the head, irrespective of the actual direction of the source. Narrow band sounds at 1 kHz will be perceived to originate behind the head of the subjects. Blauert (1969) has called this phenomenon the determining frequency bands. This effect is very robust and is attributed to the frequency characteristics of the hearing system. Needless to say, errors made on the same type of signal are more frequent in the vertical plane than in the horizontal plane. Head movements can improve performances but not in all subjects (Noble and Gates, 1985; Noble, 1987).

2.3 Dual plane localization

Based on two studies related to localization in both planes simultaneously (Oldfield and Parker, 1984; Makous and Middlebrooks, 1990), best performances are reached when signals are presented in front of the subject and the spectrum is wide. The smallest average errors were found to be about 2 and 3.5^{o} in the horizontal and vertical dimensions, respectively. The size of errors increased for more peripheral stimulus locations, to maxima of about 20^{o}.

2.4 Distance evaluation

If the auditory system is not very precise for vertical localization, its distance evaluation of sound sources is even worse. Three cues are involved in that kind of localization: level variations, the energy ratio between the direct and the reflected sounds and the spectral modifications (Canévet, 1988). Low frequency noises appear to arise from the rear regardless of their actual position and are perceived farther than high frequency noises at the same sound level. According to the few studies dealing with distance evaluation (Ashmead et al., 1990; Butler et al., 1980 Strybel and Perrott, 1984; Simpson and Stranton, 1973), the hearing mechanism is not a good rangefinder. More studies are needed to better describe the contribution of each of the three cues mentioned above.

2.5 Movement perception

Movement perception has not yet been studied in great detail despite the fact that we live in a constantly mobile environment. According to Rosenblum et al. (1987), level changes, the interaural differences and the Doppler effect seem to be crucial factors. The Doppler effect refers to the phenomenon by which sound waves' length tends to decrease at the front and increase at the rear of the source when this source is moving ahead. From the receiver's point of view, the frequency content increases as the source approaches, decreases abruptly when the source is very close and continues to decrease gradually when the source moves away.

The level changes refer to the increase or decrease of the sound level when the source is approaching or moving away from a receiver. The receiver can detect this movement but will not know exactly when he could be hurt if he can not see the source.

In their study, Rosenblum et al. (1987) have placed these three cues in a hierarchical manner: the receivers rely first on the level changes followed by the interaural time differences and lastly by the Doppler effect. As noted by the authors, their study was not done in very realistic settings. The only realistic data available on movement perception in the litterature relates to ambulance sirens. Caelli and Porter (1980) have reported that there are distance overestimations reaching twice the real distance, thereby compromising human safety. In fact, subjects did not react until the ambulance was less than 100 meters away from their car. At 60 to 80 km/hours, the ambulance siren signal would propagate as far as 33 to 44 meters, if the siren had been sounded for 2 seconds. Because subjects tend to overestimate this distance, they have very little time to react if they base their decision on auditory cues only.

2.6 Localization in noise

Localization in noise is closely related to the frequency and temporal selectivity of the auditory system (Canévet, 1988). Masking effects are predominent for the frequency range centered on the sound signal critical band. In order to optimize localization, sound levels of 10 to 15 dB over the masked threshold are proposed (Canévet, 1985; Houtgast and Plomp, 1968). Masked threshold refers to the sound level in dB necessary to just perceive the sound in a given amount of noise.

Another concept related to localization in noise is the cocktail party effect. In noisy surrondings, speech perception is possible because the receiver's attention is directed towards the speaker and he/she can then ignore interfering noise around him/her (Plomp, 1977). The dominating factor is the spatial separation of noise and speech. In this matter, the masking level difference (MLD; Hirsh, 1948) is closely related to the cocktail party effect. The MLD phenomenon refers to the improvement of masked thresholds when the phase or level interaural differences of a sound source are not identical to those of the masking noise. In real life, the MLD happens when the sound source and the noise come from different locations. Nevertheless, even if the masked thresholds are improved due to the MLD, nothing is really known about the impact of this improvement on localization abilities.

For example, if a backup alarm is heard on one side and a background noise comes from every direction, will the backup alarm be better localized due to the MLD effect which predicts an increase in the sound pressure level?

3.0 LOCALIZATION IN CLOSED SPACES

3.1 Horizontal plane

Most of the studies done in closed spaces has dealt with horizontal plane localization. Hartmann and his co-workers have investigated this problem in a series of laboratory experiments (Hartmann, 1983; Rakerd and Hartmann, 1985; Rakerd and Hartmann, 1986; Hartmann and Rakerd, 1989). According to these authors, low frequency pure tones cannot be localized inside a room. High frequency tones are easier to localize than low frequency tones but performances are still poor. A short impulse type signal (5-2000 msec) with an instantaneous rise time (< 5 msec) and a wide spectrum is the easiest sound to localize in closed spaces. Reverberation time does not seem to influence the localization of that type of signal. Unlike brief tones, continuous noises are largely disturbed by reverberation. Reflective walls can also deteriorate performances but reflections coming from the same direction as the direct sound improves performances.

More recently, Giguère and Abel (1993) confirmed that sound localization performances were lower in a reverberant room (0,6 to 1 sec.) than in an absorbent room (0.2 sec.), for one-third octave noise bands centered on 500, 1000 , 2000 and 4000 Hz. For that type of signal, they found that the benefit of a shorter rise/decay time was small and limited to low frequencies. They also found that performances depend strongly upon the array in which the speaker was embedded: localization in the lateral array led to frequency-dependent front/back confusions and response bias.

3.2 Distance perception

Mershon et al. (1989) found that short reverberation times lead to distance underestimations while longer times lead to overestimations. Background noise tended to decrease the perception of distance. In a more recent study (Hafter et al., 1994), it was shown that listeners can use echoes from a single wall reflector to improve their perception of auditory distance of single clicks and short train of clicks. However, performance was characterized by large individual differences in their subject group (N=4). Those who seemed to ignore echoes and concentrate on signal levels did better than those who did not. Several additional studies on the use of echoes in distance perception are presently underway in Hafter's laboratory. They are studying the effects of ground reflections, the most prevalent of real-world echoic surfaces. They also plan to test the importance of vision in the auditory perception of distance. Their findings will help our understanding of this complex auditory process.

4.0 EFFECTS OF HEARING LOSS

Durlach et al. (1981) have made a detailed review of the literature on the effects of hearing loss on localization performance. Based on this review, localization has been found to be more impaired in unilateral and asymetrical hearing loss cases than in bilateral cases. Localization was also statistically worse for subjects with middle ear problems and central lesions than for listeners with cochlear damage. More recently, Noble et al. (1994) confirmed this last assumption but concluded that the correlations between degree of hearing loss and localization are only moderate, suggesting that aspects of hearing impairment, in addition to simple attenuation, may also reduce auditory localization performance.

5.0 EFFECTS OF HEARING PROTECTORS

In general, localization performances are worse when protectors are worn in reverberated surroundings (quiet or noisy) than in open ear situations (Mershon and Lin, 1987). In terms of localization, Mershon and Lin (1987) concluded that hearing protectors' attenuation must be low and as uniform as possible for the entire frequency spectrum in order to minimize localization errors.

Noble et al. (1990) noticed that earmuffs induce sound source displacements to the front and earplugs induce sound source displacement to the rear. In the same line of ideas, Able and Hay (1994) found that muffs were more detrimental than plugs for front/back discrimination. In his 1981 study, Noble concluded that the removal of pinna functions through the use of earmuffs has a definite adverse effect on horizontal plane localization and a radically disruptive effect on vertical plane localization. These effects are somewhat mitigated by free head movement, but only slightly so in the vertical plane. For example, in the horizontal plane, subjects' response accuracy was 95% in the unoccluded free-head movement condition, 50% in the occluded free-head movement condition, and 24% in the occluded with head movement restriction condition. For the vertical plane, the results were 72% in the unoccluded free condition, 19% in the occluded free condition and nearly random in the restricted-head occluded condition.

Abel and Hay (1994) collected data with conventional muffs and plugs and active earmuffs worn by normal and hearing-impaired subjects. Results showed that this last group had difficulties detecting 4000 Hz one-third octave noise bands with conventional protectors but were not different from normals with active muffs. At 500 Hz, localization performances of the two groups were similar.

In an other study, Noble and Gates (1985) found that latency of localization responses were statistically longer for subjects wearing hearing protectors than for subjects in open ear conditions (5 vs 3 seconds). Noise bursts centered on 2.3 and 8.3 kHz were used as signals. In this study, subjects were free to move their head. All these studies were conducted in anechoic conditions but results seem to be similar in reverberated surroundings (Talamo, 1975; Abel and Hay, 1994). Nevertheless, as early as 1978, Wilkins and Martin stated that even if the decrease in performance due to hearing protectors varies from one study to the other, any degree of negative change can compromise workers' safety and cannot, therefore, be neglected. Coleman et al. (1984) also raised the important question of workers' safety. They suggested that if the ability to localize is important for the job at hand, then plugs are preferable to muffs. It was suggested that another option would be to develop an electronic circumaural earmuff designed to maintain the sound information as it would be perceived in the unprotected condition. There is still (ten years later) no evidence in the literature that such device exists.

6.0 EFFECTS OF HEARING AIDS

In general, localization is better with intra-aural than with other types of hearing aids, due to the minimal obstruction of the pinna (Leuuw and Dreschler, 1987; Westermann and Topholm, 1985). More recently, Noble and Byrne (1990) concluded that hearing aids in general do not restore localization ability completely. Subjects tested with in-the-canal hearing aids performed worse than with intra-aural aids. The authors could not fully explain these results. Due to the small number of subjects and a high rate of individual error they preferred to be conservative in stating that in-the-canal aids were not better than other types of hearing aids for localization.

In 1992, Byrne et al. collected new data and concluded that, when hearing level was controlled, there was no overall difference in the performance of in-the-ear and behind-the- ear aid wearers. According to these authors, the test situation they used in their experiment was more representative of real-life listening. They also demonstrated that bilateral fitting is better for moderately and severly hearing-impaired listeners. However, mildly impaired listeners fitted unilaterally performed as well, on average, as those fitted bilaterally. More data would have to be collected in order to confirm these results.

7.0 APPLICATION TO A SIMULATED CASE: LOCALIZATION OF A TRAVELLING CRANE BY A BURNER OPERATOR

The above review of the literature clearly shows that some aspects of localization must be studied in more depth in order to better understand localization in real-life situations. Wearing of hearing protectors combined with hearing loss are among the most important aspects for study. Localization in the vertical plane also needs to be clarified, especially for mobile sources. Nevertheless, based on information presented here and on a more complete review of the multiple factors involved in localization (Laroche, 1992), it is possible to relate this information to cases commonly found in noisy workplaces like the localization of a travelling crane.

7.1 Sound source

The travelling crane is used in steel plants to move scrap and metal castings. A siren is activated by a crane operator in a soundproof enclosure each time the crane circulates in the work area. Sirens found in workplaces are normally frequency-modulated sound signals between 600 and 1250 Hz. The level is not adjustable except for very few models. The sound is continuous in nature and is mobile due to the displacement of the crane.

7.2 Receptor

Mr. G. is a burner operator in a steel plant and wears earplugs and a face protector to complete his tasks. Mr G must localize the siren in a steady vertical plane and a variable horizontal plane.

7.3 Environment

The noise at the workstation varies in time, is concentrated in low frequencies (< 1000 Hz) and can reach levels as high as 100-110 dBA during the melting process. Room walls are built from concrete blocks and the roof is made of metal sheets and glass. The work area is quite limited in space.

7.4 Analysis

The localization of this siren is not done in the most favorable conditions. First of all, based on the review of the literature, it appears that sirens are difficult to localize in the vertical plane because there is no frequency content over 1250 Hz. Source localization above the head in a free field must have energy in the 8 kHz area or have a wide spectrum of up to 8 kHz. This fact can also be applied to closed spaces. This 8 kHz constraint poses a problem because a high proportion of workers have noise-induced hearing losses beginning in the 3-6 kHz range and extending to 8 kHz with age.

In order to facilitate localization in the horizontal plane, the siren should be a wide spectrum noise burst and placed in front of the workers. It is assumed that distance evaluation can be learned with practice but the fact that the siren is mobile adds to the complexity of the situation.

The siren's sound level should be 10-15 dB over the background noise in certain frequency bands in order to optimize localization. It is almost impossible to reach this target when the noise level is 100-110 dBA. Since localization in noise is closely related to frequency selectivity, workers with noise-induced hearing losses or other types of sensorineural hearing losses can experience more difficulties than normal listeners.

Secondly, Mr G may experience added difficulties with the use of earplugs. This type of hearing protector can compromise localization abilities if the attenuation is important in the high frequencies. It is also associated with front/rear confusions and leads to longer reaction times. In order to improve localization, higher signal to noise ratios would be required. This inevitably means background noises much lower than 100-110 dBA.

Thirdly, the building in which the travelling crane is installed is considered highly reverberant. The siren should therefore be pulsed and short in duration (in the order of 100-250 msec), with a 25-50 msec. rise time and a repetition rate lower than 3/sec (Patterson, 1982).

In summary, due to multiple constraints (high noise levels, long reverberation duration, presence of hearing loss and the wearing of hearing and face protectors), the localization of the siren is highly compromised. In order to improve this situation, noise reduction should be considered. This long term solution would solve two problems: it would reduce the risk of acquiring noise-induced hearing loss and allow the employee a better chance to localize sound sources. Secondly, the use of hearing protectors would then become superfluous. Aside from noise reduction per se, manufacturers must be informed of the multiple factors involved in localization and encouraged to produce safer sirens.

8.0 DISCUSSION AND CONCLUSION

The review of the literature and the simulated case demonstrate that it is difficult to generalize the results obtained in laboratories to the localization of sound in real life situations, where multiple factors interact. In fact, in the laboratory experiments reported, the number of loudspeaker positions was limited. In many studies, subjects were asked not to move their head during testing. The sound sources to localize were restricted in their spectral content, sound pressure level and duration. Most of the studies show subjects' sensitivity to one particular cue in one particular situation. We must then make this issue a research and clinical priority if we are to impact on the development of safer work environments. This can be a matter of life and death for a certain number of workers.

Presently, most of the pre-employment auditory requirements have been based on hearing thresholds within a certain range on the audiogram. With respect to the relation between auditory demands and capacities in the workplace, Hétu (1993) stated that job requirements involving auditory capacities are in fact almost always based on medico-legal definitions of hearing that were adopted in order to compensate workers affected by noise-induced hearing loss. It is now well known that if the auditory task is done in noisy surroundings, the frequency selectivity of the auditory system will be crucial. The temporal and spatial resolution (localization) are also important factors in many auditory tasks. In short, it is impossible to predict all aspects of auditory performance based on a measurement of auditory sensitivity alone.

In four recent cases of possible job disrimination filed at the Quebec and Canadian Human Rights Commission (Laroche, 1994), the audiogram was used to select candidates without considering the other auditory capacities. One exception is the case of a fireman where speech perception in silence was also considered. In all cases, localization of sound sources was part of the auditory tasks workers had to perform. Because of the lack of clinical tools, it was impossible for the present author to clearly state if these workers could safely do the jobs under analysis. It was nevertheless obvious that some adaptation of the workplace could be put in place in order to improve the safety of the workers, whatever their hearing status. With respect to the adaptation of the workplace, Hétu (1993) notes that we should explore all the facilities which might compensate for the functional limitations associated with hearing loss. For example, the workplace may be adapted by reducing the background noise or the reverberation duration and by selecting well designed warning sounds which will facilitate their localization.

In summary, no clinical tools are yet available to audiologists for the evaluation of localization abilities. The purpose of these tests should be to improve safety in noisy workplaces. Efforts should be put in the development of simple tests which will take into account the different aspects of localization such as the horizontal plane and vertical plane localization, the evaluation of distance and the movement perception, taking into consideration the wearing of hearing portectors, hearing losses and hearing aids. In the meantime, before rejecting a candidate, the auditory abilities required to perform the job should be well described and put in relation with the known auditory status (with and without hearing aids) of the candidate and all possible adapatation of the workplace should be considered. To test a candidate's real abilities in localization (or for other auditory tasks), simulations of job tasks should be performed with the candidate and his results compared to workers who are performing the same job and who are judged competent.

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Announcement and Call for Papers

1995 ACTIVE CONTROL SYMPOSIUM TO BE HELD IN NEWPORT BEACH, CALIFORNIA, USA

INCE/USA, INCE/Japan, the Acoustical Society of America, and the Acoustical Society of Japan will join in the sponsorship of ACTIVE 95, the 1995 International Symposium on Active Control of Sound and Vibration. The conference is a continuation of the biannually–organized meetings on Recent Advances on Active Control of Sound and Vibration which were held at the Virginia Polytechnic Institute in Blacksburg, Virginia in 1991 and 1993, and the International Symposium on Active Control of Sound and Vibration which was held in 1991 in Tokyo, Japan. The format of the meeting will follow that of the Blacksburg Conferences with full–length papers in a proceedings volume available to delegates at final registration.

The Symposium will be held on 1995 July 06–08 in Newport Beach, California. The organization of the Symposium will be coordinated by INCE/USA because it immediately precedes INTER–NOISE 95, the 1995 International Congress on Noise Control Engineering which is also being held in Newport Beach on 1993 July 10–12. The venue for both meetings will be the Newport Beach Marriott hotel, an attractive resort hotel overlooking Newport Beach Harbor and the Pacific Ocean.

Professor Jiri Tichy, head of the Graduate Program in Acoustics at the Pennsylvania State University, University Park, Pennsylvania, USA will be the general chairman and Professor Hideki Tachibana of the University of Tokyo will be co–chairman for the Symposium. It is expected that approximately 150 technical papers will be presented covering all aspects of active control of noise, sound fields (including auditoria), and vibration.

CONTRIBUTIONS INVITED

Technical papers in all areas related to the active control of sound and vibration are welcome. A partial list of topics of interest is on the next page of this announcement. Abstracts of papers proposed for presentation at the symposium must be received no later than **1994 November 29.** Japanese authors should send their abstracts to Professor Tachibana. Authors from all other countries should send their abstracts to Professor Tichy. The mailing addresses are on the *abstract cover sheet* which is the third page of this announcement. All abstracts must be accompanied by the *abstract cover sheet*.

If the paper is accepted, it must be typed on special manuscript paper which will be provided by the Symposium Secretariat. The completed manuscript will be printed in the Proceedings of the symposium, and must be received no later than **1995 March 28.** Because of the specialized topic of this symposium, long (10–12 pages) manuscripts will be accepted.

SUBJECT AREAS OF INTEREST

The main subject areas to be covered at the Symposium are:

- Active noise control – theory and applications
- Active vibration control – theory and applications
- Algorithms and systems for active control
- Active control in auditoria and other listening spaces
- Transducers for active noise and vibration control

SYMPOSIUM VENUE

The site of the symposium, the Newport Beach Marriott Hotel, is approximately 1 km from the Pacific Ocean on a hill with a view to the southwest of Newport Beach Harbor, Balboa Island and, on the horizion, Catalina Island about 40 km offshore. Newport Beach is located in Orange County, California, south of Los Angeles. Orange County Airport (John Wayne Airport [SNA]) is about 15 minutes to the north of the hotel by automobile. The airport was completely rebuilt in 1990–1991, and is now an excellent final destination for delegates to INTER–NOISE 95. The Newport Beach Marriott hotel provides complimentary transportation to and from the Orange County Airport. Los Angeles International Airport (LAX) is about 60 km to the northwest. Scheduled air transportation service, scheduled bus service and frequent van service are also available from LAX to Orange County Airport.

The location of the hotel is very attractive; opportunities for recreational activities include sightseeing at *Disneyland* in Anaheim, a boat trip to Catalina Island, and the harbor and beaches in the Newport Beach and Laguna Beach areas (readily accessible without an automobile). The hotel is adjacent to one of Southern California's major shopping centers, Fashion Island, in the Newport Center, and is about 20 minutes from the well–known South Coast Plaza shopping center and the Orange County Center for the Performing Arts in Costa Mesa. Some of the best restaurants in California are within a 30–minute drive from the hotel.

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AUDITORIUM ACOUSTICS AND ARCHITECTURAL DESIGN

by Michael Barron

Surely there are few better qualified to chronicle the state of room acoustics research than Michael Barron. He is responsible for several seminal works including the lateral reflections thesis, his widely accepted revised theory of sound in a room and small scale modelling techniques. His long awaited book - it was more than ten years in the making - does not disappoint.

When the book was first published last year, I overheard a consultant opine that it appeared too simplistic. The gentleman apparently missed the point, there are two forms of simplicity: uninformed and profound. Barron's is decidedly the latter. He has successfully confronted a writer's greatest challenge: to present complicated thought in clear concise language. I found many instances where a single sentence, that could be quite easily understood by the layman, held deeper layers for the specialist. Barron once described his sometime associate Harold Marshall as "a good read", he could well apply that moniker to himself.

The book grew from the Acoustic Survey of British Auditoria, organized by Barron in the early 1980s. Subjective surveys, objective measurements and brief building histories are presented for each of the 42 venues. Building types include concert halls, a separate chapter on recital halls, theatres, opera houses and multi-purpose rooms. The book opens with a friendly introduction to the science of acoustics and closes with useful appendices for the specialist.

There are clear descriptions of his revised theory of sound in a room; directional characteristics of speech and operatic singers; Rindel's reflector design equations; and a host of other useful formulae and data. Anders Gade contributes a section on stage design, including updated area allotments for instrumentalists, choristers, etc. There are unfortunately a few typographical errors in the text and this section has one of them.

Unlike Beranek's *Music Acoustics and Architecture* - it's hard to avoid the comparison - Barron includes a plethora of useful references. In Beranek's defence though, there is a lot more work to refer to now than there was in 1960. The book is also well referenced within itself, that is from chapter to chapter.

There is plenty of good advice, mixed with occasionally tentative statements and recommendations. These however represent the reality of modern acoustics, not a timid approach by the author. When Barron makes a definitive statement, for example on the use of directional sources to measure theatres, one can be sure that he does so with good reason.

Barron, one of the fathers of the lateral reflections breakthrough, is by no means married to its single minded application. In reviewing the Royal Concert Hall in Nottingham, he points out that the acoustical designers were willing to let the provision of lateral reflections compensate for inappropriate reverberation times. The result in short is a good hall but not a great one. Throughout the book Barron reiterates the importance of a multi-dimensional approach. Acoustics is after all a multi-dimensional experience. Reading his comments on the Nottingham hall, one is struck by the honest, candid approach. Contrast this to other researchers who seem to see vestiges of their own theories smiling behind every corner.

It was also comforting to see a scientist of Barron's stature point out that acoustics remains as much an art as a science. Having worked on both sides of the arts and science schism, I couldn't agree more.

Despite his laudable efforts to make the book clear and simple, an apparent Eurocentric approach may leave some wondering. Most on this side of the ocean are not familiar with "stalls" seating. Japanese research receives little attention, a fact obliquely alluded to in Harold Marshall's three page Forward to the book.

The reproduction quality of some of the figures is less than perfect. This applies mostly to extracts from others researchers' work. The plans and sections are very well done and the decision to reproduce them at a consistent scale (1:500) is a good one. They represent the most lasting resource in a book of this kind and the extra effort put into them shows.

Acoustics at this end of the century is an exciting field and Barron does indeed render an exciting book - "a good read". It is at times hard to put down. It will remain a valuable reference for years to come. Anyone with any interest in room acoustics be it specialist or generalist should have *Auditorium Acoustics and Architectural Design* on the shelf ready to pick up easily and often.

[This book (ISBN 0-419-17710-8) is available from Routledge, Chapman and Hall at the price of US$125].

Reviewed by: John O'Keefe, Aercoustics Engineering Ltd.

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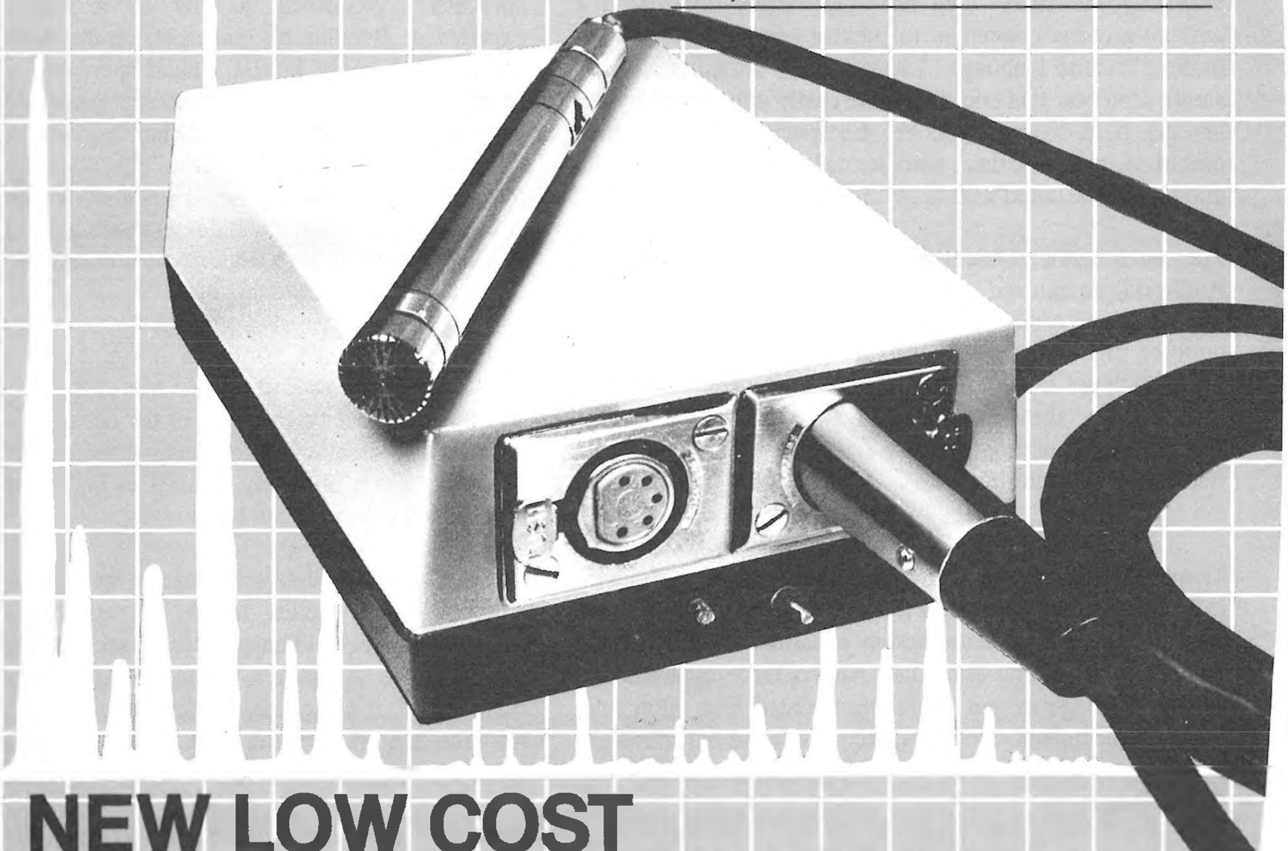

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Professional ≥30 years / Professionel ≥30 ans: **Raymond Hétu,** Université de Montréal
"Capacités auditives, critères d'embauche et droits de la personne"

Student / Étudiant: **Adel Abdou,** Concordia University
"A PC-based measurement system for obtaining spatial information and objective room-acoustic indicators"

STUDENT AWARDS / PRIX ÉTUDIANT

Martin Fortin, Université de Montréal
"Characterization of occupational sound exposure of professionals involved in highly amplified music reproduction"

Hanif M. Ladak, McGill University
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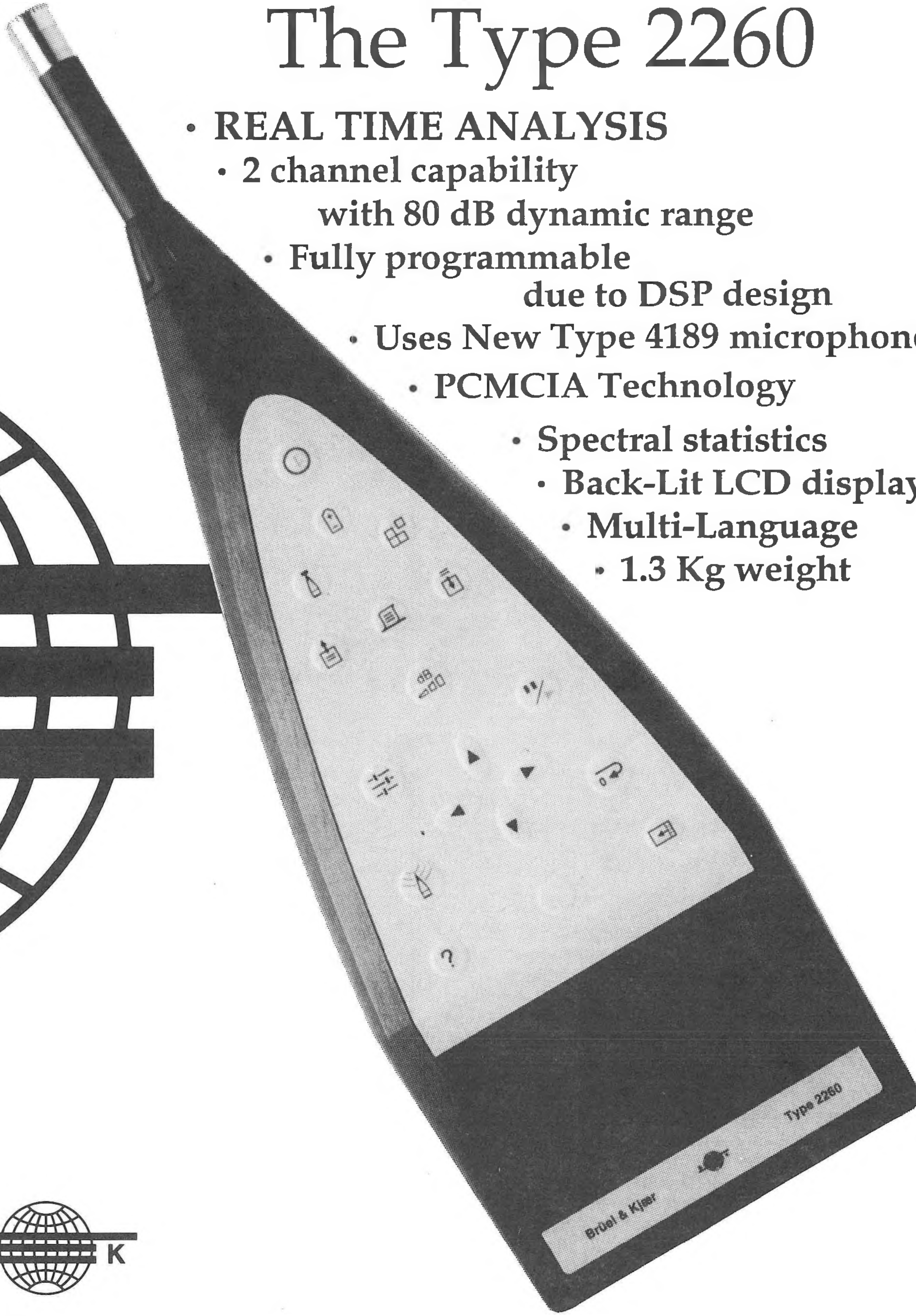

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REPORT ON THE SPECIAL SESSION ON 'HEARING ACCESSIBILITY'

Acoustics Week in Canada 1994

The session on 'Hearing Accessibility' that was held in Ottawa during Acoustics Week in Canada 1994 was the first of its kind in Canada, and it also pre-dates a similar session on Acoustical Accessibility of Public Facilities for Persons with Hearing and Vision Disabilities that will be held at the 129th Meeting of the Acoustical Society of America in Washington DC in May 1995. The purpose of the session in Ottawa was to provide an inter-disciplinary forum that would allow for the exchange of information between architects, audiologists, engineers, psychologists, consumers, manufacturers, government representatives and other CAA members, all of whom are concerned with how to best meet the acoustical needs of hard of hearing people. Furthermore, it was hoped that the session would encourage more inter-disciplinary collaboration between professionals who could combine discipline-specific solutions to arrive at integrated solutions in practice that would achieve a collaborative sum greater than the discipline-specific parts.

Kathy Pichora-Fuller, the session organizer, introduced the session by explaining that facilities or activities are considered to be 'hearing accessible' if individuals who are hard of hearing can function as effectively in those facilities or activities as can individuals who have normal hearing. The first presenter, Murray Hodgson began his paper by disputing the definition of hearing accessibility with the claim that some facilities and activities are 'inaccessible' even for people with normal hearing. He continued his paper on how acoustical environments affect people by illustrating that non-optimum acoustical environments in various facilities, including industrial workshops, classrooms, residences, or public places such as theatres, may hamper a wide range of activities for normal-hearing people and that the negative impact of such adverse acoustical environments is even greater for hard of hearing people. Bruce Schneider then described how declines in perceptual abilities such as auditory temporal resolution and declines in cognitive abilities such as working memory could undermine how a listener understands speech in signal-to-noise conditions like those described in the first paper on non-optimum acoustical environments. An important point was that when adverse acoustical conditions stress perception then speech understanding is compromised because words are misperceived but also because mental resources are allocated to perception that in more favourable listening conditions would be allocated to higher cognitive processes such as memory that are necessary for the material that is heard to be fully comprehended.

Following the first two papers that described when and why poor acoustics make listening activities difficult, Charles Laszlo talked about engineering aspects of assistive-device technologies for hard-of-hearing and deaf people that could be used to overcome adverse acoustical environments. Complications with the use of assistive devices and hearing aids due to electro-magnetic interference was the topic of the next paper by Barry McKinnon. Jean-Rémi Champagne then presented an architect's perspective on how the built world could be constructed and how it could incorporate assistive technology that would increase hearing accessibility. The next two papers were given by audiologists who reported on clinical applications concerning hearing-accessibility issues in different settings for specific populations of hard-of-hearing people.

The first paper demonstrating an audiologic application was given by Raymond Hétu and Hung Tran Quoc who reported on the validation of masked-threshold predictions among workers with sensorineural hearing loss who are required to hear warning signals in industrial settings. The second paper on an audiologic application was given by Kathy Pichora-Fuller who reported on the implementation of a rehabilitation program to achieve hearing accessibility at a home for the aged. Both of the papers on applications showed how audiologists, who have traditionally been concerned with the hearing status of individuals, are now realizing the importance of characterizing the hearing status of groups of people when hearing accessibility solutions are being implemented.

Having heard from the professionals, the final two papers were given by guests at the session, one by Ruth Warick, the President of the Canadian Hard-of-Hearing Association, and the other by Joan Harvey, an environmental psychologist at the Seniors' Secretariat at Health Canada. A theme of the presentations of both of the last speakers was the need for interaction between disciplines and sectors in developing more effective solutions for those with hearing accessibility needs.

The session was immediately followed by a well-attended plenary session that was organized by Raymond Hétu and that sparked lively discussion between the plenary panel and CAA members. While some participants in the discussion felt that they were already well acquainted with some of the information presented, many expressed frustration that they had experienced over the years in not being able to implement acoustical solutions that could have been advantageous. Some reasons for such frustrations were traced to a lack of co-ordination between disciplines, policy makers and consumers. It seemed clear from the discussion that the time at the session was well spent by members interacting with those from other disciplines to debate why good solutions are not always realized, why they may not be sufficient when they are realized, and how various professionals could work together to improve hearing accessibility by combining solutions. While the Americans with Disabilities Act has triggered an interest in these matters south of the border, it may be that Canadians will take the lead on demonstrating how hearing accessibility may be achieved more effectively.

M. Kathleen Pichora-Fuller, *University of British Columbia*

Dr. Charles Laszlo addresses the special session on Hearing Accessibility held during Acoustics Week in Canada 1994.

The Acoustical Environment - A Social Concern / L'environnement sonore - une préoccupation sociale

This was the theme of the plenary session that followed the technical session on Hearing Accessibility held on October 20, during the 1994' Acoustics week. It was intended as a mean to make visible the effort of CAA members in terms of research activities that are of particular social relevance. It had also the purpose of raising the members interest in such issues. The background question was 'Can we function in today's environment when we are hard of hearing?'.

The following outline summarizes the topics covered briefly during this round table:

1- The concept of accessibility and the social environment Louise Getty,from the Groupe d'acoustique de l'universite de Montreal, introduced the issue of accessibility within a conceptual framework. After demonstrating that availability does not means accessibility, she qualified this concept along different dimensions: acceptibility, affordability,and capacity of the individuals to adapt to the service or the environment. It was concluded by examples of socio-cultural influences on these various dimensions.

2- Reconciling accommodations with 'bona fide' occupational requirements Grace Brown,of the Canadian Human Rights Commission, presented a general frame-work for judging cases of job discrimination because of hearing disabilities. Job descriptions and criteria for assessing task performance capacities were examined through concrete examples. The possible accommodations that can be considered in cases of loss of hearing were discussed within a human rights perspective.

3- Accessibility of Courtrooms - Carole Theberge, a lawyer who is hard-of-hearing,described a series of barriers to communication in the court house for people who have less than perfect hearing. Examples of accommodations that can raise physical barriers included, among several others,lighting, reverberation control, assistive listening devices and flashing light alarms. Social barriers were also identified and an education program was outlined as a solution.

4- The Institute of Hearing Accessibility Research at University of British Columbia - Charles Laszlo, of the Faculty of Graduate Studies at the University of British Columbia, introduced the newly created and unique research institute devoted to the issue of hearing accessibility. The historical background of the institute creation presented emphasized the inter-disciplinary nature of the research activities that are undertaken,which include engineering, audiology, industrial hygiene. A major project is already undertaken, namely the accessibility of university classrooms.

5- Accessibility of auditoriums and places of worship - Stephane McDuff, who is audiolgist at the Institut Raymond-Dewar, a regional rehabilitation center for people with hearing impairment in Montreal, presented an overview of the factors that makes large halls inaccessible to people with hearing impairments: reverberation, competing noise and distance. The merits and shortcomings of different types of listening devices were presented. An account of a series of pilot trials was given involving the use of an FM transmitter and personal radio receivers. It was discussed with respect to the various dimensions of accessibility presented in the introduction of the round table.

The above presentations were followed by several animated comments and questions that confirmed the interest of CAA members in the issue of hearing accessibility.

I had the pleasure of concluding the session in showing that the degree of participation and the number of issues raised were a clear illustration of the interest of acousticians in social dimensions of the sound environment.

Raymond Hetu, *Université de Montréal*

NEWS / INFORMATIONS

CONFERENCES

129th Meeting of the Acoustical Society of America: May 31-June 4, 1995, Washington, DC, USA. Contact: Elaine Moran, Acoustical Society of America, 500 Sunnyside Blvd., Woodbury, NY 11797, USA. Telephone: +1 (516) 576-2360, Fax: +1 (516) 349-7669.

2nd International Conference on Acoustics and Musical Research: 3rd week, May 1995, Ferrara, ITALY. Contact: Conference Secretariat, CIARM95, National Research Council of Italy, Cemoter Acoustics Department, Via Canal Bianco, 28-44044 Ferrara. Tel. +39 532 731571-Fax +39 532 732250. E-mail CIARM95@CNRFE4.FE.CNR.IT

International Symposium in Music and Concert Hall Acoustics (MCHA95): May 15 to 18 ,1995, Kirishima, Kagoshima-Prefecture, JAPAN. Contact: The Kirishima International Concert Hall, Kagoshima, Japan for further details.

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17th Boundary Element International Conference: 17-19 July, 1995, Wisconsin, USA. Contact: Lis Johnstone, Conference Secretariat, BEM 17, Wessex Institute of Technology, Ashurst Lodge, Ashurst Southampton, SO40 7AA. Tel 44 (0) 703 293223, Fax 44 (0) 703 292853, EMail CMI@uk.ac.rl.ib, Intl EMail CMI@ib.rl.ac.uk

1995 World Congress on Ultrasonics: September 3 to 7, 1995, BERLIN. Contact: WCU'95 Secretariat, Prof. Dr. J. Herbertz, Gerhard-Mercator-Universitat, D-47048 Duisburg, Germany. Tel +49 (203) 379-3243,Fax +49 (203) 37 35 34

BETECH 95: September 13-15 1995, Liege, BELGIUM. Contact: Liz Johnstone, Conference Secretariat - BETECH 95, Ashurst Lodge, Ashurst, SO40 7AA UK. Tel +44 (0) 703 293223, Fax +44 (0) 703 292853, EMail CMI@uk.ac.rl.ib., Intl EMail CMI@ib.rl.ac.uk

Second International Conference on Theoretical & Computational Acoustics: August 21-25, 1995, Hawaii, USA. Contact: Dr. Ding Lee (Code 3122), Naval Undersea Warfare Center, Detachment New London, New London CT 06320 USA. Tel 203-440-4438 Fax 203-4406228

130th Meeting of the Acoustical Society of America: November 27-December 1, 1995, St. Louis, Missouri, USA. Contact: Elaine Moran, Acoustical Society of America, 500 Sunnyside Blvd., Woodbury, NY 11797, USA. Telephone: +1 (516) 576-2360, Fax: +1 (516) 349-7669.

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129e rencontre de l'Acoustical Society of America: Washington, DC, du 31 mai au 4 juin 1995. Renseignements: Elaine Moran, Acoustical Society of America, 500 Sunnyside Blvd., Woodbury, NY 11797, USA. Téléphone (516) 576-2360; télécopieur (516) 349- 7669.

2e conférence internationale sur la recherche en acoustique et en musique: Ferrara, Italie, 3e semaine de mai 1995. Renseignements: Conference Secretariat, CIARM95, National Research Council of Italy, Cemoter Acoustics Department, Via Canal Bianco, 28-44044 Ferrara, Italie. Téléphone 39 532 731571; télécopieur 39 532 732250; courrier électronique CIARM95@CNRFE4.FE.CNR.IT.

Symposium international d'acoustique musicale et de salles de concert (MCHA95): Kirishima, Kagoshima-Prefecture, Japon, du 15 au 18 mai 1995. Renseignements: The Kirishima International Conceert Hall, Kagoshima, Japon.

15e congrès international d'acoustique: Trondheim, Norvège, du 26 au 30 juin 1995. Renseignements: ICA'95, SEVU, Congress Department, N-7034 Trondheim, Norvège. Téléphone 47 7359 5251/5254; télécopieur 47 7359 5150; courrier électronique ica95@sevu.unit.no.

INTER-NOISE 95: Newport Beach, Californie, du 10 au 12 juillet 1995. Renseignements: Institute of Noise Control Engineering, P.O. Box 3206, Arlington Branch, Poughkeepsie, NY 12603, USA. Téléphone: (914) 462-4006, télécopieur (516) 473-9325.

17e conférence internationale sur les éléments de contour: Winconsin, États-Unis, du 17 au 19 juillet 1995. Renseignements: Lis Johnstone, Conference Secretariat, BEM 17, Wessex Institute of Technology, Ashurst Lodge, Ashurst Southampton, SO40 7AA. Téléphone 44 (0) 703 293223; télécopieur 44 (0) 703 292853; courrier électronique CMI@uk.ac.rl.ib; courrier électronique international CMI@ib.rl.ac.uk.

Congrès mondial de 1995 sur les ultrasons: Berlin, Allemagne, du 3 au 7 septembre 1995. Renseignements: WCU'95 Secretariat, Prof. Dr. J. Herbertz, Gerhard-Mercator-Universitat, D-47048 Duisburg, Allemagne. Téléphone 49 203 379 3243; télécopieur 49 203 37 3534.

BETECH 95: Liège, Belgique, du 13 au 15 septembre 1995. Renseignements: Liz Johnstone, Conference Secretariat, BETECH 95, Ashurst Lodge, Ashurst, SO40 7AA, Royaume-Uni. Téléphone 44 (0) 703 29 3223; télécopieur 44 (0) 703 29 2853; courrier électronique CMI@uk.ac.rl.ib, courrier électronique international CMI@ib.rl.ac.uk.

2e conférence internationale sur l'acoustique théorique de calcul: Hawaï, du 21 au 25 août. Renseignements: Dr. Ding Lee (code 3122), Naval Undersea Warfare Center, Detachment New London, New London CT 06320, États-Unis. Téléphone 203 440 4438; télécopieur 203 440 6228.

130e rencontre de l'Acoustical Society of America: St. Louis, Missouri, États-Unis, du 27 novembre au 1er décembre 1995. Renseignements: Elaine Moran, Acoustical Society of America, 500 Sunnyside Blvd., Woodbury, NY 11797, États-Unis. Téléphone (516) 576-2360; télécopieur (516) 349- 7669.

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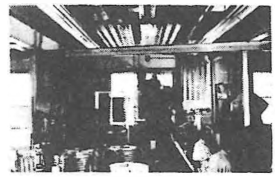

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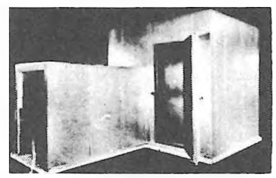

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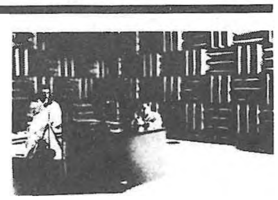

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Psycho/Physiological acoustics	6	Acoustique psycho/physiologique
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The Canadian Acoustical Association
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ANNONCE DE PRIX

Plusieurs prix, dont les objectifs généraux sont décrits ci-dessous, sont décernés par l'Association Canadienne d'Acoustique. Quant aux quatre premiers prix, les candidats doivent soumettre un formulaire de demande ainsi que la documentation associée au coordonateur de prix avant le dernier jour de février de l'année durant laquelle le prix sera décerné. Toutes les demandes seront analysées par des sous-comités nommés par le président et la chambre des directeurs de l'Association. Les décisions seront finales et sans appel. L'Association se réserve le droit de ne pas décerner les prix une année donnée. Les candidats doivent être membres de l'Association. La préférence sera donnée aux citoyens et aux résidents permanents du Canada. Les candidats potentiels peuvent se procurer de plus amples détails sur les prix, leurs conditions d'éligibilité, ainsi que des formulaires de demande auprès du coordonateur de prix.

PRIX POST-DOCTORAL EDGAR ET MILLICENT SHAW EN ACOUSTIQUE

Ce prix est attribué à un(e) candidat(e) hautement qualifié(e) et détenteur(rice) d'un doctorat ou l'équivalent qui a complèté(e) ses études et sa formation de chercheur et qui désire acquérir jusqu'à deux années de formation supervisée de recherche dans un établissement reconnu. Le thème de recherche proposée doit être relié à un domaine de l'acoustique, de la psycho-acoustique, de la communication verbale ou du bruit. La recherche doit être menée dans un autre milieu que celui où le candidat a obtenu son doctorat. Le prix est de $3000 pour une recherche plein temps de 12 mois avec possibilité de renouvellement pour une deuxième année. Coordonnatrice: Sharon Abel, Mount Sinai Hospital, 600 University Avenue, Toronto, ON M5G 1X6. Les récipiendaires antérieur(e)s sont:

1990	*Li Cheng*	*Université de Sherbrooke*
1993	*Roland Woodcock*	*University of British Columbia*
1994	*John Osler*	*Defense Research Establishment Atlantic*

PRIX ÉTUDIANT ALEXANDER GRAHAM BELL EN COMMUNICATION VERBALE ET ACOUSTIQUE COMPORTEMENTALE

Ce prix sera décerné à un(e) étudiant(e) inscrit(e) dans une institution académique canadienne et menant un projet de recherche en communication verbale ou acoustique comportementale. Il consiste en un montant en argent de $800 qui sera décerné annuellement. Coordonnateur: Don Jamieson, Department of Communicative Disorders, University of Western Ontario, London, ON N6G 1H1. Les récipiendaires antérieur(e)s sont:

1990	*Bradley Frankland*	*Dalhousie University*
1991	*Steven D. Turnbull*	*University of New Brunswick*
	Fangxin Chen	*University of Alberta*
	Leonard E. Cornelisse	*University of Western Ontario*
1993	*Aloknath De*	*McGill University*
1994	*Michael Lantz*	*Queen's University*

PRIX ÉTUDIANT FESSENDEN EN ACOUSTIQUE SOUS-MARINE

Ce prix sera décerné à un(e) étudiant(e) inscrit(e) dans une institution académique canadienne et menant un projet de recherche en acoustique sous-marine ou dans une discipline scientifique reliée à l'acoustique sous-marine. Il consiste en un montant en argent de $500 qui sera décerné annuellement. Coordonnateur: David Chapman, DREA, PO Box 1012, Dartmouth, NS B2Y 3Z7.

1992	*Daniela DiIorio*	*University of Victoria*
1993	*Douglas J. Wilson*	*Memorial University*
1994	*Craig L. McNeil*	*University of Victoria*

PRIX ÉTUDIANT ECKEL EN CONTROLE DU BRUIT

Ce prix sera décerné à un(e) étudiant(e) inscrit(e) dans une institution académique canadienne dans n'importe quelle discipline de l'acoustique et menant un projet de recherche relié à l'avancement de la pratique en contrôle du bruit. Il consiste en un montant en argent de $500 qui sera décerné annuellement. Ce prix a été inauguré en 1991. Coordonnateur: Murray Hodgson, Occupational Hygiene Programme, University of British Columbia, 2206 East Mall, Vancouver, BC V6T 1Z3.

1994	*Todd Busch*	*University of British Columbia*

PRIX DES DIRECTEURS

Trois prix sont décernés, à tous les ans, aux auteurs des trois meilleurs articles publiés dans l'*Acoustique Canadienne*. Tout manuscrit rapportant des résultats originaux ou faisant le point sur l'état des connaissances dans un domaine particulier sont éligibles; les notes techniques ne le sont pas. Le premier prix, de $500, est décerné à un(e) étudiant(e) gradué(e). Le deuxième et le troisième prix, de $250 chacun, sont décernés à des auteurs professionnels âgés de moins de 30 ans et de 30 ans et plus, respectivement. Coordonnateur: Blaise Gosselin, Hydro Québec, 5^{e} étage, 1010, rue Ste-Catherine est, Montréal, QC H2L 2G3..

PRIX DE PRESENTATION ÉTUDIANT

Trois prix, de $500 chaqun, sont décernés annuellement aux étudiant(e)s sous-gradué(e)s ou gradué(e)s présentant les meilleures communications lors de la Semaine de l'Acoustique Canadienne. La demande doit se faire lors de la soumission du résumé. Coordonnateur: Alberto Behar, 45 Meadowcliffe Drive, Scarborough, ON M1M 2X8.

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

PRIZE ANNOUNCEMENT

A number of prizes, whose general objectives are described below, are offered by the Canadian Acoustical Association. As to the first four prizes, applicants must submit an application form and supporting documentation to the prize coordinator before the end of February of the year the award is to be made. Applications are reviewed by subcommittees named by the President and Board of Directors of the Association. Decisions are final and cannot be appealed. The Association reserves the right not to make the awards in any given year. Applicants must be members of the Canadian Acoustical Association. Preference will be given to citizens and permanent residents of Canada. Potential applicants can obtain full details, eligibility conditions and application forms from the appropriate prize coordinator.

Edgar and Millicent Shaw Postdoctoral Prize in Acoustics

This prize is made to a highly qualified candidate holding a Ph.D. degree or the equivalent, who has completed all formal academic and research training and who wishes to acquire up to two years supervised research training in an established setting. The proposed research must be related to some area of acoustics, psychoacoustics, speech communication or noise. The research must be carried out in a setting other than the one in which the Ph.D. degree was earned. The prize is for $3000 for full-time research for twelve months, and may be renewed for a second year. Coordinator: Sharon Abel, Mount Sinai Hospital, 600 University Avenue, Toronto, ON M5G 1X6. Past recipients are:

1990	*Li Cheng*	*Université de Sherbrooke*
1993	*Roland Woodcock*	*University of British Columbia*
1994	*John Osler*	*Defense Research Establishment Atlantic*

Alexander Graham Bell Graduate Student Prize In Speech Communication and Behavioural Acoustics

The prize is made to a graduate student enrolled at a Canadian academic institution and conducting research in the field of speech communication or behavioural acoustics. It consists of an $800 cash prize to be awarded annually. Coordinator: Don Jamieson, Department of Communicative Disorders, University of Western Ontario, London, ON N6G 1H1. Past recipients are:

1990	*Bradley Frankland*	*Dalhousie University*
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1993	*Aloknath De*	*McGill University*
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Fessenden Student Prize in Underwater Acoustics

The prize is made to a graduate student enrolled at a Canadian university and conducting research in underwater acoustics or in a branch of science closely connected to underwater acoustics. It consists of $500 cash prize to be awarded annually. Coordinator: David Chapman, DREA, PO Box 1012, Dartmouth, NS B2Y 3Z7.

1992	*Daniela Dilorio*	*University of Victoria*
1993	*Douglas J. Wilson*	*Memorial University*
1994	*Craig L. McNeil*	*University of Victoria*

Eckel Student Prize in Noise Control

The prize is made to a graduate student enrolled at a Canadian academic institution pursuing studies in any discipline of acoustics and conducting research related to the advancement of the practice of noise control. It consists of a $500 cash prize to be awarded annually. The prize was inaugurated in 1991. Coordinator: Murray Hodgson, Occupational Hygiene Programme, University of British Columbia, 2206 East Mall, Vancouver, BC V6T 1Z3.

1994	*Todd Busch*	*University of British Columbia*

Directors' Awards

Three awards are made annually to the authors of the best papers published in *Canadian Acoustics*. All papers reporting new results as well as review and tutorial papers are eligible; technical notes are not. The first award, for $500, is made to a graduate student author. The second and third awards, each for $250, are made to professional authors under 30 years of age and 30 years of age or older, respectively. Coordinator: Blaise Gosselin, Hydro Québec, 5e étage, 1010, rue Ste-Catherine est, Montréal, QC H2L 2G3.

Student Presentation Awards

Three awards of $500 each are made annually to the undergraduate or graduate students making the best presentations during the technical sessions of Acoustics Week in Canada. Application must be made at the time of submission of the abstract. Coordinator: Alberto Behar, 45 Meadowcliffe Drive, Scarborough, ON M1M 2X8.

INSTRUCTIONS TO AUTHORS PREPARATION OF MANUSCRIPT

Submissions: The original manuscript and two copies should be sent to the Editor-in-Chief.

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