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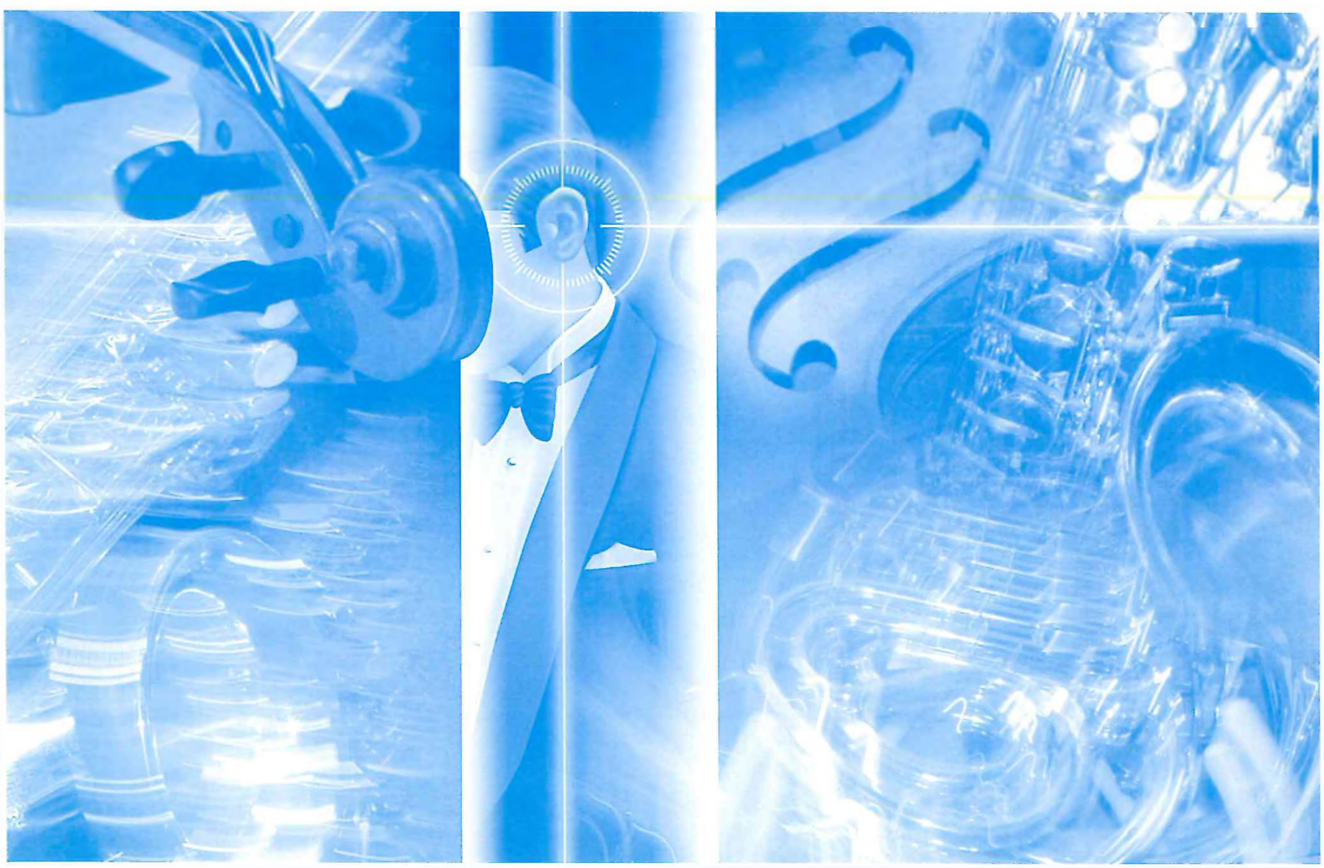

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THE CANADIAN ACOUSTICAL ASSOCIATION
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L'ASSOCIATION CANADIENNE D'ACOUSTIQUE
C.P. 1351, SUCCURSALE "F"
TORONTO, ONTARIO M4Y 2V9

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EDITOR-IN-CHIEF / RÉDACTEUR EN CHEF

Ramani Ramakrishnan
Department of Architectural Science
Ryerson University
350 Victoria Street
Toronto, Ontario M5B 2K3
Tel: (416) 979-5000; Ext: 6508
Fax: (416) 979-5353
E-mail: rramakri@ryerson.ca

EDITOR / RÉDACTEUR

Chantal Laroche
Dépt. d'orthophonie et d'audiologie
Université d'Ottawa
545 King Edward
Ottawa, Ontario K1N 6N5
Tél: (613) 562-5800 extn/poste 3066
Fax: (613) 562-5256
E-mail: claroche@uottawa.ca

ASSOCIATE EDITORS / REDACTEURS ASSOCIES

Advertising / Publicité
Karen Fraser
Jade Associates Inc.
545 Rivermede Road, Suite 203
Concord, Ontario L4K 4H1
Tel: (905) 660-2444
Fax: (905) 660-4110
E-mail: karen@jadeacoustics.com

News / Informations
Francine Desharnais
DREA - Ocean Acoustics
P. O. Box 1012
Dartmouth, NS B2Y 3Z7
Tel: (902) 426-3100
Fax: (902) 426-9654
E-mail: desharnais@drea.dnd.ca

EDITORIAL / ÉDITORIAL

De mémoire, je crois que c'est la première fois que j'ai la chance d'écrire l'éditorial de l'Acoustique Canadienne. Je suis rédactrice adjointe depuis plus de 13 ans, mais l'occasion ne s'était jamais présentée de partager avec vous mes réflexions. Ceux qui me connaissent savent que mon champ d'expertise est axé vers l'audiologie et les sciences de l'audition. Je me permettrai donc de vous parler de mes préoccupations à l'égard de ce domaine de spécialisation. Je crois que ce que je vais dire s'applique aussi aux autres champs de l'acoustique au Canada, que ce soit en sciences de la parole, en génie ou en acoustique sous-marine, par exemple.

Sans vouloir être négative, je suis un peu découragée de constater que si peu d'étudiants canadiens optent pour des études doctorales en audiologie ou dans un domaine connexe. Nous avons un besoin urgent de relève dans les universités canadiennes, et le besoin est encore plus criant pour les deux universités francophones du pays, soit Montréal et Ottawa. J'encourage tous les professeurs d'université et les collègues qui côtoient des étudiants en formation à inciter ces jeunes à poursuivre des études avancées. Les perspectives d'emploi sont, à mon avis, excellentes et les défis sont nombreux. Nous avons besoin de sang neuf et d'idées innovatrices.

Plusieurs d'entre vous seront tentés de demander comment amener les jeunes à considérer poursuivre des études alors que le marché du travail est attirant et les salaires relativement convenables, du moins en audiologie. Par ailleurs, comment convaincre les candidats potentiels à se lancer dans des études qui les mèneront vers des emplois qui peuvent s'avérer très exigeants? On ne peut se le cacher, le travail de professeur ou de chercheur n'est pas de tout repos. Il faut constamment se battre pour obtenir des fonds de recherche et la pression est forte pour publier des articles. Ce travail doit se faire en parallèle avec l'enseignement et les tâches administratives. Il y a de quoi se brûler si on ne fait pas attention. J'ose espérer que cette période de travail intense sera considéré comme chose du passé lorsque la relève se manifestera. Plus on sera nombreux, plus le travail d'équipe sera possible et plus le climat de travail sera sain. Il nous faut viser cet idéal si nous désirons améliorer la qualité de vie des gens aux prises avec des problèmes d'audition. N'oublions pas que 10% des canadiens sont atteints de déficiences auditives à divers degrés. Raymond Hétu a su nous démontrer, par ses nombreux travaux de recherche, comment une atteinte auditive peut miner la qualité de vie des gens qui en sont atteints ainsi que les gens qui les côtoient. Raymond nous a légué un immense héritage. Il serait dommage de ne pas pouvoir poursuivre la voie qu'il a si activement tracée.

Pour terminer sur une note positive, n'oubliez pas de vous inscrire au congrès de l'Acoustique canadienne qui se tient cette année à l'Île du Prince Édouard. Nos collègues ont tout mis en place pour faire de ce congrès une expérience mémorable. Venez en grand nombre!

Chantal Laroche, Ph.D.
Rédactrice adjointe

As far as I can remember, this is my first opportunity to write the Canadian Acoustics' editorial. I have been assistant editor for well over 13 years but the opportunity has never before presented itself for me to share my thoughts with you. Those of you who know me are aware that my field of expertise is oriented towards audiology and hearing sciences. I will thus share my preoccupations with respect to this field of specialization, but those preoccupations can also be applied to other acoustic fields in Canada, such as, for example, speech sciences, engineering and undersea acoustics.

Without wanting to sound negative, I am a bit discouraged to note that few Canadian students choose to pursue doctoral studies in audiology or related fields. There is an urgent need of new professors in Canadian universities, and this need is even more pressing for the two French universities in this Country, which are situated in Montreal and Ottawa. I strongly encourage all university professors and colleagues to motivate students in training to pursue advanced studies. In my opinion, job opportunities are excellent and challenges are great. We are in need of new blood and innovative ideas.

Many of you will be tempted to ask how to bring young students to consider pursuing advanced studies when the job market is very enticing and salaries are relatively expedient, at least in audiology. Moreover, how can we convince potential candidates to pursue studies that will lead to jobs that can become very demanding? We certainly can't hide the fact that the work of a professor or researcher isn't easy. We constantly need to fight in order to obtain research funds, and the pressure to publish articles is tremendous. This work must also be done in parallel with teaching and administrative tasks. If we are not careful, exhaustion can easily occur. I can only hope that this intense work period will be considered a thing of the past when we will have sufficient number of doctoral prepared professors. The more we are, the easier it will be to establish teamwork and to create a healthier job atmosphere. We must aim to reach this ideal if we want to improve the quality of life of people who experience auditory difficulties. Let's not forget that 10% of Canadians are touched by auditory difficulties of varying degrees. Through his work, Raymond Hétu was able to shown us how an auditory impairment can reduce the quality of life of those affected, as well as people in their surroundings. Raymond has left us a tremendous heritage. It would be a shame not to follow the path that he has so actively set out.

To end on a positive note, don't forget to register to the Canadian Acoustic convention that will be held this year in Prince Edward Island. Our colleagues have taken great care in order to make this convention a wonderful experience. Come in large numbers!!!

Chantal Laroche, Ph.D.
Assistant editor

Obituary - Tom Northwood - Past President of CAA-ACA

Compiled by Dr. Alf Warnock
Institute for Research in Construction, National Research Council, Ottawa

Tom Northwood died on Monday, June 11, 2002. Dr. Northwood was head of the Acoustics group at NRC from its inception until he retired in 1979. The folllowing is the citation that was prepared when Tom Northwood received the W.C Sabine medal from the Acoustical Society of America in 1982.

Orlando, Florida 1982

THE WALLACE CLEMENT SABINE MEDAL of the Acoustical Society of America is being awarded this year to Thomas D. Northwood for his contributions to architectural acoustics. His activities over a long and distinguished career have covered many areas in this field.

Tom was born in Peterborough, Ontario in 1915 and studied engineering physics at the University of Toronto, receiving his B.Sc. in 1938. After a short period spent doing design work with Northern Electric, he joined the National Research Council of Canada in 1940 as a research physicist working in underwater sound. After the war years, his area of interest was expanded to include architectural acoustics, and in 1948 he was given leave of absence from NRC to do postgraduate studies in seismology. He received his MA in 1950 and his Ph.D. in 1952 from the University of Toronto, both in Physics. He rejoined the National Research Council to head a new research section concerned with structural dynamics, building acoustics and vibration, noise, and related matters. He held this position in the Division of Building Research until his retirement in 1979. These activities in building research and acoustical testing developed quite naturally into a strong interest in acoustical standards. He joined the American Society for Testing and Materials (ASTM) around 1951 and has been active on the Committee on Environmental Acoustics for over 30 years, serving as its chairman from 1966 to 1972. Over the years Tom has been active on many task groups and subcommittees charged with writing standards and solving problems in building acoustics. In 1975 he received the ASTM Award of Merit for "outstanding contributions to research and development of standards in building acoustics" and was made a Fellow of the Society.

As chairman of the Canadian Advisory Committee on Acoustics reporting to the Standards Council of Canada he extended his work into international standards, and represented Canada at meetings of the International Organization for Standardization for many years. He has held membership in the Engineering Institute of Canada, the Association of Professional Engineers of Ontario, and the Seismological Society of America. He is a member of the Institute of Noise Control Engineering and a Fellow of the Acoustical Society of America and of the American Association for the Advancement of Science. In 1962 he invited together a small number of Canadian acousticians to discuss topics of mutual interest and from this gathering, the Canadian Committee on Acoustics was born. The group has since grown considerably, and was recently renamed the Canadian Acoustical Association. Tom was President of the Association from 1979 until 1982. His most notable research interests over the years have included noise control, architectural acoustics, and the measurement of sound transmission and absorption. His considerable presence in the field of architectural acoustics led to an appointment as associate editor of the Journal of the Acoustical Society of America in 1964, a position he still holds. He has edited a volume in the Benchmark series entitled "Architectural Acoustics" and has published many papers in every area he has worked in.

Tom Northwood has had a long and productive career and made many significant contributions to architectural acoustics. The present award is a fitting acknowledgement of these achievements.

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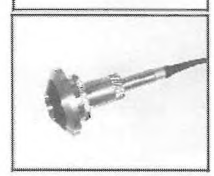

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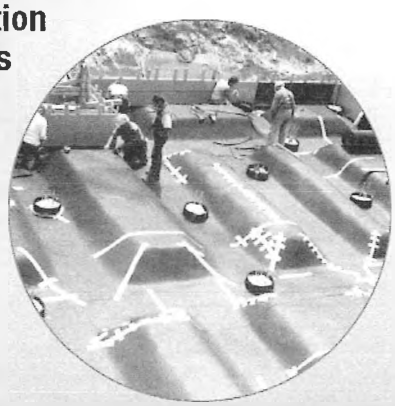

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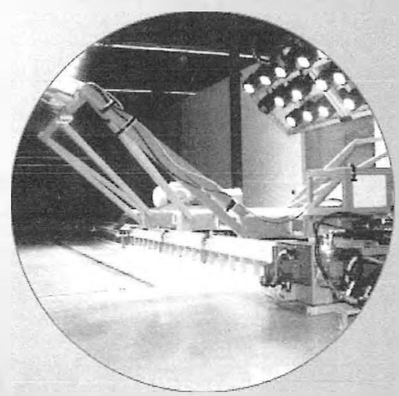

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REVIEW OF ORCHESTRA MUSICIANS' HEARING LOSS RISKSS

Stuart Eaton and Heather Gillis

Workers Compensation Board of BC, P.O. Box 5350, Stn. Terminal, Vancouver, BC V6B 5L5

ABSTRACT

This paper reviews the literature concerning the noise exposure and hearing loss of symphony orchestra musicians and reports new data on 53 members of the Vancouver Symphony Orchestra (VSO).

Musicians' noise exposures reported in three studies were analyzed. The mean equivalent sound level, L_{eq}, of 146 symphony musicians was 90 dBA. Brass and woodwind players have higher L_{eq} values than stringed instrumentalists. Eight studies which examined hearing sensitivity of orchestra musicians were reviewed. Most studies suggest musicians' hearing levels are not significantly different than a non-exposed population. However, several studies identified high-frequency notches suggestive of noise-induced threshold shift. In addition, elevated hearing levels for certain instrument groups (woodwind, percussion and brass) were observed. No conclusive evidence for the effectiveness of risers and screens (the only two physical means proposed for controlling noise exposure) emerged in the review, and, considering the physical acoustics of the situation, significant benefits by these means are unlikely.

Evaluation of hearing test results for 53 members of the VSO indicate median hearing levels similar to age-expected levels for non-exposed populations. Age-corrected mean hearing levels for four instrument groups were not ranked by predicted noise exposures. However, thirteen musicians (25%) had a high-frequency notch suggestive of noise damage. Less than half of the musicians reported regular use of hearing protection. Whereas conventional hearing protectors are unsuitable for musicians, specialized hearing protectors with uniform attenuation may be appropriate for certain situations. An educational program to inform musicians about the effects of sound exposure, risk of hearing loss, and exposure control options is warranted.

SOMMAIRE

Cet article examine la documentation concernant l'exposition des musiciens d'orchestre symphonique à la pollution sonore et à la perte de l'ouïe. L'article examine aussi des données récentes sur 53 membres du Vancouver Symphony Orchestra (VSO).

Trois études d'exposition à la pollution sonore fût examinées. L'equivalent moyen du niveau de son, L_{eq}, de 146 musiciens symphonique était de 90 dBA. Les joueurs d'instruments de bois et de cuivre ont une valeur plus élevée de L_{eq} que les instrumentistes à cordes. Huit études qui examine la sensibilité de l'ouïe des musiciens d'orchestre ont été revisées. La plupart des études semblent indiquer qu'il n'y a pas de différence considérable entre le niveau de l'ouïe des musiciens d'orchestre et d'une population non éxposée. Par contre, plusieurs études ont identifiées des pointes de haute fréquence qui suggèrent un changement de niveau provoqué par le bruit. En plus, un niveau de l'ouïe élevée fût observé parmi certains groupes d'instruments (bois, cordes et cuivre). La revue ne demontre aucune évidence décisive sur l'éfficacité des contremarches et des écrans (les deux seuls moyens physique proposé comme contrôle aux expositions à la pollution sonore). Étant donné l'acoustique physique de la situation, des gains significatifs par ces moyens sont peu probable.

L'évaluation des résultats d'examen de l'ouïe de 53 membres du VSO indique un niveau médian de l'ouïe semblable, anticipé par âge, d'une population qui n'as pas été éxposée à la pollution sonore. Le classement du niveau médian, justifié par âge, pour quatre groupes d'instrument n'a pas tenu compte d'un résultat prédit en ce qui concerne les expositions à la pollution sonore. Cependant treize musiciens (25%) avaient une pointe de haute fréquence qui suggère l'endommagement de l'ouïe par le bruit. Moins de la moitié des musiciens auraient utilisé, régulièrement, des dispositifs de protection contre le bruit. Quoique les dispositifs conventionnels de protection de l'ouïe ne conviennent pas aux musiciens, des dispositifs de protection spécialisé avec atténuation uniforme peut cependant être approprié dans certaines situations. Un

programme éducatif conçu pour informer les musiciens des effets nuisifs de la pollution sonore, de la perte de l'ouïe, et des méthodes optionelles de contrôle contre l'exposition au bruit est justifié.

1. OBJECTIVES

In 1996 the Workers' Compensation Board of British Columbia (WCB of BC) lowered its regulatory noise criterion level from 90 to 85 dBA. The change created a noise-exposure knowledge gap for workers in sectors with noise exposures in the range 85 to 90 dBA. To improve the WCB noise database, projects were undertaken to obtain noise exposures for workers in laundries and kitchens, tire shops, fast food restaurants, etc. In 1999, WCB jurisdiction was extended to performers in the entertainment sector for the first time. However, rather than initially launch an extensive noise survey to determine the noise exposure for symphony musicians in BC, it was decided that an international literature review would be valuable as a foundation and context for understanding the situation of local professional musicians.

Initially, the literature was reviewed to:

a) Determine the sound exposure for symphony musicians;
b) Evaluate the risk the sound exposures pose to the hearing of the musicians;
c) Evaluate musicians' hearing loss by comparison with that of groups who were not exposed to noise;
d) Examine the effectiveness and practicability of techniques for controlling noise exposure.

Following a presentation of the WCB of BC review, the Vancouver Symphony Orchestra (VSO) instituted a hearing conservation program, beginning with hearing tests of their musicians. Upon receipt of copies of the musicians' audiograms WCB also decided to:

> Compare the VSO orchestra musicians' hearing thresholds with expected values.

2. NOISE EXPOSURE

International Standard ISO 1999 (1990) presents in statistical terms the relationship between noise exposures and the "noise-induced permanent threshold shift" (NIPTS) in people of various ages. The NIPTS which the Standard addresses is progressive and is acquired gradually over a period of several years. The Standard, then, can be applied to the calculation of risk of sustaining hearing handicap due to regular occupational or any daily repeated noise exposure.

The noise exposure descriptor used by ISO 1999 (1990) is the equivalent continuous A-weighted sound level, L_{eq}. The Standard assumes the worker is exposed to noise over an 8-hour day, 5-day week. For workers exposed to noise in some other pattern, a related descriptor, $L_{EP,d}$, has been recommended (EEC, 1986) and is employed in this review. $L_{EP,d}$ is the steady sound level which, energy-averaged over 8 hours, would give the same average daily noise exposure dose as the varying noise. It is related to the L_{eq} measured by an integrating meter:

$$L_{EP,d} = L_{eq} + 10 \log_{10} (\text{Average daily shift duration in hours/8 hours}) \text{ dBA}$$

ISO 1999 (1990) excludes hearing loss due to high-energy impact noise. Peak sound pressure levels are not considered here as they do not relate to gradual noise-induced hearing loss; very high peaks can often be shown to be artifacts in dosimetry. Kwiatkowski, Schäcke, Fuchs, and Silber (1986) suspected peak artifacts were caused by accidental contacts with the microphone. Peak values are liable to be compared wrongly with permissible $L_{EP,d}$ values.

High sound levels have been measured with conventional sound level meters within the body of orchestras by Axelsson, Lindgren and Sanden (1981) and Westmore and Eversden (1981). This is to be expected since the orchestra must generate sufficient sound power to "fill" an auditorium. Orchestras can generate high continuous equivalent sound levels with high crest factor (about 30 dB, Sabesky, 1995). Maximum "Fast" levels of 120 dBA and still higher "Peak" sound pressure levels have been detected.

More recently, integrating meters have been used to measure L_{eq} values within orchestras. McBride, Gill, Proops, Harrington, Gardiner and Attwell (1992) measured "general" L_{eq} sound levels, but reported only nine personal dosimeter L_{eq} values in five rehearsals and two concerts. Personal L_{eq} values for second violins were 0.8 dB higher and bassoonists were 10 dB higher than "general" levels. Performance L_{eq} values were 2.5 to 3.5 dB higher than rehearsal values. Williams (1994) reports 212 L_{eq} samples, giving a spatial average sound level of 87 dBA. The L_{eq} data were obtained over about 250 hours in front of, behind, to the side and within certain orchestra sections for a range of concerts, composers and auditoria but only eight personal noise exposures on two types of instruments were reported.

Kwiatkowski et al (1986) acquired personal dosimetry on 29 musicians playing in the pit of the Deutsche Oper Berlin

(DOB). They concluded exposure levels primarily depended upon the instrument and to a lesser extent on the composer. They subdivided the musicians' exposures into four instrumental groups and presented mean group L_{eq} values as shown in Table 1. Members of the brass group have the highest levels, followed by clarinet, flute, bassoon, percussion group (most of whose members are traditionally located in front of the brass), violin and viola, and finally cello, bass, harp and piano.

Royster, Royster and Killion (1991) obtained 68 dosimeter L_{eq} samples from the 100-member Chicago Symphony Orchestra (CSO) under rehearsal and performance conditions for a variety of orchestral works. Royster et al displayed L_{eq} distributions with class width 2 dB for Kwiatkowski's instrumental groups. The data are summarized in Table 1. In an exploratory study of the sound field around the heads of a violinist and a violist, Royster et al showed the left ear was exposed to sound levels 6 and 8 dB higher than the right ear, respectively. Greater differences occurred as players inclined the head towards their instruments.

An extensive study of the Winnipeg Symphony Orchestra (WSO) was carried out by Sabesky and Korczynski (1995). Personal dosimeter samples were obtained from the 67-member orchestra in seven surveys covering three different venues and a variety of musical works under both rehearsal and performance conditions. The samples were obtained in accordance with CSA Z107.56-1994 for a total sampling time of over 180 hours. The present article takes 49 of the WSO dosimeter samples after eliminating records (obtained by private communication from Sabesky, 2000) which contained overloads and partial rehearsal exposures. These data are summarized in Table 1 for the four instrumental groups.

The agreement between the three studies for the mean L_{eq} values is excellent for like groups and orchestras.

The mean L_{eq} for all musicians in the three orchestras is 89.7 dBA (n = 146). As Kwiatkowski et al (1986) did not report individual L_{eq} values, the overall standard deviation cannot be calculated. The samples of Royster et al (1991) and Sabesky et al (1995) together give a mean L_{eq} = 89.6 dBA, standard deviation = 4.6 dB (n = 117) and corresponding 95 % Confidence Interval = 0.9 dB.

The WSO and CSO employ their musicians for 15 hours per week over an 8-month annual season. Thus, for these orchestras a total correction of -5.9 dB (= $10\log_{10}$(520 h/y/2000 h/y) can be applied to the measured L_{eq} to obtain:

Annual Mean $L_{EP,d} = 84 \pm 1$ dBA (95% CI).

3. HEARING LOSS RISK

Table 2 details the expected NIPTS for male musicians, based on three different $L_{EP,d}$ exposure ranges: 85-89.9, 90-94.9 and 95-99.9 dBA over a 30-year exposure. Values for males were used as hearing levels are poorer for males than females in the general population and thus a "worst case scenario" is presented. Also noted is the percentage of musicians who will incur the predicted degree of hearing loss.
It is well known that median hearing levels increase with each decade of life for non-noise-exposed populations. Annex B of ISO 1999 (1990) provides median expected hearing threshold levels associated with age (HTLA) for non-noise-exposed populations at various age groups for males and females. The expected HTLA shown in Table 2 is for 50 year-old males at the 50th fractile. The expected NIPTS shown is at the 10th fractile, that is 90% of the exposed group will have hearing no worse than the predicted levels.

The Hearing Threshold Level (HTL) of 0 dB is the statistical average normal hearing for young adults with no history of ear disease or significant noise exposure. Hearing thresholds for this population of young adults have a range of ±20 dB, normally distributed around 0 dB. Hearing loss is not

Group No.	Instruments in Group	CSO			WSO			DOB		
		L_{eq}, dBA	s, dB	n	L_{eq}, dBA	s, dB	n	L_{eq}, dBA	s, dB	n
1	Violin and viola	88.4	5.3	23	88.5	2.7	18	89.1	-	14
2	horn, trumpet & trombone	93.5	3.2	13	94.5	3.5	10	93.4	-	6
3	Clarinet, flute, bassoon & percussion	91.2	3.2	17	92.2	3.1	10	91.9	-	4
4	bass, cello, harp and piano	84.9	2.6	15	86.2	2.4	11	87.0	-	5
Mean L_{eq}, dBA, all groups of musicians		**89.3**	**4.9**	**68**	**90.0**	**4.1**	**49**	**90.0**	**-**	**29**

Table 1. Comparison of Musicians' L_{eq} derived from Personal Dosimetry
(s = standard deviation, n = number of samples)

$L_{EP,d}$ Range	Noise-induced Permanent Threshold Shift, dB					Predicted % Musicians	
dBA	1 kHz	2 kHz	3 kHz	4 kHz	6 kHz	In $L_{EP,d}$ range	With HL
85 – 89.9	0	5	12	13	10	35.5	3.6
90 – 94.9	2	14	25	26	21	12.8	1.3
95 – 99.9	10	27	45	43	36	1.6	0.16
HTLA	**5**	**8**	**19**	**26**	**31**		**50**

Table 2. Predicted Noise-induced Hearing Loss (10^{th} fractile, 50 year old males, ISO 1999:1990) and Expected Rate of Incidence in Population and Orchestra (based on 15 h/week "service")

considered present until HTLs of 20 dB or greater are reached (Davis and Silverman, 1970, p. 193).

In Table 2, a slight noise-induced hearing loss is predicted at 3kHz and above for $L_{EP,d}$ 90 to 94.9 dBA for the most susceptible 10% of musicians; the predicted percentage of musicians affected will be 1.3%. For exposures of 95 - 99.9 dBA, a mild to moderate hearing loss is predicted at 2 kHz and above for the most susceptible 10%, which affects 0.16% of the musicians.

HTLA combines with NIPTS, though not in strictly arithmetical fashion (ISO 1999:1990). Figure 1 provides an example of this, showing the predicted NIPTS at the 10th fractile for a male of 50 years of age with 30 years exposure $L_{EP,d}$ = 90 dBA. Also shown is the combined NIPTS and HTLA, which is much greater than NIPTS, reducing the significance of the latter.

4. HEARING LOSS IN ORCHESTRA MUSICIANS

Studies that examined hearing sensitivities of orchestra musicians were reviewed. The review revealed that the methodology typically used is to compare mean or median hearing threshold levels (HTLs) of musicians with HTLs of a non-exposed reference group. The choice of reference group varies across studies, and may be screened for non-occupational noise exposure and ear disease, or unscreened.

Axelsson et al (1981) evaluated hearing levels of 139 musicians in Gothenburg, Sweden. The musicians worked an average of 29 hours per week in the orchestra. Thirty-five percent of the musicians worked in an orchestra pit, rather than on an open stage. The authors found poorer hearing in bassoon, French horn, trumpet and trombone players compared to a non-exposed reference group. History of firearm use and serving as a military musician were also associated with poorer hearing levels.

A follow up study of the Gothenburg Symphony (Kähäri, Axelsson, Hellström and Zachau, 2001) examined hearing levels of 140 musicians and found no severe hearing losses. Male musicians' median hearing levels indicated a high-frequency "notch", suggesting noise damage. Percussion and woodwind players had slightly poorer hearing levels than other musicians.

Johnson, Sherman, Aldridge and Lorraine (1985) found that instrument type and position on the orchestral stage were not significantly correlated with hearing loss for 62 members of the Minnesota Orchestra. Musicians' hearing levels were not significantly different from an unscreened control group of non-exposed individuals.

In a later study, Johnson, Sherman, Aldridge and Lorraine (1986) compared hearing sensitivities of 60 orchestra musicians with 30 non-musicians for the conventional audiometric frequencies (0.5-8kHz) and for extended high-frequencies (9-20 kHz). The musicians' mean practice/performance time was 33 hours per week and a mean of 31 years at their occupation. The authors found no significant difference in hearing sensitivity between the two groups, nor any ear or gender effect. Both musicians and non-musicians showed an age effect of similar magnitude at the extended high frequencies.

Ostri, Eller, Dahlin and Skylv (1989) compared median hearing levels of 95 orchestra musicians with the ISO 1999 (1990) screened non-noise exposed population. These musi-

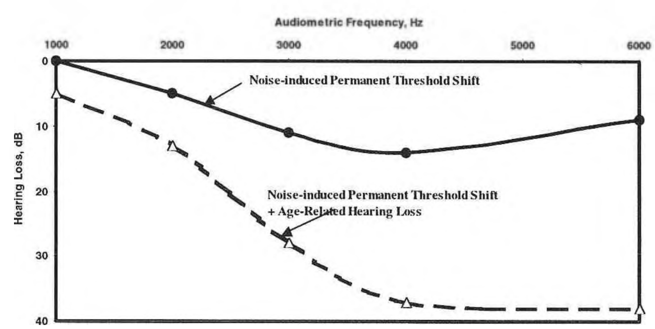

Figure 1. Predicted Hearing Levels ($L_{EP,d}$ = 90 dBA, 10th fractile, 50 year-old Males)

cians worked an average 26 hours per week in the orchestra pit for the Royal Danish Theatre. Median hearing levels of the musicians were slightly poorer than those of the reference population for all age groups. An additional finding was that violinists had significantly poorer hearing in their left ear at the higher frequencies.
McBride et al (1992) compared mean hearing levels of two groups of City of Birmingham Orchestra musicians (n = 63) with different exposure levels: woodwind and brass musicians comprised the higher exposure group, and strings players the lower exposure group. No significant hearing level differences were found between the two groups, when matched for age.

Royster et al (1991) compared mean hearing levels of 59 Chicago Symphony Orchestra musicians to age and sex-matched ISO 7029 screened and unscreened non-exposed populations. Musicians showed better average hearing than the unscreened non-exposed group, and slightly poorer hearing than the screened non-exposed group. Fifty percent of musicians showed a high-frequency notch suggestive of noise-induced threshold shift. Mean age-corrected hearing levels for four different groups of instruments showed differences in hearing ranked as follows from best to worst: a) bass, cello, harp and piano, b) violin and viola, c) horn, trumpet & trombone, d) clarinet, flute, bassoon and percussion.

The authors concluded that a small amount of noise-induced permanent threshold shift is predicted for orchestra musicians with average susceptibility based on a 15-hour/week exposure.

Karlsson, Lundquist and Olaussen (1983) examined the hearing of 417 musicians from five Swedish orchestras. Hearing levels were tested twice for 123 musicians, 6 years apart. Median hearing levels for the musicians did not differ from those of non-exposed (screened and unscreened) reference populations. The only exception to this was flute players, who showed very slightly elevated hearing levels. The authors point out that noise-induced hearing loss typically develops most rapidly in the early years of exposure. However, in the musicians, the development of hearing loss followed the normal course of presbycusis, that is hearing loss accelerating in later years. Karlsson concluded the risk of noise-induced hearing loss in symphonic musicians is nil or negligible.

It should be noted that only exposure resulting from the orchestra rehearsals and performances is reported in the studies reviewed here. However, it is recognized that musicians have additional exposure through solo practice, teaching and other performing. The hearing threshold studies would reflect the impact of the cumulative exposures, from all sources, for the musicians.

5. NOISE EXPOSURE CONTROL

5.1 "Engineering" Controls

References to "engineering" or "physical" noise control for orchestral musicians are scant in the literature. Indeed, the concept is recognized as counterproductive since the orchestra exists to generate sound, and interference with the perception of the sound may well be unacceptable to experienced, professional musicians. Engineering controls must reduce sound at the musicians' ears without causing unwanted redistribution of the sound.

Transparent screens of plexiglass and polycarbonate have been suggested as means to reduce sound levels for musicians playing near loud instruments. Chasin and Chong (1994, p. 194) point out that shields "only give significant protection if used within 18 cm of the musician's head", a severe restriction on the musician. Presbury and Williams, of Australia's National Acoustic Laboratory (NAL), after contacting 16 orchestras around the world commented (p. 339):

> "Often the 'acoustic performance' of the barriers is either unknown or inappropriate, given the circumstances. Indeed ... most of the sound barriers used by orchestras had never been subjected to any form of performance–based testing".

The authors noted that while personal "acoustic shields" may reduce noise from adjacent musicians they can also generate spurious reflections and elevate levels for surrounding musicians. The authors relate the development, at NAL, of acoustic shields shaped to reduce unwanted reflections. A shield in anechoic conditions gave insertion losses of 8-10 dB; insertion losses in the more diffuse sound field of the orchestra environment realized 3-5 dB. They noted the musicians' "cultural resistance" to the shields.

Williams (1994) reports that Camp and Horstmann concluded "freestanding clear plastic shields provide little protection downstream from a sound-generating source". Williams also reports Rosser's remark:

> "It was interesting to note that the perspex screens were not effective in the new rehearsal studio. This was probably due to multiple reflections and high levels of reverberation in this studio".

Chasin and Chong (1994, 1995) conjectured that situating trumpets on risers should reduce noise for "downwind" players by taking advantage of the instruments' directional radiation properties at high frequency. Spectral envelopes of brass instruments playing *mezzoforte* are rich in overtones as shown by Fletcher and Rossing (1998, p. 231, p. 454). The time-averaged spectrum of the trumpet attains a broad maximum at mid frequencies (about 1.6 kHz). Spectra of other brass instrument peak at lower frequencies. Above the maximum in the spectra, sound pressure levels fall at the rate of about 12 dB/octave.

Directivity functions given by Davis and Davis (1975, p. 250) for the trumpet at different frequencies instruments have been replotted in Figure 2 to show Directivity Indices (at angle = 0º).

Below 2 kHz, sound intensity levels at 30° are lower than on-axis levels by less than 2.7 dB. Even at 4 kHz, the 0° sound intensity level is reduced by directivity by only 3.3 dB at 30°.

Thus, high frequency spectral components in the trumpet spectrum are not significant contributors to the A-weighted sound level nor do they have strong directivities. The suggested control technique of using directivity of brass instruments with risers will therefore be ineffective; the dominant mid-frequency components of the brass have weak directivities, whereas the more directional components at higher frequencies are insignificant contributors to the overall sound level. Kwiatkowski et al (1986) concluded that there was no realistic means to control the noise exposure of musicians.

5.2 Hearing Protection

Conventional hearing protectors are often unsuitable for musicians due to their frequency-dependant attenuation characteristics and the occlusion effect. Conventional protectors attenuate high frequencies more than low frequencies, resulting in distortion of the music. The occlusion effect (an enhancement of low frequency bone-conducted sound

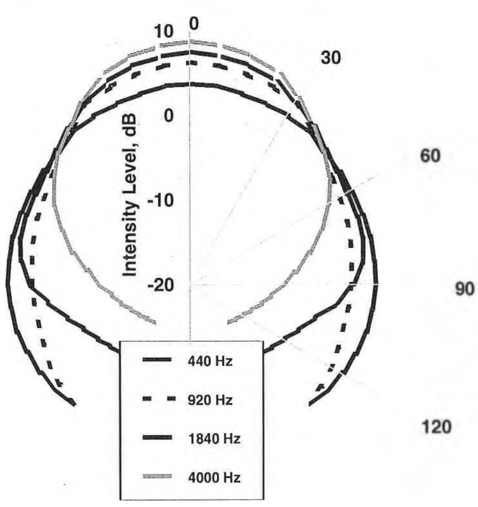

Figure 2. Polar Radiation Pattern for the Trumpet (after Davis & Davis, 1975, p. 250)

due to plugging the ear canal) causes an "echoey" perception of sound unacceptable to musicians. For musicians, the most appropriate hearing protection would be earplugs such as:

i) Etymotic Research's ER plug series (ER9, ER15, ER25), which gives a fairly flat insertion loss (of about 9, 15 and 25 dB respectively) across the audio-spectrum. The plug is available as a custom-molded earplug with an add-on filter. The filters are interchangeable, so if a user tries one level and finds it unsatisfactory, then a different filter can be substituted without remaking the entire earplug. The occlusion effect can be reduced if the custom-molded earplug is fabricated with deep insertion (a long ear canal).
ii) E-A-R's UltraTech plug series (Ultra Tech 12 and 16) which has the same acoustical filter as the ER series in a pre-molded, triple flanged body.

Experience has shown that even the special hearing protectors described above are not readily accepted by musicians, due to difficulty monitoring their own playing and that of other musicians in ensemble performance. This points to the necessity of a strong educational program for musicians, to inform them of the risks of hearing loss, the implications of even a mild loss to their profession, and the application of available hearing protection options.

6. POSTSCRIPT: ANALYSIS OF VSO HEARING TEST DATA

The authors met with the Health & Safety Committee of the Vancouver Symphony Orchestra (VSO) to present the foregoing review. Subsequently, VSO implemented a hearing conservation program which included education sessions for musicians regarding effects of sound on hearing, hearing protection and hearing tests. Hearing test data for noise-exposed workers in British Columbia are submitted to a central data registry at the Workers' Compensation Board. The authors analyzed the VSO hearing test results in order to evaluate the extent of hearing loss in these musicians.

The hearing tests were conducted by trained/certified Industrial Audiometric Technicians using a standard test protocol (modified ascending/descending technique for threshold determination) and audiometers calibrated annually to ANSI Standard S3.6-1996 specifications. Tests were conducted in audiometric booths meeting ANSI Standard S3.1-1999 criteria for permissible ambient noise levels. In addition to hearing thresholds at 500 through 8000 Hz, information on hearing protection use, years at occupation, age and gender was recorded at the time of the test.

Fifty-three VSO members (31 males and 22 females) were tested. Median hearing levels for male and female musicians were similar to the hearing threshold levels associated with age (HTLA) per ISO 1999 Annex B, unscreened 50th fractile) as shown in Figures 3.A and B. Mean hearing levels (males and females combined) for the four instrument groups outlined in Table 1 showed differences in hearing ranked as follows from best to worst: a) cello, bass, harp b) violins, violas c) clarinet, flute, bassoon & percussion and d) horn, trumpet, trombone, tuba (see Figure 3.C). This ranking follows the predicted noise exposure rankings for the four instrument groups.

Age-corrected mean hearing levels were established by subtracting the appropriate ISO 1999 HTLA from each musician's hearing levels prior to determining the mean. Age-corrected mean hearing levels for the four instrument groups were **not** ranked by predicted noise exposure. The age-corrected means were clustered around 0 dB HTL except for the brass group, which showed slightly poorer hearing (see Figure 3.D).

Thirteen of the 53 musicians (24.5%) had a high-frequency "notch" in the audiogram, suggestive of noise damage. A notch was defined as a drop of 15 dB centered at 3000, 4000, or 6000 Hz with recovery of 15 dB at a frequency above the drop, in either ear. No significant left/right ear differences were found for any of the instrument groups, in contrast to the finding of Royster et al (1991) that violinists and violists had significant left ear asymmetries at 4000 Hz.

Forty-seven percent of VSO musicians reported regular use of hearing protection, with most using CSA Class A earplugs. Class A protectors according to Canadian Standards CSA Z94.2-94 provide approximately 30 dB of attenuation at 1000 Hz and above. One would expect a greater use of the "musicians" earplugs (with uniform attenuation, Class B or C). Interestingly, musicians in the instrument group with the highest estimated noise exposure (horn, trumpet and trombone) reported the least frequent regular use of hearing protection (10%).

7. SUMMARY

The noise exposure data of Royster et al (1991) and Sabesky and Korczynski (1995) combine to give a mean $L_{EP,d}$ = 84 ± 1 dBA (95% C.I.) normalized from a 15 h/week and 8 month year to a 40 h/week. About 42% of musicians will have L_{EX} greater than 85 dBA; 10% will have $L_{EP,d}$ greater than 90 dBA and 1% will have L_{EX} greater than 95 dBA. VSO musicians are contracted to provide 20 hours per week of "service" for a 39 week season. This exposure duration for the VSO gives:

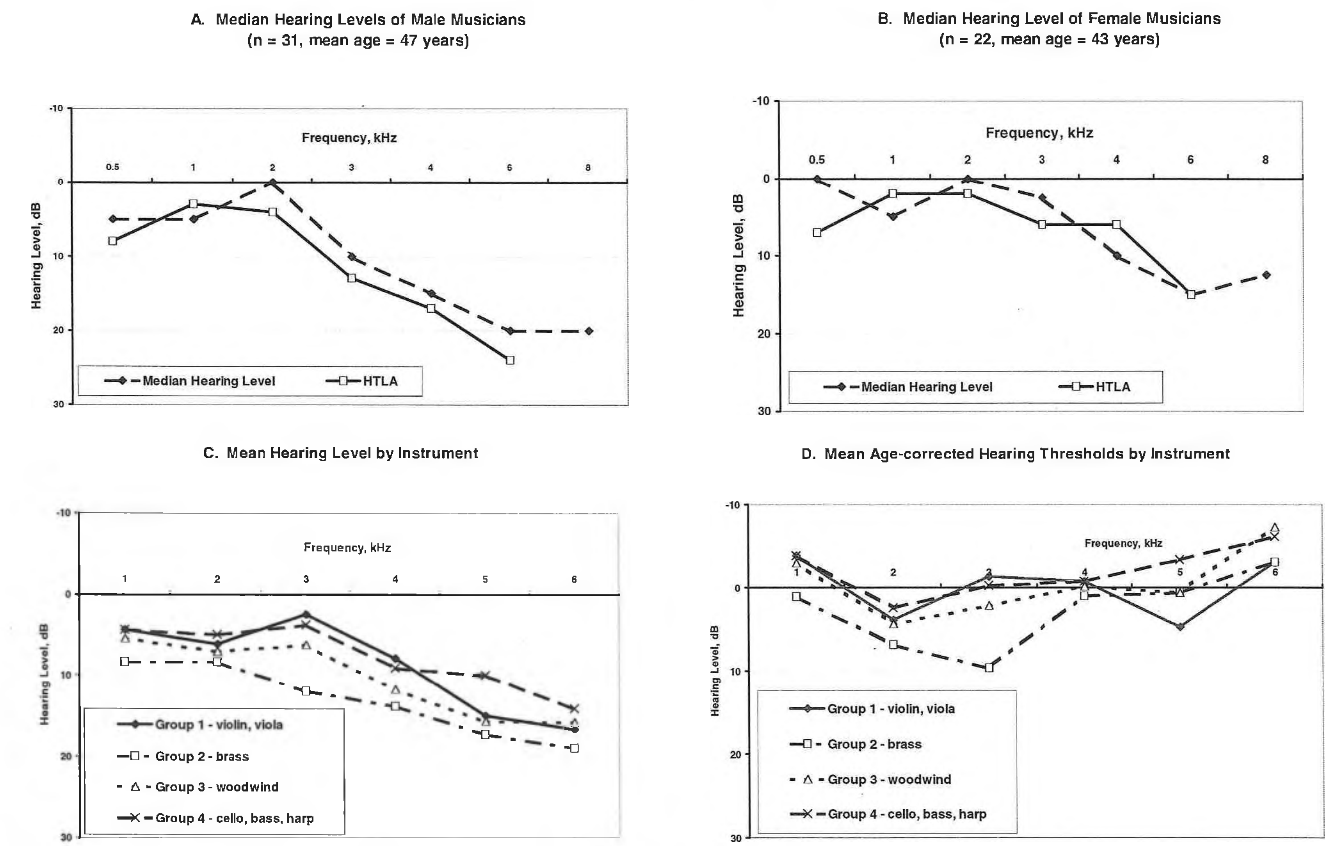

Figure 3. Hearing Levels for Vancouver Symphony Orchestra Musicians.

$$\text{Annual Mean } L_{EP,d} = 86 \pm 1 \text{ dBA.}$$

Based on the exposures established, some noise-induced hearing loss is predicted for some orchestra musicians. However, most studies of musicians' hearing, including the present analysis of VSO hearing test data, found threshold levels not significantly different than non-exposed populations. This finding is interesting, since musicians typically have additional sound exposure outside their orchestra work, from solo practice, teaching and other performing which will elevate noise exposure. However, several studies including the VSO data indicated high-frequency notches suggesting minimal noise damage in some musicians, possibly the more susceptible individuals or those with higher exposures, such as the brass section. Asymmetries in hearing were found for violinists and flutists in some studies, which could be attributed to asymmetrical sound exposure.

Screens as noise barriers seem to be impracticable and risers will not offer significant attenuation of the brass instruments' sound due to the latter's weak directional effects at their most contributory frequencies.

While conventional hearing protectors are unsuitable for musicians, specialized hearing protectors with uniform attenuation have been suggested for certain applications. However, the majority of VSO musicians reported using CSA Class A earplugs, which are conventional, highly attenuating protectors. This points to the need for an educational program to inform musicians about the effects of sound exposure, risk of hearing loss, exposure control options and appropriate hearing protection selection.

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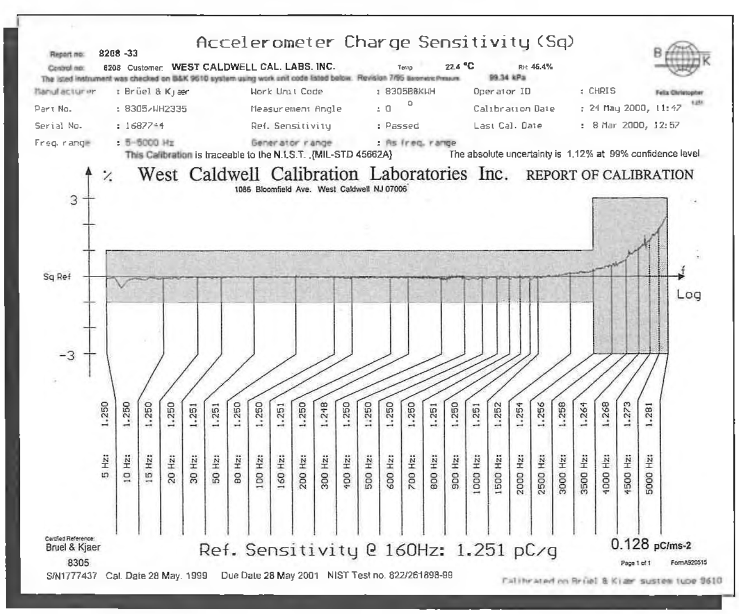

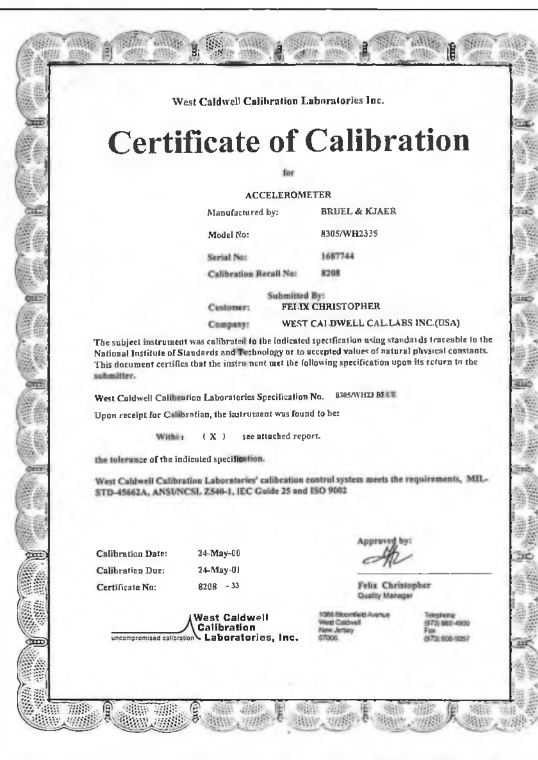
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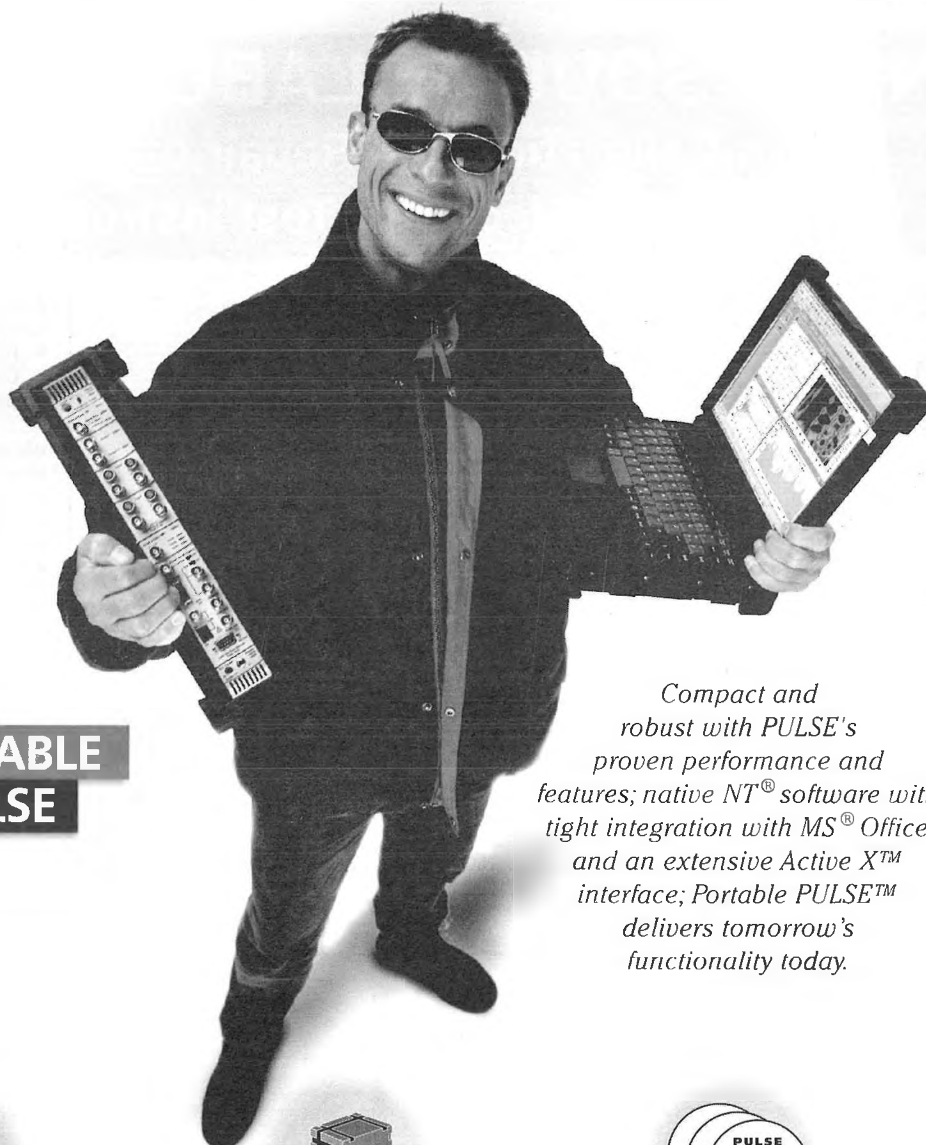

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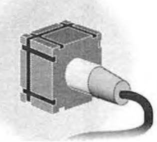

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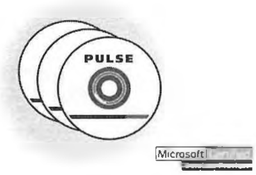

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WEIGHING THE ANCHOR IN CATEGORIZATION OF SOUND LEVEL

Elad Sagi[1,2] and Kenneth H. Norwich[1,2,3]
1 - Institute of Biomaterials and Biomedical Engineering, University of Toronto
2 - Department of Physiology and 3 - Department of Physics, University of Toronto

ABSTRACT

Categorization of sound level requires that the subject classify the intensity of stimulus tones into appropriate response categories. Intensities are selected at random from a fixed stimulus range and stimulus-response pairs are tabulated into a stimulus-response matrix. "Anchor" or edge effects are well-recognized phenomena by which tones selected from the extremities of the stimulus range are classified with greater accuracy than tones in mid-range. Observation reveals that data in the center rows of a matrix follow a typical normal error distribution, while data in extreme rows follow a heavily skewed distribution with smaller variance. We propose that the distribution of responses along all rows of the stimulus-response matrix is described by a single, underlying normal density of constant variance. We develop the mathematical theory for extracting this constant underlying variance, σ^2, from an experimental "parent" matrix. A set consisting of all possible matrices (including the parent matrix) with core variance, σ^2, and containing the usual anchor phenomena, can then be generated at will. Using this core variance, we derive an expression for the transmitted information, I_t, that comprises a non-anchor and anchor contribution, whereby the size of the anchor effect may be quantified. Essentially, we provide a method for removing anchor effects and revealing the single core variance that represents, by hypothesis, the stimulus-response matrix.

SOMMAIRE

Pour catégoriser le niveau sonore, le participant doit classer l'intensité des stimuli sonores selon des catégories de réponse adaptées. Les intensités sont choisies au hasard dans une étendue prédéterminée de stimuli et les couples stimulus-réponse sont reportés dans une matrice stimulus-réponse. Les « effets des points d'ancrage » sont des phénomènes connus selon lesquels les fréquences sonores appartenant aux extrémités de l'étendue de stimuli sont classées avec plus de précision que celles du milieu de l'étendue. Les données des rangées au milieu de la matrice sont réparties selon une courbe de Gauss classique, tandis que les données des rangées aux extrémités forment une distribution très asymétrique dont la variance est moins prononcée. Nous proposons que la répartition des réponses dans toutes les rangées de la matrice stimulus-réponse s'explique par la présence d'une courbe normale à variance constante. Nous élaborons la théorie mathématique visant à extraire cette variance constante sous-jacente, σ^2, d'une matrice « parentale » expérimentale. Une série composée de toutes les matrices possibles (y compris la matrice parentale), se caractérisant par une variance fondamentale, σ^2, et contenant les phénomènes classiques d'ancrage, peut alors être générée à volonté. En utilisant cette variance fondamentale, nous dérivons une expression pour l'information transmise, I_t, qui comprend un volet, tant ancré que non ancré, sur la base duquel l'ampleur de l'effet d'ancrage est quantifiable. Essentiellement, nous présentons une méthode visant à éliminer les effets d'ancrage et à révéler la variance fondamentale qui représente, selon l'hypothèse posée, la matrice stimulus-réponse.

1. INTRODUCTION

In tests of categorization of sound level, subjects are required to classify the intensity of tones into specific categories. For example, consider an experiment where a subject is presented with a tone, the intensity of which is selected randomly from a fixed range of 1 to 90 decibels (dB). This intensity range can be subdivided into 9 large categories of 10 dB width where 'category 1' equals 1-10 dB, 'category 2' equals 11-20 dB, and so on; or 30 small categories of 3 dB width where 'category 1' equals 1-3 dB, 'category 2' equals 4-6 dB, and so on. The number of categories used depends only on the requirements of the experimenter. The subject's task is to estimate the category to which the stimulus belongs to the best of his/her ability. More generally, the intensity of tones are randomly selected by the experimenter, typically using a uniform distribution, from a discrete set of stimulus categories, $X = \{X_1, ..., X_m\}$. Observers are required to classify each stimulus using a corresponding set of response categories, $Y = \{Y_1, ..., Y_m\}$. Results are tabulated in the form of a stimulus-response or "confusion" matrix such that the element n_{jk} represents the number of times stimulus X_j was identified as response Y_k.

Illustrated in Figure 1 is a 10 x 10 stimulus-response matrix obtained from an experiment on stimulus categorization conducted in our laboratory using stimulus tones fixed at 1000 Hz and varying in intensity from 1 to 10 dB Hearing Level, i.e. decibels above a population threshold (dB HL). Each stimulus and response category is of width 1 dB. For example '(X_5, Y_4) = 14' means that the subject identified a 5 dB stimulus tone as a 4 dB tone 14 times out of the 45 times that this stimulus tone was given.

We consider here tones of a fixed frequency of 1000 Hz that vary only in intensity, from which we shall calculate Shannon's mutual or transmitted information, I_t, by the methods of Garner and Hake (1951).

Adequate estimates of I_t require on the order of 10,000 trials, which, in the past has required pooling of data from several subjects. We have avoided pooling by extending data from a given participant using computer simulation. Wong and Norwich (1997) extended the work of Houtsma (1983) in developing such a simulator that permits estimation of I_t from limited data. Simulation is made possible because the distribution of responses in most rows of a confusion matrix has been observed to be Gaussian, with a constant row variance.

The simulator operates in the following way. Using a limited set of measured data, the row variance, σ^2, is estimated. Responses that are normally distributed with the measured variance, σ^2, are then computer generated by Monte Carlo techniques. The 'simulated' stimulus-response pair, (X_j, Y_k), can then be compiled into a stimulus-response matrix and I_t can be measured. Continuing this process for an arbitrarily large number of trials provides an estimate of I_t that is based on a simulated stimulus-response matrix free from any small sample bias. The value of σ^2 utilized by the simulator is estimated from a limited number of experimental trials conducted on a single subject. Converging estimates of σ^2 require far fewer experimental trials than are required for overcoming the small sample bias in I_t. By way of illustration, the largest stimulus-response matrix obtained in our experiments is a 90 x 90 matrix corresponding to a stimulus range spanning 1 – 90 dB HL. Using our simulator it is easily verified that, whereas converging estimates of I_t require on the order of 50,000 simulated trials, less than 500 trials are required to obtain converging estimates of σ^2.

A drawback to the simulation approach as we had employed it is that apparent anchor effects were accounted for in only preliminary fashion. Although an observer's responses to the mid-range intensities may follow normal distributions of common variance, the response distributions surrounding the more extreme intensities display heavy skewing or "anchoring". That is, participants perform better in resolving intensities located at the extremes

	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	X_j^{total}
X_1	20	7	12	9	4	1	0	0	0	0	53
X_2	10	10	15	10	10	1	1	0	0	0	57
X_3	14	11	7	10	6	1	2	1	0	0	52
X_4	1	5	14	16	9	2	4	0	0	0	51
X_5	4	1	4	14	11	8	2	1	0	0	45
X_6	0	0	5	8	14	12	10	6	0	1	56
X_7	0	0	0	2	8	7	8	14	7	1	47
X_8	0	0	0	1	2	7	17	9	9	4	49
X_9	0	0	0	0	3	4	11	18	11	4	51
X_{10}	0	0	0	1	1	0	2	4	18	13	39
Y_k^{total}	49	34	57	71	68	43	57	53	45	23	500

Figure 1: A 10 x 10 stimulus-response matrix conducted over a stimulus range of 1 - 10 dB HL. Note normal distribution about main diagonal across middle rows.

of the stimulus range, as if their responses were intrinsically anchored.

This can be seen in Figure 1, especially along row 1 and row 10 where the subject's responses are heavily skewed, or anchored, to the sides of the matrix. Please notice that responses along the middle rows tend to follow a normal distribution about the main diagonal, while responses along the extreme rows are skewed due to anchor effects. Since the reduced variances of these extreme distributions would be incorporated into a sample estimate for σ, the accuracy of the resulting information estimates would be affected. We propose that one can remove the skewing and assign a common normal distribution to all the rows.

In this paper we are interested in developing a means of estimating σ^2 that is not affected by the anchoring process. A model is developed where σ^2, the 'anchor-free' variance underlying the stimulus-response matrix, is extracted from a measure of the average row variance of this matrix, σ^2_{eff}, which contains the anchor effect. This model is used to obtain more accurate estimates of the transmitted information as measured from the stimulus-response matrix. Finally, an expression for the transmitted information is derived that decomposes into a sum of two parts, a non-anchor and an anchor contribution, whereby the magnitude of the anchor effect may be measured.

2. A CONSTANT VARIANCE (CV) MODEL FOR THE STIMULUS-RESPONSE MATRIX

It is assumed that there is a single, unique normal distribution governing responses in each row of the matrix, which is perturbed by the "anchor" process. Let σ^2 be the "constant variance" of this normal distribution and let σ^2_{eff} represent the arithmetic mean of variances across all rows of the stimulus-response matrix, including the extreme distributions. If σ underlies all responses of the stimulus-response matrix, it should be possible to relate σ^2_{eff} to σ.

Finding a relationship between σ^2_{eff} and σ requires a model of the row distributions. For ease in calculation, the set of discrete responses, Y, will be represented by the continuous random variable, y, and the set of discrete stimuli, X, will be represented by the continuous random variable, x. One should note the necessary correction of the form $y = Y_k - 0.5$ and $x = X_j - 0.5$ when transforming from the continuous domain to the discrete domain (cf Snedecor, 1980, p118).

We represent distributions along any row of the stimulus-response matrix as a conditional probability of response y given a value of x. This distribution, p*(y|x) is a continuous normal distribution with variance σ^2:

$$p^*(y \mid x) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left[-\frac{1}{2}\left(\frac{y-x}{\sigma}\right)^2\right] \qquad (1)$$

$p^*(y|x)$ is, however, unbounded in y such that $y \in (-\infty, \infty)$.

To conform to the boundaries of the matrix more realistically, one can confine $p^*(y|x)$ to the width of the matrix; namely, define y such that $y \in [0, R]$ (which is the continuous analogue of $Y \in \{1, 2, \ldots, R\}$). If we now integrate over the space of y,

$$\int_0^R p^*(y \mid x)dy = \int_0^R \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left[-\frac{1}{2}\left(\frac{y-x}{\sigma}\right)^2\right]dy$$
$$= \frac{1}{2}\left[erf\left(\frac{R-x}{\sigma\sqrt{2}}\right) + erf\left(\frac{x}{\sigma\sqrt{2}}\right)\right]$$
$$= C(x).$$

Dividing $p^*(y|x)$ by $C(x)$ renormalizes Eq. (1) over the range, giving an expression, $p(y|x)$, for the row distributions as follows:

$$p(y \mid x) = \frac{1}{C(x)\sqrt{2\pi\sigma^2}} \exp\left[-\frac{1}{2}\left(\frac{y-x}{\sigma}\right)^2\right]$$
$$C(x) = \frac{1}{2}\left[erf\left(\frac{R-x}{\sigma\sqrt{2}}\right) + erf\left(\frac{x}{\sigma\sqrt{2}}\right)\right] \qquad (2)$$
$$x, y \in [0, R]$$

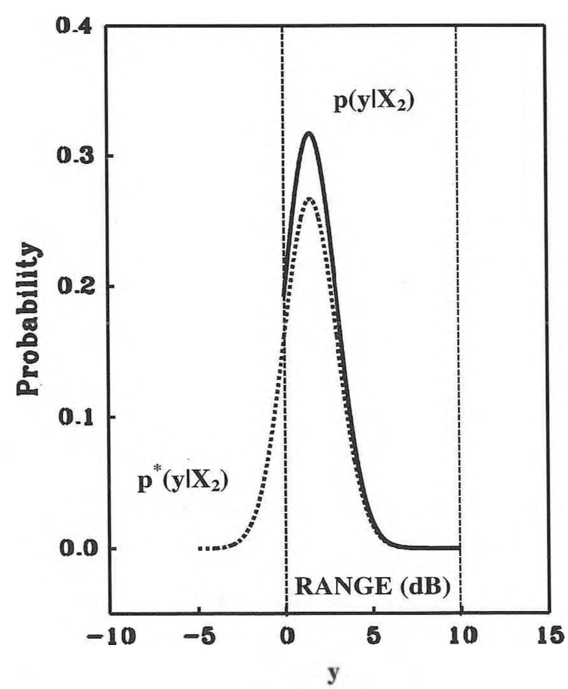

Figure 2: A continuous normal distribution, whose mean lies at the center of the second column of a 10 x 10 matrix, is renormalized over the continuous range [0, 10] dB.

This procedure is outlined graphically in Figure 2 where we consider the second row (X_2) of a typical 10 x 10 confusion matrix over a range 1 – 10 dB. The dashed curve represents a continuous, normal distribution, $p^*(y|X_2)$, of variance σ^2 centered over the second column (y = 1.5). The solid curve is the distribution, $p(y|X_2)$, that results from renormalizing $p^*(y|X_2)$ over a fixed range [0, 10] dB. This range is the continuous analogue of the discrete categorical range {1, ..., 10}. As a result of confining $p^*(y|X_2)$ to the stimulus range, $p(y|X_2)$ is skewed and of smaller variance.

The renormalized distribution, $p(y|x)$, is now sufficient to describe the distribution of responses along the rows of a stimulus-response matrix as seen in Figure 3. The resulting set of distributions are all related to the same underlying normal distribution of constant variance, σ^2. We observe that the distributions skew as the mean approaches the edges.

Renormalizing $p^*(y|x)$ (unskewed) over the range and shifting the means appropriately gives rise to the set of skewed distributions, $p(y|X_i)$ (i = 1,...,R). Since σ^2 is the variance belonging to $p^*(y|x)$ and σ^2_{eff} is the average variance of the $p(y|X_i)$'s, we should expect that $\sigma^2_{eff} \leq \sigma^2$.

To evaluate σ^2 as a function of σ^2_{eff}, we first evaluate the variance of each row. That is,

$$\text{var}[p(y \mid x)] = \langle y^2 \rangle - \langle y \rangle^2$$

where $\langle y \rangle$ and $\langle y^2 \rangle$ are the first and second moments of

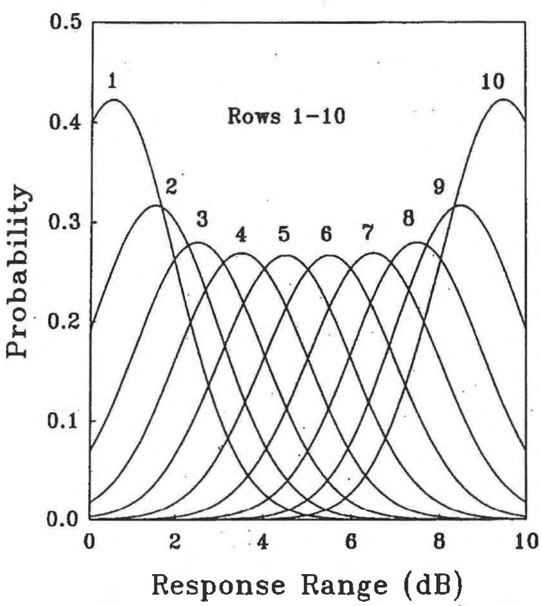

Figure 3: The process of renormalizing $p^*(y|X_j)$, as displayed in Figure 2, for all stimulus categories X_j (j = 1, ..., 10) over the fixed range [0, 10] dB.

$p(y|x)$ respectively. We have defined σ^2_{eff} as the arithmetic mean of the row variances, or

$$\sigma^2_{eff} = \frac{1}{R}\int_0^R \text{var}[p(y \mid x)]dx.$$

In the appendix, part I, it is shown that for $R >> \sigma$,

$$\sigma^2_{eff} = \sigma^2 - \frac{4}{R\sqrt{2\pi}}\sigma^3. \quad (3)$$

Eq. (3) allows us to convert the average variance of the skewed distributions in the stimulus-response matrix to the variance of the unskewed normal distribution that underlies responses. That is, Eq. (3) can be used to extract the underlying variance, σ^2, from the average row variance, σ^2_{eff}, measured from experiment. We observe that $\sigma^2_{eff} \leq \sigma^2$, as expected.

3. APPLICATION OF CV MODEL TO EXPERIMENT

We shall now simulate the matrix in Figure 1 using Eq. (3). Measuring the average row variance from the matrix gives $s^2_{eff} = 2.21$. The notation s^2_{eff} is used to describe the sample mean row variance corresponding to σ^2_{eff}, the actual mean row variance. Similarly, s^2 is the sample estimate corresponding to σ^2. Substituting (s^2_{eff}, s^2) for (σ^2_{eff}, σ^2) into Eq. (3) and solving gives $s^2 = 3.07$. This value is now used as an input into the simulator.

In Figure 4, the dashed curve depicts information calculated progressively from the stimulus-response matrix displayed in Figure 1 as the matrix fills by increasing numbers of experimental trials. The solid curve represents information calculated progressively from an average of 20 Monte Carlo simulations. Two types of input were used for simulation. The first was the arithmetic mean row variance calculated directly from the matrix in Figure 1; i.e. $s^2_{eff} = 2.21$ (top panel). The second was the corrected variance obtained by substituting s^2_{eff} (for σ^2_{eff}) into Eq. (3) to give $s^2 = 3.07$ (bottom panel). Notice how, after 500 trials, the simulator that implements Eq. (3) to obtain $s^2 = 3.07$ as an input conforms more closely to the experimental curve, thus improving upon the method of overcoming small sample bias developed by Wong and Norwich (1997). Furthermore, the close correspondence between experiment and simulation in Figure 4 using the anchor free estimate of σ^2 attests to the validity of the constant variance assumption.

The procedure in our example can be generalized. For

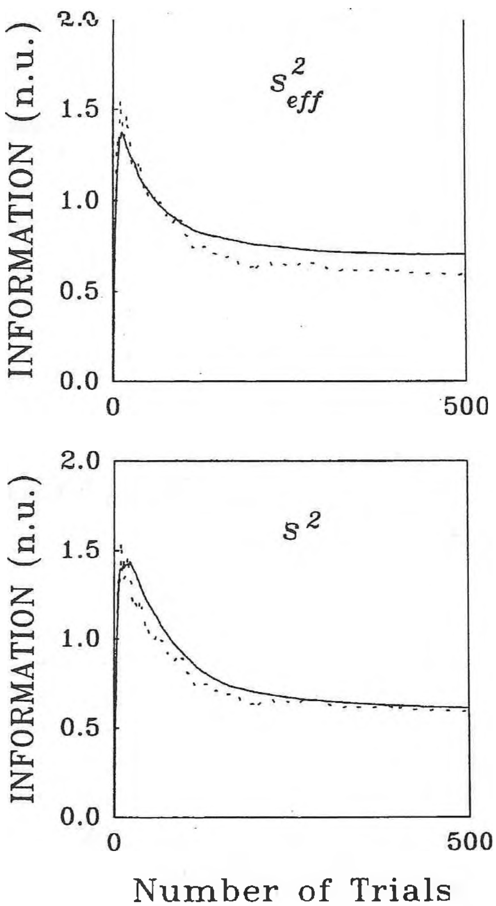

Figure 4: Comparison of two inputs for simulation, upper and lower panels. Information calculated from experiment (dashed curve) and simulation (solid curve) as stimulus-response matrix fills by increasing number of trials.

any experimentally determined stimulus-response matrix, measure the average row sample variance, s^2_{eff}. "Unwrap" this measure (or "weigh" the anchor) using Eq. (3) to obtain the anchor-free estimate, s^2, of the response error underlying the matrix. Simulate using s^2 to obtain an estimate for information, $I(N)$, to any desired number of trials.

One should note that averaging simulations gives a stronger estimate of the expected value of information $\langle I(N)\rangle$ corresponding to the underlying response error, σ. $I(N)$ resulting from a single simulation can be considered as a single experiment. The corresponding expectation, $\langle I(N)\rangle$ would represent a long term average over many experiments and has a one-to-one correspondence with σ. The characteristic shape of $\langle I(N)\rangle$ as depicted in Figure 4 has been discussed by Norwich, Wong and Sagi (1998). One should note that for $N \to \infty$, $I(N) \to I_t$. That is, after a sufficient number of trials, the small sample bias in the information estimate, $I(N)$, is overcome and one obtains the information transmitted to the subject, I_t.

4. BYPASSING SIMULATION BY APPROXIMATION: THE ASYMPTOTIC INFORMATION

As mentioned, the original purpose for simulation was to overcome the small sample bias in calculated information, $I(N)$, which approaches transmitted information, I_t, only after a significant number of trials. One of the advantages of the CV model is that it provides a trial-independent, *a priori* description of the row distributions found in the stimulus-response matrix; namely, $p(y|x)$, which can be substituted into the equation that describes I_t (Garner and Hake, 1951).

$$I_t \equiv I(Y \mid X) = H(Y) - H(Y \mid X)$$
$$= -\sum_{k=1}^{R} p(y_k)\log p(y_k) + \sum_{j=1}^{R}\sum_{k=1}^{R} p(x_j)p(y_k \mid x_j)\log p(y_k \mid x_j) \quad (4)$$

This equation is independent of N and describes I_t exactly, but is too difficult to handle analytically. We can, however make some approximations. First, let us transfer from the discrete realm to the continuous, thereby converting sums into integrals. This procedure is analogous to considering infinitesimally small category widths. The increase in I_t due to an increasing number of categories is a well known phenomenon (Miller, 1956). This increase, however, is bounded. That is, for a large enough number of categories, I_t approaches a constant value, i.e. the channel capacity for that stimulus range.

By way of example, the channel capacity for a stimulus range spanning 90 dB is reached after about 30 categories, i.e. each category having a width of 3 dB. Similarly, the channel capacity for a stimulus range spanning 30 dB is reached after about 10 categories. Of course, the channel capacity for the 90 dB stimulus range is larger than that for the stimulus range of 30 dB. In our experiments, we use categories of 1 dB width, which is the same as requiring that the number of categories equals the discrete stimulus range, i.e. $m = R$ dB. Since, using this many categories, the transmitted information has reached channel capacity, we therefore make the conjecture that increasing the number of categories from $m = R$ dB to $m \to \infty$ in Eq. (4) has little or no effect on I_t (Sagi, Wong and Norwich, 2001).

Hence,

$$I_t = -\int_0^R p(y)\log p(y)dy + \int_0^R\int_0^R p(x)p(y \mid x)\log p(y \mid x)dydx$$

Symmetry in a stimulus-response matrix would imply that $p(y) = p(x) = 1/R$:

$$I_t = \log R + \frac{1}{R}\int_0^R\int_0^R p(y \mid x)\log p(y \mid x)dydx$$

Using the expression for the row distributions in Eq. (2), the integral of the rightmost term can be expanded as shown in the appendix, part II. The transmitted information in natural units now becomes

$$I_t = \ln R - \frac{1}{2}\ln(2\pi e\sigma^2) - \frac{1}{R}\int_0^R \left(\ln C(x) + \frac{\sigma^2}{2C(x)}\frac{d^2C(x)}{dx^2} \right) dx$$

The rightmost term can be defined as follows:

$$\Phi(R,\sigma) = -\frac{1}{R}\int_0^R \left(\ln C(x) + \frac{\sigma^2}{2C(x)}\frac{d^2C(x)}{dx^2} \right) dx$$
$$C(x) = \frac{1}{2}\left[erf\left(\frac{R-x}{\sigma\sqrt{2}}\right) + erf\left(\frac{x}{\sigma\sqrt{2}}\right) \right] \tag{5}$$

and the information transmitted to the subject in natural units can be expressed as

$$I_t = \ln R - \frac{1}{2}\ln\left(2\pi e\sigma^2\right) + \Phi(R,\sigma) \tag{6}$$

Please note that in Eq. (5), $\Phi(R, \sigma) \geq 0$ and must be evaluated numerically, but vanishes for large R. One can consider $\Phi(R, \sigma)$ as an information gain due to the presence of edges. Notice how, in this model, no assumptions were necessary regarding mechanisms for anchoring. Instead, the anchor effect comes about naturally from the boundary condition $y \in [0, R]$.

If we drop $\Phi(R, \sigma)$, Eq. (6) becomes

$$I_t^* = \ln R - \frac{1}{2}\ln\left(2\pi e\sigma^2\right) \tag{7}$$

This expression compares well with that derived in Wong and Norwich (1997) where transmitted information was approximated without the anchor effect. A similar expression was also suggested by Baird (1984). Hence, it is possible to describe I_t in terms of a non-anchor contribution and an anchor contribution, or

$$I_t = I_t^* + \Phi(R,\sigma) \tag{8}$$

Data in Table 1 demonstrate the correspondence between the transmitted information, I_t, calculated from Eq. (6); the transmitted information independent of anchor effects, I_t^*, calculated from Eq. (7); and I_t^{sim}, the value of transmitted information obtained from the simulator. All information measurements were made in natural units (n.u.). For estimates of information using the simulator, 100,000 trials were used to overcome any small sample bias. Also, 20 runs are averaged for each simulation to ensure the simulator approximates $\langle I(N)\rangle$. All information measures make use of the subject's estimated error of response, s (for σ), for a given range. This estimate was "unwrapped" from s_{eff} (for σ_{eff}), obtained experimentally from subject "W" over several ranges, using Equation (3). The information gain due to the presence of edges is expressed in terms of %Φ, defined below in Eq. (9).

Please notice in Table 1 the correspondence between I_t and I_t^{sim}. That is, Eq. (6) is sufficient to describe the results of simulations over large trials. Furthermore, the term $\Phi(R, \sigma)$ allows us to quantify the added contribution of edge effects to I_t. Hereafter, all estimates of I_t will be obtained from Eq. (6).

5. EXPERIMENTS ON STIMULUS CATEGORIZATION

Experiments on categorization of intensities of auditory stimuli were conducted over several ranges of stimuli (Norwich et al, 1998). Stimulus tones of 1000 Hz and 1.5 s duration were presented binaurally through headphones to 5 participants. Each categorization experiment was conducted over a fixed stimulus range using 500 experimental trials. For each stimulus range, the number of categories equals the discrete range, or $m = R\ dB$, and s^2_{eff} was measured from the resulting stimulus-response matrix. For each participant, s^2 was obtained from s^2_{eff} using Eq. (3) above. Subsequently, s^2 was used to calculate I_t and Φ for each subject and each stimulus range using Eq. (6). The results are compiled in Table 2. Transmitted information (I_t) increases with increasing stimulus range in accordance with the findings of previous investigators (Norwich et. al., 1998). Using Eq. (6) and Eq. (7) of the constant variance model, we are now able to quantify the percent contribution of the edge effect to the transmitted information, I_t, expressed as %Φ, calculated from

$$\%\Phi = 100\frac{I_t - I_t^*}{I_t} \tag{9}$$

We observe that the edge or anchor effects predominate at smaller ranges and decrease with increasing stimulus range.

6. DISCUSSION AND CONCLUSION

We have presented a means by which anchor effects can be removed from a stimulus-response matrix. A constant variance model of the stimulus-response matrix was utilized. The primary assumption of the model is that the distribution

Range (dB)	s_{eff} (dB)	s (dB)	I_t^{sim} (n.u.)	I_t (n.u.)	I_t^* (n.u.)	%Φ
1 - 10	1.49	1.75	0.557	0.563	0.324	42
1 - 30	2.50	2.71	1.110	1.107	0.985	11
1 - 50	3.72	3.99	1.224	1.215	1.109	8.7
1 - 70	4.41	4.66	1.391	1.376	1.291	6.2
1 - 90	5.58	5.90	1.427	1.391	1.306	6.1

Table 1: Data from subject "W". s_{eff} obtained from experiment over given range. s obtained from s_{eff} using Eq. (3). s used to measure I_t^{sim} from simulation (see text), I_t from Eq. (6), and I_t^* from Eq. (7). %Φ from Eq. (9). Information in natural units (n.u.).

Range	Subject "C"		Subject "E"		Subject "J"		Subject "R"		Subject "W"	
(dB)	I_t (n.u.)	%Φ	I_t (n.u.)	%Φ	I_t (n.u.)	%Φ	I_t (n.u.)	%Φ	I_t (n.u.)	%Φ
1-10	0.841	20	0.632	35	0.595	39	0.790	22	0.563	42
1-30	1.086	11	1.125	10	0.979	14	1.208	8.7	1.107	11
1-50	-	-	1.226	8.5	1.049	12	-	-	1.215	8.7
1-70	-	-	-	-	1.232	8.4	-	-	1.376	6.2
1-90	1.252	8.1	1.432	8.1	1.482	5.2	1.499	5.0	1.391	6.1

Table 2: Percent contribution of the edge effect, %Φ (Eq. (9)), to the transmitted information, I_t (Eq. (6)) in natural units (n.u.), measured over several stimulus ranges for 5 subjects.

of responses along each row of the matrix, including the extreme intensities of the stimulus range, can be described by a single underlying normal density of constant variance, σ^2.

Although stimulus categorization experiments were performed with a limited number of experimental trials, accurate estimates of I_t are obtainable for each participant from the resulting stimulus-response matrix through Monte Carlo

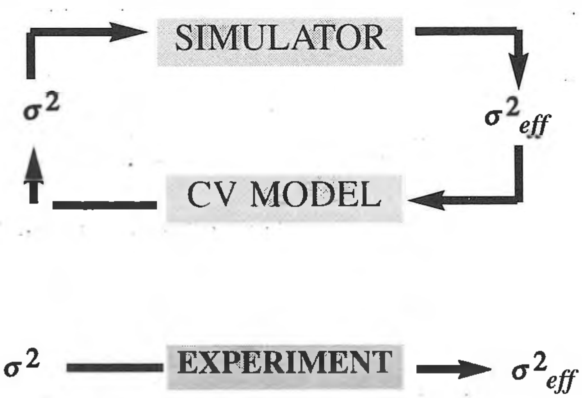

Figure 5: Using σ^2_{eff} measured from experiment, the CV model (Eq. 3) provides us with σ^2 (anchor-free) as an input to the simulator, in turn, giving rise to the same σ^2_{eff} as an output: a kind of "Koch cycle".

simulation. Using a single input value for the subject's response error, σ^2, pseudo-stimulus-response pairs are generated for an arbitrarily large number of trials and the resulting information is calculated from the simulated stimulus-response matrix. In this way, small sample bias is minimized or eliminated.

The single input value, σ, can be measured from the experimentally obtained stimulus-response matrix in the form of an average row variance, σ^2_{eff}. This measure is, however, distorted or anchored by edge effects due to stimuli at the extremities of the stimulus range. The constant variance model removes the anchor, replacing σ^2_{eff} by the more accurate σ^2. This process is described qualitatively in Figure 5 where the process of "weighing the anchor in stimulus categorization" is summarized. Consider an experiment in stimulus categorization conducted over a sufficiently large number of trials. We can measure a subject's response error by taking an arithmetic mean of the variances across all the rows of the resulting matrix, to estimate σ^2_{eff}. This measure is anchored due to stimuli at the extremities of the stimulus range. The anchor effect can be removed (or "weighed") by substituting σ^2_{eff} into Eq. (3) of the constant variance model to obtain an estimator of σ^2. If we now utilize σ^2 as input for simulation, we find, after a sufficiently large number of simulated trials, that the mean row variance of the resulting simulated stimulus-response matrix is equal to σ^2_{eff}, the value originally measured from experiment. Inputting σ^2 into the simulator gives rise to σ^2_{eff} in the resulting simulated stimulus-response matrix. The constant variance model lets us estimate the value of σ^2 that originally gave rise to σ^2_{eff}.

The process of beginning with σ^2_{eff} from experiments on the "outside world", passing it through the model and simulator, and then retrieving σ^2_{eff} back into the outside world, is strangely reminiscent of the postulates (criteria) of microbiologist Robert Koch (see, for example, Dorland's Illustrated Medical Dictionary, 28th Edition). That is, our ability to extract an otherwise hidden parameter, i.e. σ^2, depends on the extent to which we are able to reproduce the observable, σ^2_{eff}.

Our ability to recreate the experimentally observed stimulus-response matrix is best demonstrated using the calculated information, *I(N)*, as in Figure 4. Using σ^2 that is free from the anchor effect as the single input parameter to the simulator, both the small sample bias in *I(N)* and its subsequent approach to I_t are accounted for. In this way, we have a theoretical 'handle' on what may not be just a statistical bias, but a description of the progressive acquisition of auditory information.

Furthermore, confining the underlying normal distribution of constant variance, σ^2, to the stimulus range and then renormalizing this distribution over that range provides us with an *a priori* description of the probability distribution for any given row. This leads to a trial-independent expression for the transmitted information, obviating the need for simulation. The expression for I_t decomposes into a sum of two components, the first independent of, and the second dependent upon the anchor effects. Hence, we are truly able to "weigh" the contribution of the anchor effect to the transmitted information that arises somewhat as an artifact from the boundary conditions of the experiment.

The primary utility of the constant variance assumption is that an experiment on categorization of sound level over a fixed stimulus range becomes completely determined by a single parameter, i.e. σ^2. As demonstrated in Table 2, σ^2 increases as the stimulus range is increased. Recently, we have demonstrated that the rate of increase of σ^2 with stimulus range mirrors the rate of increase of psychophysical loudness with stimulus intensity. In this way, σ^2 becomes a rather 'objective' representation of loudness (Norwich and Sagi, 2002, in press).

Although the focus of our experiments was on categorization, or absolute identification of sound level, the theory outlined herein could be applied to categorization, or absolute identification of other dimensions such as pitch, spatial perception, etc.

7. ACKNOWLEDGMENTS

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APPENDIX

(I) σ^2_{eff} as a Function of σ^2

To obtain σ^2_{eff} as a function of σ^2, we require the first two moments of $p(y|x)$; namely $\langle y\rangle$ and $\langle y^2\rangle$.

$$\langle y\rangle = \int_0^R y p(y\mid x)dy$$

$$= \int_0^R \frac{y}{C(x)\sqrt{2\pi\sigma^2}} \exp\left[-\frac{1}{2}\left(\frac{y-x}{\sigma}\right)^2\right]dy$$

Employing the following substitution:

$$t = \frac{y-x}{\sqrt{2}\sigma}$$

$$y = \sqrt{2}\sigma t + x$$

we obtain

$$\mathrm{var}[p(y\mid x)] = \langle y^2\rangle - \langle y\rangle^2$$

$$= 2\sigma^2\left(\langle t^2\rangle - \langle t\rangle^2\right)$$

Making the necessary substitutions,

$$\langle t\rangle = \int_{\frac{-x}{\sqrt{2}\sigma}}^{\frac{R-x}{\sqrt{2}\sigma}} \frac{t\exp(-t^2)}{C(x)\sqrt{\pi}}dt$$

$$= \frac{\sigma}{C(x)\sqrt{2}} \frac{\exp\left(-\frac{1}{2}\left(\frac{x}{\sigma}\right)^2\right) - \exp\left(-\frac{1}{2}\left(\frac{R-x}{\sigma}\right)^2\right)}{\sqrt{2\pi\sigma^2}}$$

This equation can be conveniently expressed in a short-hand using the normalizing factor $C(x)$:

$$\langle t\rangle = \frac{\sigma}{C(x)\sqrt{2}} \frac{dC(x)}{dx}$$

$$C(x) = \frac{1}{2}erf\left(\frac{R-x}{\sqrt{2}\sigma}\right) + \frac{1}{2}erf\left(\frac{x}{\sqrt{2}\sigma}\right)$$

One can take a similar approach for the second moment:

$$\langle t^2\rangle = \int_{\frac{-x}{\sqrt{2}\sigma}}^{\frac{R-x}{\sqrt{2}\sigma}} \frac{t^2\exp(-t^2)}{C(x)\sqrt{\pi}}dt$$

$$= \frac{1}{C(x)2\sqrt{\pi}}\left(-t\exp(-t^2)\Big|_{\frac{-x}{\sqrt{2}\sigma}}^{\frac{R-x}{\sqrt{2}\sigma}}\right) + \frac{1}{2}$$

Using the same shorthand above,

$$\langle t^2\rangle = \frac{\sigma^2}{2C(x)} \frac{d^2C(x)}{dx^2} + \frac{1}{2}$$

We now can express the variance of any row distribution as a function of its mean:

$$\mathrm{var}[p(y\mid x)] = 2\sigma^2\left(\langle t^2\rangle - \langle t\rangle^2\right)$$

$$= \frac{\sigma^4}{C(x)} \frac{d^2C(x)}{dx^2} + \sigma^2 - \frac{\sigma^4}{(C(x))^2}\left(\frac{dC(x)}{dx}\right)^2$$

One should note that

$$\frac{d}{dx}\left(\frac{1}{C(x)}\frac{dC(x)}{dx}\right) = \frac{1}{C(x)}\frac{d^2C(x)}{dx^2} - \frac{1}{(C(x))^2}\left(\frac{dC(x)}{dx}\right)^2$$

so the variance of any row distribution becomes:

$$\mathrm{var}[p(y\mid x)] = \sigma^4 \frac{d}{dx}\left(\frac{1}{C(x)}\frac{dC(x)}{dx}\right) + \sigma^2$$

The latter is still a complicated expression and difficult to work with. However, if we measure the average row variance over the mean, we can obtain an expression for σ^2_{eff}. In the discrete case, taking an arithmetic mean for the row variance simply involves adding the variances of rows 1 to R and dividing by the range, R. Deriving a closed expression for this using $var[p(y|x)]$ above would be quite difficult. It is possible, however, to consider jumping from the discrete case to the continuous case over the mean x. Specifically, σ^2_{eff} in the continuous case takes the form:

$$\sigma^2_{eff} = \frac{1}{R}\int_0^R \mathrm{var}[p(y\mid x)]dx$$

$$= \frac{1}{R}\int_0^R\left[\sigma^4\frac{d}{dx}\left(\frac{1}{C(x)}\frac{dC(x)}{dx}\right) + \sigma^2\right]dx$$

It is easily verified that for $R >> \sigma$,

$$\left(\frac{1}{C(x)}\frac{dC(x)}{dx}\right)_0^R = \frac{\sqrt{2}}{\sigma}\left(\frac{\frac{2}{\sqrt{\pi}}\exp\left[-\left(\frac{R}{\sqrt{2}\sigma}\right)^2\right] - \frac{2}{\sqrt{\pi}}}{erf\left(\frac{R}{\sqrt{2}\sigma}\right)}\right)$$

$$\cong -\frac{4}{\sqrt{2\pi\sigma^2}}$$

So to a strong approximation,

$$\sigma_{eff}^2 = \sigma^2 - \frac{4}{R\sqrt{2\pi}}\sigma^3$$

which is Eq. (3).

(II) Asymptotic Approximation

We would now like to evaluate the integral:

$$H(Y \mid X) = -\frac{1}{R}\int_0^R\int_0^R p(y \mid x)\ln p(y \mid x)dydx,$$

where $p(y|x)$ is defined in Eq. (2).

$$H(Y \mid X) = -\frac{1}{R}\int_0^R\int_0^R\left[\frac{e^{-\frac{1}{2}\left(\frac{y-x}{\sigma}\right)^2}}{C(x)\sqrt{2\pi\sigma^2}}\right]\ln\left[\frac{e^{-\frac{1}{2}\left(\frac{y-x}{\sigma}\right)^2}}{C(x)\sqrt{2\pi\sigma^2}}\right]dydx$$

After some simplification

$$H(Y \mid X) = \frac{1}{R}\int_0^R\langle t^2\rangle dx + \frac{1}{R}\int_0^R \ln(C(x))dx + \frac{1}{2}\ln(2\pi\sigma^2)$$

where $\langle t^2\rangle$ is described previously in the appendix. The full expression therefore becomes

$$H(Y \mid X) = \frac{1}{R}\int_0^R\left(\frac{\sigma^2}{2C(x)}\frac{d^2C(x)}{dx^2} + \frac{1}{2}\right)dx + \frac{1}{R}\int_0^R \ln C(x)dx + \frac{1}{2}\ln(2\pi\sigma^2)$$

or finally,

$$H(Y \mid X) = \frac{1}{2}\ln(2\pi e\sigma^2) + \frac{1}{R}\int_0^R\left(\frac{\sigma^2}{2C(x)}\frac{d^2C(x)}{dx^2} + \ln C(x)\right)dx$$

as used in Eq. (5).

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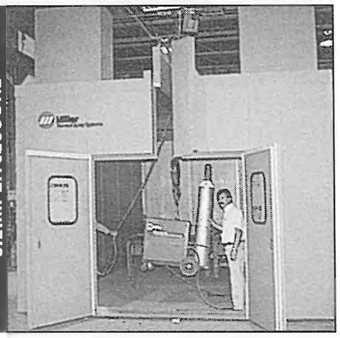

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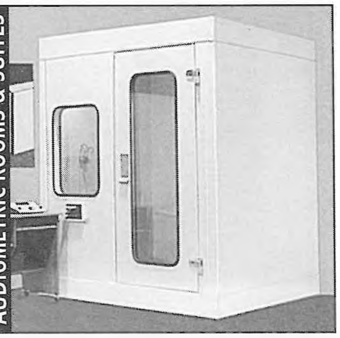

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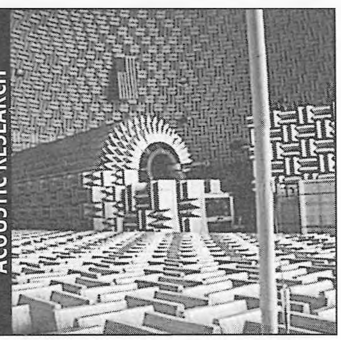

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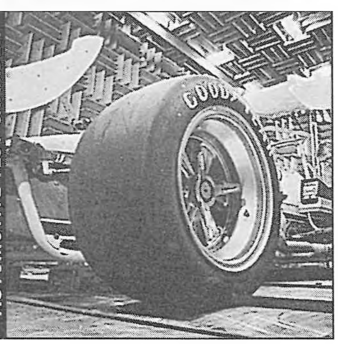

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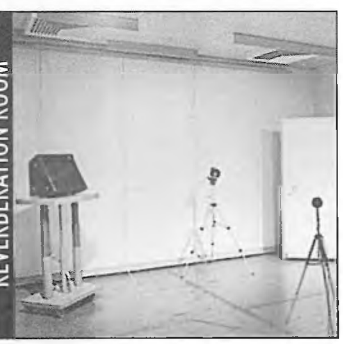

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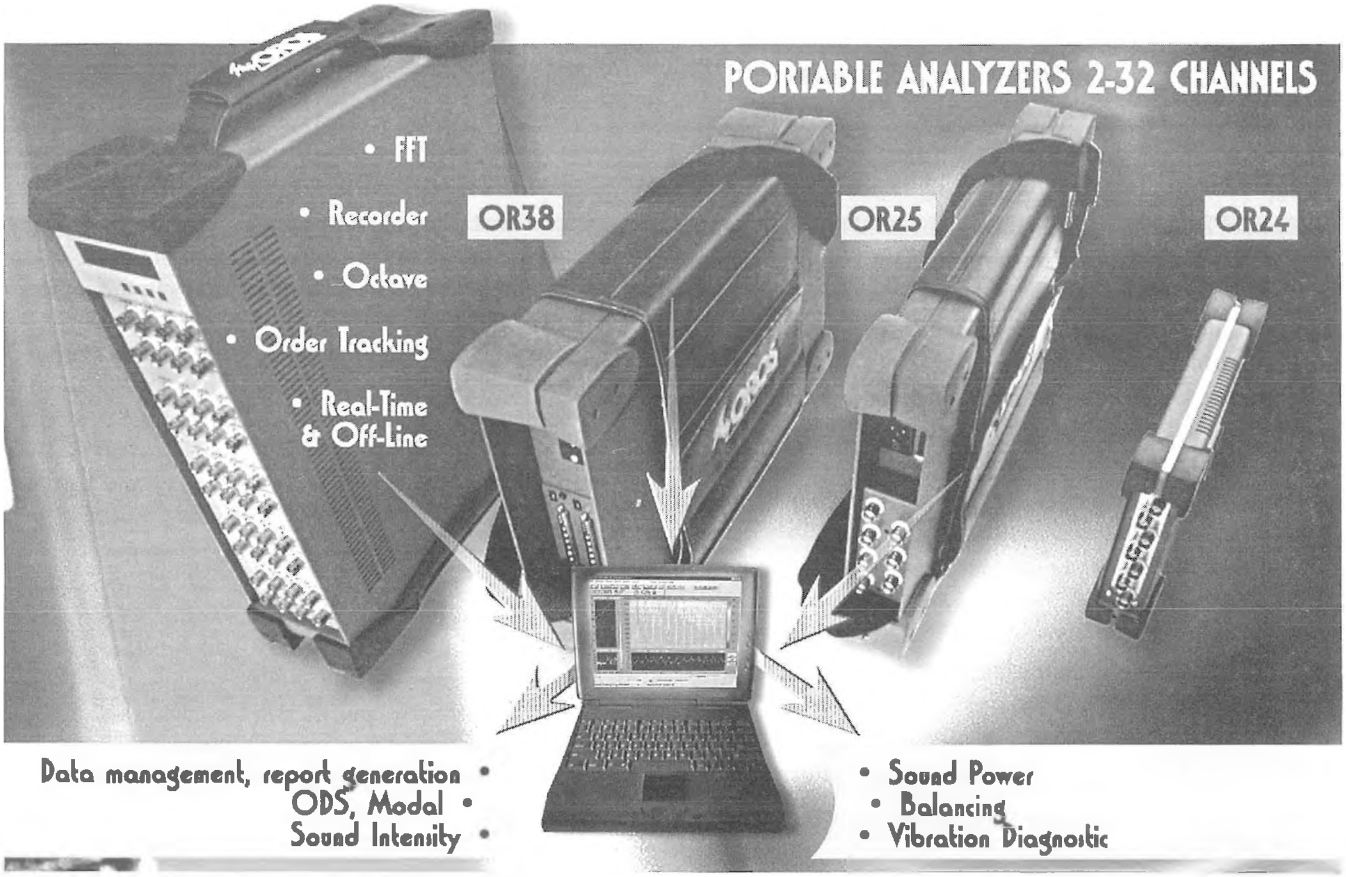

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"DODEC" SPEAKER CONSTRUCTION

Peter Patrick

Scientific Acoustics, 10 Harth Street, Too woomba, 4350, Australia

If you have occasional need for a dodecahedral loudspeaker, and would build one yourself but for the compound mitre joints involved, this process could be for you.

The "stitch 'n glue" process is well known to plywood boat builders. The outcome is definitely more certain to be successful from the outset than a compound mitre affair and it will definitely be stronger by several orders of magnitude. Strength and Beauty in the final product as with any project, are a fair measure of your input. In this case however, the skill levels demanded by compound mitre joints are not required.

Ingredients are: (a) hardwood plywood 9mm – 1 small sheet, (b) epoxy resin – 1litre at the most, (c) 50mm Fibre Glass tape – 1 roll, (d) micro-sphere filler – 55gm, (e) soft copper wire approx 1mm diameter, (f) very low cost paint brushes for applying epoxy (each will only be used once).

9mm plywood can be obtained at most hardware stores. System West have a comprehensive display at www.sterndrives.com. I suggest 403 Micro-spheres, 105 Resin and 206 Hardener. The slow hardener gives time for the liquid epoxy to be absorbed into the surface of the plywood and form a strong bond. Polyester resin is not recommended. Most boat builder supply the hardware, and ships chandler shops can supply the glass tape, the epoxy resin and micro-spheres in small quantities.

The loudspeakers will be "front mounted" or secured to the exterior of the completed enclosure. It is therefore necessary to purchase the loudspeakers and measure the back of the mounting flange to ascertain the size of clearance hole required – the hole diameter must clear the tapered frame but support the flat portion of the flange.

Mark out a pattern pentagon from scrap 9mm or 12mm plywood. Start by scribing the circle for the speaker mounting hole with a compass. (In my case this was exactly 100mm). Using the same centre scribe a larger circle within which to construct your pentagon. Make sure there is a nice solid patch of "land" around the speaker hole and cut the pentagon out from the scrap ply. Drill a pilot hole (1/8in or 3mm) in the centre of the pattern. Do not cut the speaker hole out.

Use the pattern to mark out twelve pentagons on the 9mm sheet. Cut the pentagon faces to size and use the pattern as an overlay to pilot drill the centres of all twelve faces. Use a metal-cutting blade in a jig saw for this to obtain splinter free edges. Note that rebating the exterior edges is optional. I did this with a router set to about 1mm depth to a width of approximately 25mm. Drill two small holes (approximately 1.5 to 2 mm) along each edge of each pentagon.

Cut the copper wire into 100mm lengths and "stitch" the pentagons together through the 1.5mm holes near the edges. Assemble all but one face into the familiar ball shape. Keep the faces aligned at the inside edge and maintain an even gap or "V" in the exterior joints. A few gaps in the joinery are no problem at this stage.

Next mix a batch of about 10 table-spoons of epoxy and 2 of hardener (or whatever proportions are specified by the manufacturer), and add micro-spheres a little at a time until a wet putty consistency is obtained. Note that it is counter productive to mix a large batch of epoxy and hardener. The chemical reaction generates heat, which initiates premature curing of the epoxy. Please note the manufacturers material safety data sheets and apply whatever precautions are recommended for the sake of your health. Some people might contract dermatitis from epoxy and breathing the vapours might not be good for ones health.

Now plaster the "putty" into the gaps. I recommend both inside and outside for maximum strength. Fibreglass tape is weakened by sharp bends or kinks. Filling the inside of the joints in a smooth radius is recommended. Ensure the exterior gap is full. A photograph of an enclosure at this stage of construction is shown in Figure 1. Once the putty has set, cut out the copper stitches and sandpaper the interior and exterior joints to a smooth finish.

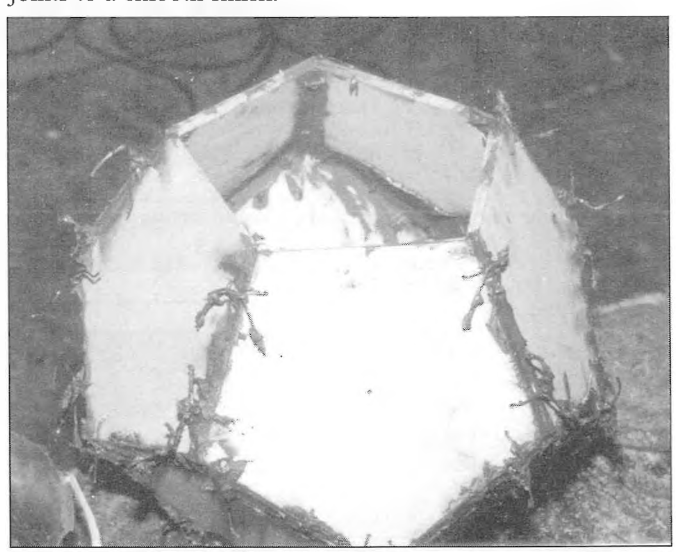

Figure 1. The speaker box, "stitched" with copper wire and "puttied" with epoxy resin. One face of the dodecahedron still has to be attached.

Cut about 30 fibreglass tape strips to the length of an inside edge of the DODEC and paint the inside joins with epoxy/hardener mix. The fibreglass strips are then applied length-wise along each join. Paint epoxy over the strips to ensure they are well filled with epoxy. Any left-over resin should be mixed with micro-spheres and used to fill remaining holes and irregularities. It is preferable, in the opinion of this writer, to discard the brush once the epoxy has hardened it to a useless slab, rather than purchase epoxy thinner chemicals and clean the brush after use. Note: cut the fibreglass strips well before mixing the epoxy and hardener to avoid contaminating scissor blades with epoxy. Trim the final plywood pentagon to fit the last hole with a hand plane or sandpaper and putty it in place.

Once the epoxy has set in the last pentagon, sand the exterior joins to a smooth finish in readiness for the fibreglass tape process. Radius all edges with sandpaper and apply the epoxy and fibreglass tape along the joins, overlapping at the corner points. It is good practice to fill the tape with plenty of clear epoxy. Suspend the enclosure on a hook through a pilot hole to avoid permanent adhesion to any surface in contact with it.

Next use the pilot centres to cut the holes for the speakers. I obtained excellent results using a 100mm fixed diameter hole saw. A skilled operator with a power jig saw might obtain a similar outcome. Reach in through the speaker holes to putty the inside of the untaped joins of the last pentagon face to be glued in place. Sandpaper this last set of five joins to a smooth radius and apply epoxy and tape as elsewhere. If you have rebated the exterior edges of the faces plaster the rebated area with epoxy and micro-sphere putty to provide a smooth exterior. Sand the exterior edges to a smooth radius and finish with fine paper (approx 240 wet-and-dry paper).

Automotive exhaust pipe can be used as a mounting point. Speaker stands (35mm) are an odd size (for automotive exhaust installers) so I had a piece of exhaust pipe stretched at one end to make a snug fit on a speaker stand. Cut three slots with a hacksaw at approximately 120° intervals in the unstretched end of the pipe. Bend the tabs to fit one point of the box. A photograph of an enclosure at this stage of construction is shown in Figure 2. A socket fitting for an acoustic guitar should have appropriate mounting thread or flange to mount properly on the 9mm plywood enclosure.

All that is needed is a coat of paint and a set of speakers. I connected four series-connected sets each of three 8 ohm speakers (24 ohms) in parallel to form a 6 ohm load. Take care to ensure all loudspeakers are connected in the same polarity. I also added a switch to permit operation with just one loudspeaker, thus approximating, in rather vague terms, the acoustic behaviour of the human head. A completed loudspeaker is shown in Figure 3.

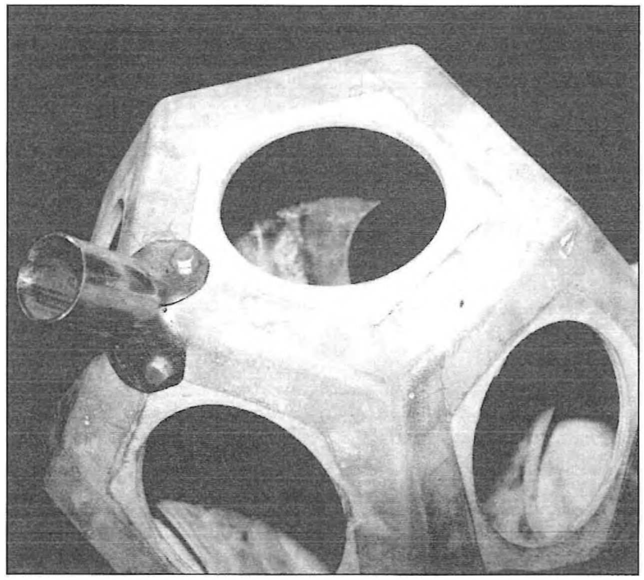

Figure 2. The completed raw speaker box, showing the taped joints and the fixing bracket.

Figure 3. The completed dodecahedral speaker box with speakers mounted.

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INTELLIGENT ROBOT WATCHDOG LOOKS FOR LEAKS

(Acoustic and vibration technology works in oil refinery)

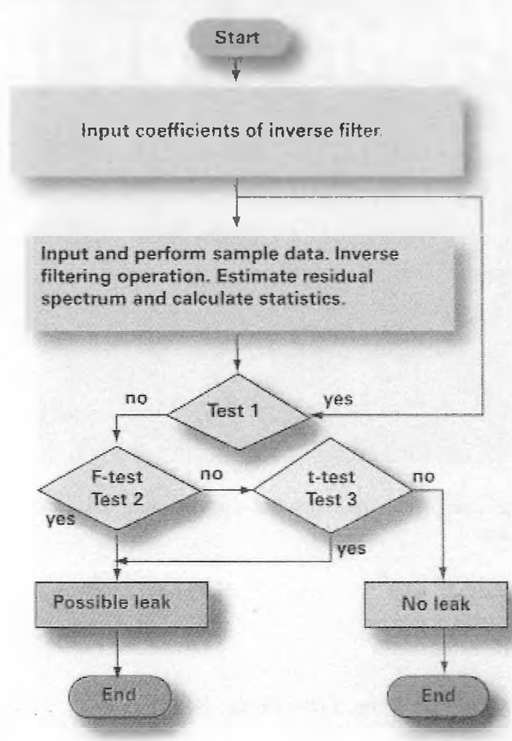
Ryoji Ohba[1], Yoshihito Tamanoi, Toshiyuki Kuwahara2, and Kozo Edanami[2]
1. Department of Applied Physics, The Graduate School of Engineering, Hokkaido University, Sapporo, Japan.
2. Yamatake Industrial Systems, Yokohama, Japan.

There is considerable demand for automated and reduced-manpower operation of plants in modern Japanese industries. Japan sees this as a trend of youthful new industrial employees not wanting to be plant operators.

An automated abnormal-signal segregation and extraction technique based on inverse filtered acoustic/vibration signals has proved effective for monitoring abnormal conditions in rotary machines, compressors, piping, and high-pressure vessels. Using pattern recognition techniques, an intelligent sensor system detects possible leakage of high-pressure gases in oil refineries. Leakage produces continuous sonic and ultrasonic tones.

In real plants, many sources other than leakage generate tones in the identical frequency band. The principle of this present method is to first reduce the sonic components from normal plant operation and then see what is left.
An inverse filter *whitens* any stationary signal. *Whiten* means characteristic peaks cancel from the spectrum of a signal by inverse filtering.

Leak detection flowchart



An abnormal condition's signal, which is not included in the ambient noise signal used to design the filter, does not flatten through the inverse filter and gives some amount of *colored* signal.

This robot watchdog monitors leakage of high-pressure gas in an oil refinery. We recently completed and tested a prototype.

Principle of leak detection

Besides generating tones in the identical frequency band, different sources also cause intermittent tones in the same band. Of the continuous tones, there is not only abnormal leakage but also normal leakage, as from a hydraulic pressure apparatus.

Intermittent sources such as a steam trap are akin to normal leakage in a plant. It is crucial for a real, workable leak detector to distinguish tones of possible abnormal leakage from those of normal leakage.

The principle of this method is to detect tones in the ultrasonic band, after reducing sonic components from the normal operation of plants using the inverse filter. That is, the ambient noise signals collect during normal process operating conditions, and an inverse filter evolves using that signal. Any signal that has the same statistical properties of the ambient noise under normal operations of the plants whitens as it passes through the inverse filter. If any abnormal signal, whose properties are different from the ambient noise signal, passes through the inverse filter, it leaves a residue. This residue is a colored signal.

Steam trap intermittent

Intermittent signals, like those generated during a steam trap action, also give such nonwhitened residual signals after inverse filtering and should be distinguished from real abnormal ones.

To classify such normal signals from abnormal ones, we have designed a pattern-recognizing sensor system, applying a statistical testing method using plural data sets sampled over a constant time interval. That is, the power spectrum of the residual signal is rather flat over the frequency band from 50 kilohertz (kHz) to 100 kHz when neither abnormal leakage signals nor intermittent signals exist. But it varies significantly when either of the two signals is present. If one calculates a set of power spectra from residual signals, the set corresponding to the intermittent signals varies more than the abnormal signals do.

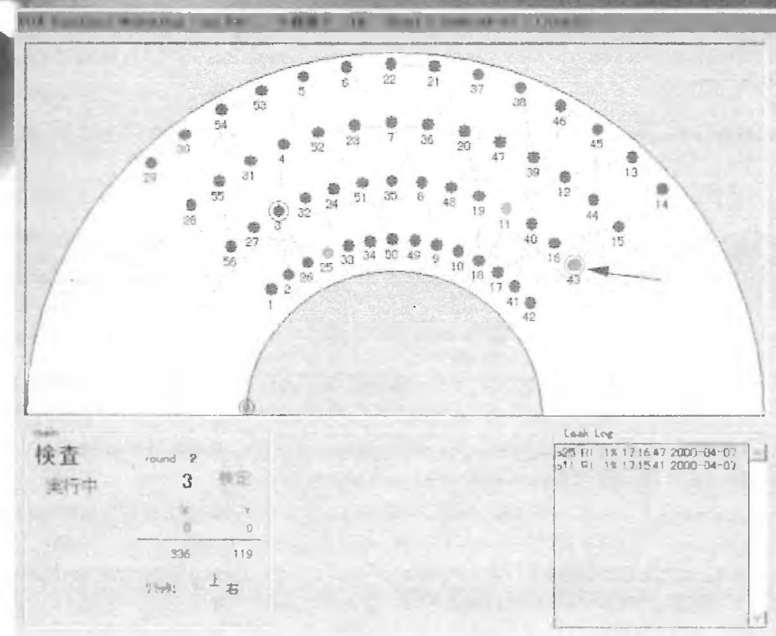
Gimbals mounted watchdog

The pilot model watchdog robot detects a gas leakage from a hole with a diameter as small as 1.5 millimeters (mm) and pressure as low as 0.3 megapascal (44 pounds per square inch) from a distance of 50 meters (m). Its width, height, and depth are 690, 914, and 400 mm, respectively, and it weighs about 80 kilograms.

The main body of the robot is a scanning quarter-inch condenser microphone whose head is at the focal point of a 36.5-centimeters-long, sound-collecting hood. The hood mounts on two-axis gimbals.

Dogged pursuit of a leak

This display shows an array of 56 checkpoints in a coverage area. A blue circle denotes the point undergoing present checking action (#3). Pertinent data for that point is in the box at bottom left. A simulated leak source is at point #43. There is a red circle around this point indicating warning. A leak log is at the bottom right.



A computer controls the gimbals motion via a hydraulic pressure system. Each of the two rotation axes of the gimbals is equipped with a rotary encoder, which can determine the direction of the hood.

The gimbals system has a combination of a mechanical stopper and a limit switch for each axis, which prevents the robot from overrunning the predefined area. The hood aims itself by referring to the difference between the given direction and the rotational angles around the two axes.

The computer positioned in an instrumentation station 100 m distant collects the data sets and carries out data processing as well as the gimbals control.

Hood collects sound

The robot sits on one of the middle decks of a continuous catalyst regeneration platform 27 m high. All of the signals between the robot and the computer are electronic and delivered via burstproof piping.

Control signals to the robot transform into hydraulic signals in a transition terminal box near the robot, which also adopts the burstproof structure. The sound-collecting hood can point in any direction using the rotational angles of respective gimbals' axes.

The principle of this method is to detect tones in the ultrasonic band.

The robot-mounted hood scans 56 points of a hexagonal lattice every 8 minutes. The robot monitors about 3,700 m^2 from a height of 5 m.

The signal from the condenser microphone in the hood feeds to the computer after sampling, is stored in memory, and is then used in the succeeding data processing. Ten data sets of 1,024 samples collect and profile each single direction. There is a half-second time interval between the successive data sets.

The robot has two operational control modes: the learning mode and the monitoring mode. In the learning mode, the robot makes an inverse filter and creates a set of reference data used in the monitoring mode for each point.

At each point, it collects the 10 data sets, the first of which helps in designing the inverse filter. All 10 data sets comprise the reference data for the statistical testing used in the monitoring mode. The results of this data processing are stored in computer memory.

In the monitoring mode, the robot also scans the 56 points. At each point it collects the same number of data sets as in the learning mode, and the inverse filter processes each of the data sets designed during the learning mode.

The statistical F- and t-tests use the results of all 10 data sets to judge possible leakage. If the testing indicates possible leakage, the same testing is carried out twice more by taking 10 new data sets for each point. If both tests indicate leakage, an alarm signal occurs.

Editor's Note: *The above article was first published in the June 2001 issue of InTech magazine, pp. 46-49 and is reproduced here with permission. InTech is the the official publication of ISA--The Instrumentation, Systems, and Automation Society.*

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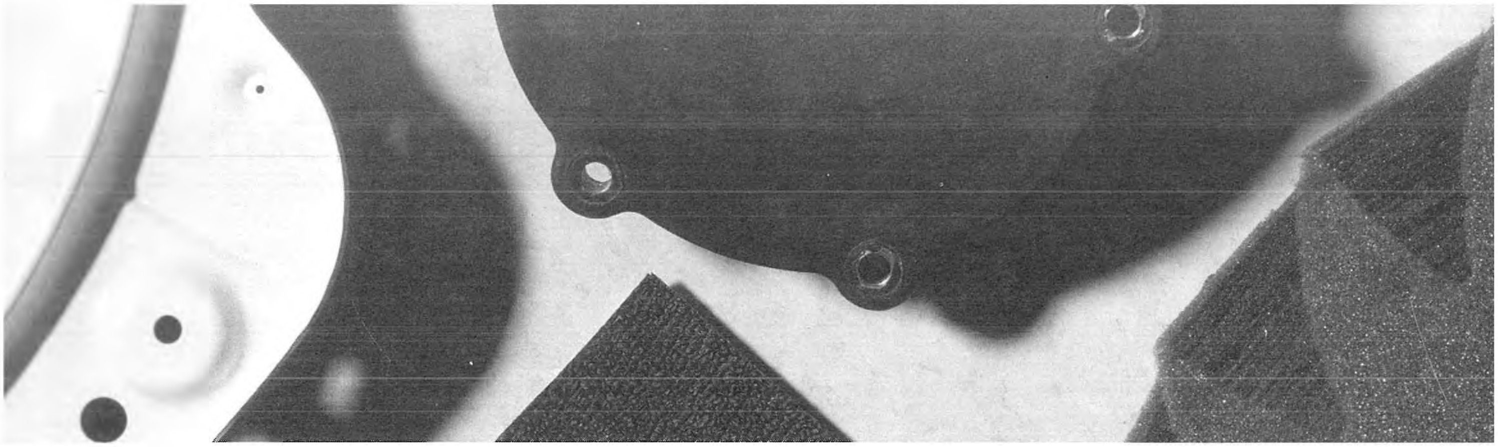

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It is well known that noise is emitted from vibrating structures or substrates. The amount of noise can be drastically reduced by the application of a layer of a vibration damping compound to the surface. The damping compound causes the vibrational energy to be converted into heat energy. Blachford's superior damping material is called ANTIVIBE and is available in either a liquid or a sheet form.

Antivibe® DL is a liquid damping material that can be applied with conventional spray equipment or troweled for smaller or thicker applications.

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Sound barriers are uniquely designed for insulating and blocking airborne noise. The reduction in the transmission of sound (transmission loss or "TL") is accomplished by the use of a material possessing such characteristics as high mass, limpness, and impermeability to air flow. Sound barrier can be a very effective and economical method of noise reduction.

Barymat® is a sound barrier that is limp, has high specifi gravity, and comes in plastic sheets or die cut parts. It can b layered with other materials such as acoustical foam, protec tive and decorative facings or pressure sensitive adhesives t achieve the desired TL for individual applications.

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Blachford's **Conasorb®** materials provide a maximur reduction of airborne noise through absorption in the fre quency ranges associated with most products that produc objectionable noise. Examples: Engine compartments computer and printer casings, construction, forestry an agriculture equipment, buses and locomotives.

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Working with data supplied by you, H.L. Blachford Ltd. wi recommend treatment methods which may include specifi material proposals, design ideas, or modifications to com ponents.

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Invitation to Attend the Annual Meeting of the Canadian Acoustical Association, 2002

Acoustics: Bridge to the Future. Inspired by the unique locale of the Province of Prince Edward Island (PEI) and its recently completed Confederation Bridge, the theme of Acoustics Week in Canada 2002 emphasizes links in the various disciplines of acoustics. For example, close to the site of this next Annual Meeting, models of vibrational modes contributed to the final design of the 13 km bridge from PEI to New Brunswick. In a research station housed inside the bridge, acoustical work continues to monitor vibrations in relation to weather conditions. In the same way that knowledge of acoustics enabled the safe construction and maintenance of the Confederation Bridge, knowledge of acoustics helps forge new paths in domains as diverse as human communication, mapping the seabed, and the aerospace industry. The Annual Meeting of the Canadian Acoustical Association (CAA) builds and reinforces bridges between sub-disciplines of acoustics, over geographical boundaries, and across acoustical and non-acoustical fields.

Contributions from *all* fields of the science of sound are welcome for the CAA meeting, including but not limited to: Architectural Acoustics, Engineering Acoustics/Noise Control, Physical Acoustics/Ultrasound, Musical Acoustics/Electroacoustics, Psychological Acoustics, Physiological Acoustics, Shock/Vibration, Hearing Sciences, Hearing Conservation, Speech Sciences, Underwater Acoustics, Signal Processing/Numerical Methods, and Education in Acoustics.

The short abstract should be prepared and sent (for receipt by May 31, 2002) in accordance with the instructions printed in this issue of *Canadian Acoustics*. Abstracts will be peer reviewed and will be printed and posted. Direct on-line submission will also be available through the conference web-site. For those without access to e-mail, digital files on diskette or paper copy should be mailed to either technical program co-coordinator. The voluntary 2-page proceedings paper is due August 14. This deadline will be strictly enforced to meet the publication schedule of the proceedings issue of the journal *Canadian Acoustics*.

Student participation in Acoustics Week in Canada is strongly encouraged. **Awards** are available to students whose presentations at the conference are judged to be particularly noteworthy. To qualify, students must apply by enclosing an Annual Student Presentation Award form. Students presenting papers may also apply for a travel subsidy to attend the meeting if they live at least 100 km from Charlottetown. To apply for this subsidy, students must submit an Application for Student Travel Subsidy. Forms are also available on the web-site.

Accommodation. The Delta Hotel located in downtown Charlottetown PE will provide accommodation and meeting space (http://www.deltaprinceedward.pe.ca). The special (double/single occupancy) room rate for delegates is $109.00 per night. This rate applies to several days prior and after the conference (including the following Thanksgiving weekend). To reserve accommodation, please contact the hotel directly by telephone (1-800-268-1133; Fax 1-902-566-1745) and mention the CAA meeting. You may also contact Jason Clark directly (jclark@deltahotels.com, 902-894-1237, fax 902-566-1746). The reservation cut-off date is August 27, 2002. After these dates, the special rates are subject to availability. Several other hotels for every budget are located within walking distances from the conference site. For details, check the PEI tourist web site: http://www.gov.pe.ca/visitorsguide/

Workshops/Seminars. As a tradition, several half-day and full-day workshops may be offered Oct. 8, the day before the technical program and exhibition begins, giving opportunity for continuing education in acoustics. If you are interested in giving a workshop, please contact the convener. An IRC/NRC full day seminar "Containing Fire and Sound: Challenges and Solutions" is now scheduled. It focuses on design tradeoffs to deal effectively with both fire resistance and sound insulation between units in multi-family buildings. (Contact Dave.Quirt@nrc.ca, tel: 613-954-1495).

Exhibits. An exhibition of the latest technologies in acoustics and vibration equipment, materials and software will take place Wed. and Thurs. Oct. 9-10. Exhibitors will be well integrated into the conference setting and featured in a special session of the conference program. Sponsorship by exhibitors of nutrition breaks and/or lunches is also welcome. (Contact the conference convener or Teresa Drew).

Canadian Standards Acoustics. Canadian Standards Association Committee Z107 in Acoustics and Noise Control will hold a meeting (organizer: Cameron Sherry, Cwsherry@aol.com). All welcome.

Hospitality. In the tradition of past CAA meetings, a full program is planned for receptions, meals, banquet, award ceremony, and a sample of the best Prince Edward Island and Maritime hospitality and entertainment.

Important Dates 2002	
Wed., August 14	Deadline for receipt of summary paper and early registration
Tues., October 8	Workshops/Seminars
Wed.-Fri. October 9-11	Technical Program and Exhibition

Contact Persons & Information	
Convener **Annabel Cohen**	acohen@upei.ca Dept. of Psychology Univ. Prince Edward Island 550 Univ. Ave Charlottetown, PE C1A 4P3 (902) 628-4325 FAX: (902) 628-4359
Co-coordinator Technical Program **David Stredulinsky**	dave.stredulinsky@drdc-rddc.gc.ca DRDC Atlantic PO Box 1012 Dartmouth NS B2Y 3Z7 (902) 426-3100 x352 FAX: (902) 426-9654
Program Secretariat **Reina Lamothe**	rlamothe@upei.ca Dept. of Psychology Univ. Prince Edward Island (902) 628-4331 tel FAX: (902) 628-4359
Exhibits **Teresa Drew**	tdrew@jacqueswhitford.com Jacques, Whitford & Assoc. 3 Spectacle Lake Drive Dartmouth, NS B3B 1W8 (902) 468-7777 FAX: (902) 468-9009
Audio Visual **Robert Drew**	rdrew@upei.ca Dept. of Psychology (902) 628-4331 FAX: (902) 628-4359
Web-site address	http://caa-aca.ca/PEI-2002.html

Invitation à participer
La réunion annuelle de l'Association canadienne de l'acoustique, Charlottetown 2002

Acoustique: Un pont vers l'avenir. Inspiré par l'unique situation de la province de l'Île-du-Prince-Édouard (ÎPÉ) et le Pont de la Confédération qui fut récemment complété, le thème de la semaine d'acoustique au Canada 2002 souligne les liens entre les disciplines variées de l'acoustique. Par exemple, situé non loin du site de cette prochaine réunion annuelle de l'ACA, des modèles de modes de vibrations ont contribué au plan final du pont de 13 km qui rejoint l'IPÉ au Nouveau-Brunswick. Le travail en acoustique se poursuivent dans la station de recherches située dans l'intérieur du pont où les vibrations sont analysées en correspondance avec les conditions climatiques. De la même façon que nos connaissances en acoustique ont put faciliter la prudente construction et entretien du pont de la Confédération, nos connaissances en acoustique facilitent la création de nouvelles directions dans des domaines aussi divers que la communication humaine, la caractérisation du fond de la mer, et l'industrie aérospatiale. La réunion annuelle de l'Association canadienne d'acoustique crée et renforce les liens entre les sous-disciplines de l'acoustique à travers les frontières géographiques et entre les domaines acoustiques et non-acoustiques.

Les contributions de toutes les disciplines de la science du son seront les bienvenues pour la réunion de l'ACA, incluant mais non limitées à: l'acoustique architecturale, le génie acoustique et contrôle du bruit, l'acoustique physique et l'ultrason, l'acoustique musicale et l'électro-acoustique, la psycho-acoustique, l'acoustique physiologique, les chocs et vibrations, l'audiologie, la science du langage, l'acoustique sous-marine, le traitement du signal et les méthodes numériques, et finalement l'éducation en acoustique.

Les résumés seront préparés et envoyés (pour être reçus avant le 31 mai 2002) suivant les instructions incluses dans ce numéro d'Acoustique canadienne. Les résumés seront examinés par un pair et publiés. Les soumissions par courrier électronique seront disponibles sur le site web. Pour ceux qui n'ont pas accès au courrier électronique, les documents digitaux sur disquette ou papier devront être envoyés à l'un des co-présidents du programme technique. Les sommaires optionnels de 2 pages devront Ltre soumis avant le 14 août 2002. Cette échéance sera strictement respectée afin de pouvoir publier le programme dans les actes d'Acoustique canadienne.

La participation des étudiants à la conférence de l'ACA 2002 est fortement encouragée. Des **prix** seront accordés aux étudiants dont la présentation à la conférence aura été jugée particulièrement remarquable. Afin d'être éligibles à ces prix, les étudiants doivent remplir et envoyer le formulaire du Prix Annuel de Présentation Étudiante. Les étudiants qui habitent dans une région suffisamment éloignée de Charlottetown (plus de 100 km) et qui désirent présenter leur article à la conférence, peuvent également faire application pour une subvention de voyage, afin de défrayer leurs frais de déplacement. Les formulaires sont disponibles sur le site web.

Logement. L'Hôtel Delta Prince Édouard (http://www.deltaprinceedward.pe.ca) situé à Charlottetown ÎPÉ fournira l'hébergement et les salles de réunion. Le prix spécial de chambre (double ou simple) pour les délégués est de 109$ par nuit. Ce prix s'applique aussi pour plusieurs jours avant et après la réunion, y compris la fin de semaine de l'action de grâce. Pour réserver une chambre, s'il-vous-plaît contactez l'hôtel directement (1-800-268-1133; Fax 1-902-566-1745) et mentionnez la réunion de l'ACA. Vous pouvez aussi contacter Jason Clark directement (jclark@deltahotels.com, 902-894-1237; fax: 902-566-1746). Les réservations doivent être faites avant le 27 août 2002. Après cette date, le tarif préférentiel sera sujet à la disponibilité des chambres. Pour d'autres hôtels et auberges, près du site de la conférence, visitez le site web de la ville de Charlottetown (http://www.gov.pe.ca/visitorsguide/).

Ateliers. Suivant la tradition, plusieurs ateliers (demi- ou pleine-journée) pourront être offerts le jour précédent le début des programmes scientifiques et techniques. Si vous êtes intéressé à présenter un atelier, S.V.P. contactez la présidente de la conférence. Un atelier pleine-journée sera offert par IRC/CNRC intitulé "Containing Fire and Sound: Challenges and Solutions". L'atelier porte sur les compromis apportés au design pour améliorer la résistance au feu et l'insonorisation entre les unités de domiciles multi-familiaux. (Personne contact: Dave.Quirt@nrc.ca, tel: 613-954-1495)

Exposants. Une exposition portant sur les dernières technologies entourant l'équipement, l'instrumentation, les matériaux, et les logiciels reliés aux domaines de l'acoustique et des vibrations, sera ouverte mercredi-jeudi (9-10 oct.). Les exposants seront intégrés à la conférence et seront mis en vedette durant une session spéciale du programme. La commandite des périodes de pauses alimentaires et/ou de déjeuners est également invitée. (Contactez Annabel Cohen ou Teresa Drew).

Normes canadiennes en acoustique. Une rencontre du normes canadiennes en acoustique Z107 est organisée par Cameron Sherry (cwsherry@aol.com). Tous sont invités.

L'hospitalité. Suivant la tradition des conférences passées, un programme social sera organisé avec des réceptions, des repas, un banquet, une cérémonie de remise de prix et des exemples d'hospitalité et de divertissement de l'Île-du-Prince-Édouard et des Maritimes.

Dates à retenir	
mercredi, 14 août	Date limite pour la soumission des articles-sommaires et l'inscription à l'avance
mardi, 8 octobre	Ateliers
mercredi-vendredi 9-11 octobre	2002 programme technique et exposition (9-10)

Personnes contacts	
Présidente de la conférence **Annabel Cohen**	acohen@upei.ca Dept. de Psychologie U. de l'Île-du-Prince-Édouard Charlottetown, PE C1A 4P3 (902) 628-4325 (902) 628-4359 (fax)
Co-président du programme technique **David Stredulinsky**	stredulinsky@drea.dnd.ca Defence R& D Canada Atlantic PO Box 1012 Dartmouth NS Dartmouth, NS B2Y 3Z7 (902) 426-3100 x352 (902) 426-9654 (fax)
Secrétaire du programme **Reina Lamothe**	rlamothe@upei.ca Dept. de Psychologie, UPEI (902) 628-4331 (902) 628-4359 (fax)
Exposition **Teresa Drew**	tdrew@jacqueswhitford.com Jacques, Whitford & Assoc. Ltd. (902) 468-7777 (902) 468-9009 (fax)
Audio-visuel **Robert Drew**	rdrew@upei.ca (902) 628-4331 (902) 628-4359 (fax)
Site web	**http://caa-aca.ca/PEI-2002.html**

ACOUSTICS CONFERENCE IN CANADA 2002
SEMAINE CANADIENNE D'ACOUSTIQUE 2002

9, 10 and 11 October, 2002/*du 9 au 11 octobre 2002*
Delta Prince Edward Hotel, Charlottetown, Prince Edward Island

REGISTRATION FORM / *FORMULAIRE D'INSCRIPTION*

(1) Full Three Day Registration. Includes:

Conference + exhibits
Lunch each day for 3 days
Dinner Wednesday night
Coffee breaks, morning and afternoon
Entertainment
Banquet Thursday night (not included for students)
All taxes & gratuities

(1) Inscription complète. Comprend:

La participation à la conférence + l'exhibition
Le dîner pendant 3 jours
Le souper mercredi soir
Les pauses café, le matin et l'après-midi
L'hospitalité/le divertissement
Le banquet jeudi soir (sauf pour les étudiants)
Toutes les taxes

Registration/ ***Inscription***	**CAA Members** ***Membres de l'ACA***	**Non-members** ***Autres***	**Students** ***Etudiant(e)s***	
			CAA Membres	**Autres**
Before Aug. 14/ ***Avant*** *le 14 août*	$235.00	$285.00	$50	$75
After Aug. 14/ ***Après****le 14 août*	$285.00	$335.00	$75	$100

(2) Daily Rates. Includes:

Conference
Lunch each day
All taxes & gratuities

(2) Tarif à la journée. Comprend:

Une journée à la conférence
Le dîner pour une journée
Toutes les taxes

CAA Members ***Membres de l'ACA***	**Students** ***Etudiant(e)s***	**Non-members** ***Autres***
$285.00	$285.00	$285.00

Note: All Conference passes are non-transferable.
Les tickets d'accès à la conférence sont personnels et ne peuvent être transférés.

(3) Extras/ *Suppléments*

Banquet Ticket/*Participation au Banquet:* $55.00 each/*par personne*
$25.00 each student/*par étudiant(e)*

Dinner Wednesday/Le souper le mercredi $40.00 each/*par personne*
$12.50 each student/*par étudiant(e)*

The Canadian Acoustical Association — l'Association Canadienne d'Acoustique

REGISTRATION FORM / *FORMULAIRE D'INSCRIPTION*

Name/*Nom*:____

Company/*Institution*:____________________________________

Address/*Adresse*:______________________________________

__________________________Postal Code/*Code Postal*:__________

Tel:______________________E-mail:______________________

Full 3 day Conference	$__________	***Inscription complète***
Additional banquet ticket(s)	$__________	*Participation(s) supplémentaire(s) au banquet*
Total	$__________	*Total*

Daily Rate Check applicable day(s)	Wednesday *Mercredi*	Thursday *Jeudi*	Friday Vendredi	***Inscription à la journée*** Entourez le(s) jour(s) choisi(s)

Daily rate	$__________	Montant
Banquet ticket(s)	$__________	*Participation(s) au banquet*
Dinner Wednesday	$__________	*Le souper le mercredi*
Total	$__________	*Total*

Payable by cheque in Canadian Funds made out to U. P. E. I. CAA-PEI-2002 or payable by VISA. ***Payable par chèque, en dollars canadiens, à l'ordre de U. P. E. I. ACA-IPE-2002 ou par carte VISA.***

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Ms. Carol MacDonald
Department of Psychology
University of Prince Edward Island
Charlottetown, PE C1A 4P3

Fax: (902) 628-4359

Tel: (902) 566-0563 or/ou (902) 628-4331

Please note: Hotel rooms must be booked by Sept. 4, 2002 to guarantee availability.
Pour des questions de disponibilité, les chambres doivent être réservées avant le 4 septembre 2002.

The Canadian Acoustical Association — l'Association Canadienne d'Acoustique

CAA Student Travel Subsidy and Student Presentation Award

Application Form

Deadline for Receipt, August 14, 2002

Procedure

Complete and submit this application to:
Dr. Reina Lamothe, Student Awards CAA-2002
Department of Psychology
University of Prince Edward Island
Charlottetown, PE C1A 4P3

Subsidy cheques will be mailed directly to you by Nov. 30, 2002.

Eligibility Requirements

In order to be eligible for the Travel Subsidy, you must meet the following requirements:

1. Full-time student at a Canadian University
2. Student member in good standing with the Association
3. Distance travelled to the Conference must exceed 100 km (one way)
4. Submit a summary paper for publication in the Proceedings Issue of *Canadian Acoustics* with the applicant as the first author
5. Present an oral paper at the Conference. Due to limited funding, a travel subsidy can only be given to the presenter of the paper though there may be more than one student author.

Section A: All applicants must complete this section
Name of Student: ____________________
Address (where the cheque is to be sent)____________________
____
Title of the proposed paper:____________________
____
Is the paper to be judged in the Student Presentation Awards [Yes/No]
Name and Location of the University ____________________
Faculty and Degree Being Sought:

Section B: Complete this section only if you are applying for the CAA Student Travel Subsidy

I hereby apply for a travel subsidy from CAA

Proposed Method of Transport to conference ____________________
Provide least expensive transportation cost____________________

Date of Departure to and Return from the Conference____________________

Other Sources of Funding (excluding personal) ____________________

Signature of Applicant	Signature of University Supervisor
____________________	____________________
I certify that the information provided above is correct	I certify that the applicant is a full-time student
____________________	____________________
Print Name	Print Name

Subvention de l'ACA pour les Frais de Déplacement des etudiants et prix Récompensant les présentations d'etudiants

Formulaire d'inscription
Date limite de réception, 14 Août 2002

Procédure
Compléter le formulaire et le soumettre à:
Dr. Reina Lamothe, Student Awards ACA-2002
Department of Psychology
University of Prince Edward Island
Charlottetown, PE C1A 4P3

Les chèques de Subvention vous seront directement envoyés avant le 30 Novembre 2002.

Conditions d'Eligibilité
Pour avoir droit à la Subvention pour les Frais de Déplacement, vous devez remplir les conditions suivantes:

1. Etre étudiant à temps plein dans une Université Canadienne
2. Etre Membre de l'ACA
3. La distance parcourue jusqu'à la Conférence doit être supérieure à 100km (aller simple)
4. Soumettre un sommaire en vue de sa publication dans les actes d'Acoustique Canadienne, l'étudiant doit être le premier auteur du sommaire
5. Présenter une communication orale pendant la conférence. En raison du financement limité, une Subvention pour les Frais de déplacement ne peut être attribuée qu'à l'étudiant présentant la communication même si plusieurs étudiants sont auteurs du sommaire.

Section A: Tous les candidats doivent remplir cette section
Nom de l'étudiant:______________________________
Addresse (où le chèque doit être envoyé):____________________
____
Titre de la communication proposée:____________________
____
La communication est elle inscrite au concours pour le Prix Récompensant les Communications d'Étudiants [Oui/Non]
Nom et adresse de l'université: ____________________
Faculté et niveau d'étude en cours:

Section B: Compléter cette section si vous postulez pour une Subvention des Frais de Déplacement
Je postule par le présent document à une Subvention de l'ACA pour les Frais de Déplacement

Moyen de Transport proposé pour se rendre à la conférence:____________________
Fournir le coût de transport le moins élevé:____________________

Date de Départ pour la Conférence et de Retour:____________________

Autres sources de financement pour le transport (excluyant les sources personnel)____________________
____

Signature du candidat	Signature du superviseur
____________________	____________________
Je certifie que les informations fournies ci dessus sont plein	Je certifie que le signataire est un(e) étudiant(e) à temps correctes
____________________	____________________
Nom	Nom

Acoustics of Fluid-Structure Interactions
By M. S. Howe, Cambridge University Press, 1998
560 pages, US$90, ISBN No. 0-521-63320-6

A noise control engineer, solving problems in wind tunnels, heat exchanger chambers and in regions of flow, such as the low speed flows encountered in HVAC systems, is always interested in strong theoretical support for the many noise control designs. The above book by M. S. Howe is a timely addition to this vast field of fluid flow acoustics, in particular, in areas of structural interactions. Further, this reviewer has been familiar with the vast research output of M. S. Howe during Howe's tenure at many research and academic institutions such as BBN, University of Southampton, and Boston University. His vast theoretical output is beyond question and this monograph under the Cambridge series on Mechanics is a clear example of his work. Further, this book provides a compendium of the varied work undertaken by different researchers, an added assistance for a consulting engineer with limited time.

The book is divided into six chapters. Chapter 1 contains the usual introductory material. Beginning with the fluid equations necessary to derive the wave equation, the materials covered are the governing equations of sound propagation, their solution procedures, as well as the governing equations for structural motions and the interactions between the two. Most of the information is presented through brief descriptions only and the examples shown are also very elementary. However, this chapter is invaluable as all the necessary equations are contained within one chapter. Howe's description on vorticity is clear, concise and the best treatment I have seen in any acoustic book.

Chapters 2, 3 and 4 deal with aerodynamic sound in unbounded medium, interaction of fluid and rigid boundaries and interaction of fluid and flexible boundaries respectively. In addition, these chapters deal with sound generation as well as sound interaction for the above scenarios. Within this large canvas, jet noise, trailing edge noise and wave scattering were provided with special treatment.

The last two chapters cover interactions of sound with solid structures and the oft vexing resonant phenomena and unstable systems. Chapter 6 also includes a separate section on thermoacoustic engines which can convert resonant acoustic phenomenon into useful thermal and /or mechanical work. The thermoacoustic section is something new and very useful.

The book is a compilation of all the relevant theoretical development necessary to solve the problem. It is ideal as a graduate level textbook where a student can apply the equations to solve particular problems.

The main drawback of this book is the lack of concrete examples. Actual field examples would attract a much larger readership and the material can be put to good use. For example, this reviewer is currently working on two very difficult problems in a wind tunnel - heat exchanger Aeolian tones and cavity resonance; and boundary layer noise due to rough foams in the test section. Howe's book has two very interesting sections on these two topics, but the theoretical developments were very formal and difficult to quantify. If these developments accompanied some concrete examples, say with some of the problems solved by the engineers at BBN, the marriage between theory and field would have been strong. Due to the lack of field examples, many of the noise control engineers would find the book to be esoteric and user-unfriendly. Perhaps, the second edition would fill this void.

Reviewed by Ramani Ramakrishnan, Ph. D., P. Eng.
e-mail: rramakri@ryerson.ca

Dictionary of Acoustics
by Chris Morfey, Acdemic Press, 430 pages + XVI, 2001, US$64.95, ISBN 0-12-506940-5

Is there a need for a book on acoustical terms? Well, it is every acoustician's nightmare to navigate through papers and even books, finding terms that are either wrongly used or plainly wrong. Best example, according to this reviewer, is the term "intensity" used as SPL even by distinguished scholars, mainly from the biological/hearing field. Acoustics is a vast discipline encompassing diverse physical phenemena such as engineering and psychology. Terms that have one specific meaning in one sector, are used loosely in another, without causing problems, until the sectors overlap. Dictionary of Acoustics, therefore, bridges the void.

The author of the book has been very thorough in researching the latest documents on acoustical terms from sources such as ANSI, BSI, IEC, etc. He has also consulted many of colleagues, mainly from the UK and with impeccable acoustical background.

The book begins with the chapter "Dictionary Guide and Abbreviations," that helps navigate the reader. It also includes a section on abbreviations and unit symbols.

The main body is well presented in an easy to read manner. Numerous cross references direct the reader to related terms. Each entry has the corresponding units. In a subject as wide as acoustics, the author has included terms that are not strictly acoustic but frequently used, such as "standard deviation," "stapedius muscle," or "irreversibility." The dictionary includes a "Selected Bibliography" of otherdictionaries, standards and selected books.

In summary, this is a valuable and useful contribution that should find its place in many libraries.

Reviewed by Alberto Behar
behar@sympatico.ca

Canadian Acoustical Association

Minutes of the Board of Directors Meeting
2 June 2002, Toronto, Ontario

Present: J. Bradley, D. Giusti, D. Quirt, C. Buma, M. Cheesman, K. Fraser, M. Hodge, R. Ramakrishnan, D. Stredulinsky

Regrets: N. Atalla, J. Hemingway, T. Kelsall, K. Pichora-Fuller.

Meeting was called to order at 9:06 a.m.

Minutes of the Board of Director's meeting on 30 September 2001 were approved as published in the December 2001 issue of Canadian Acoustics. (Moved by D. Giusti, seconded by R. Ramakrishnan, carried).

President's Report

J. Bradley reported that there have been no major changes or problems in the affairs of the Association. The website is becoming increasingly useful, as discussed under a later item. There have been communications with foreign acoustical associations about possible CAA sponsorship of a conference in Vancouver in 2005; discussion of this was deferred to "Past and Future Conferences". Succession of Directors was identified as an issue for the next meeting; three directors must be replaced in September 2002, and suggestions were solicited.

Treasurer's Report

The Treasurer provided an itemized report of the Association's finances, including a summary for the last four years. The report indicated a solid financial position. Consistently, revenues have exceeded operating costs, with significant boosts from the successful conferences in 2000 and 2001. Progress has been made in eliminating he backlog in collecting advertising revenue.

After discussion of the desired distribution of funds between the operating and capital accounts, it was proposed that ten thousand dollars be invested in Ontario Savings Bonds. (Moved by D. Giusti, seconded by R. Ramakrishnan, carried)

The Treasurer reported that a VISA merchant's account was used to accept payments for registration at the October 2001 conference, and will be introduced after June 2002 for annual membership dues. The merits of opening a US dollar account were discussed but it was decided not to proceed with that, at this time.

To reduce problems with charges for international payments, and to minimize the need for individuals to pay (and subsequently recover) the costs for other corporate expenses, it was proposed that the Treasurer be authorized to acquire a corporate credit card. (Moved by D. Giusti, seconded by D. Quirt, carried).

(K. Fraser moved acceptance of Treasurer's report, D. Stredulinsky seconded, carried)

Secretary's Report

D. Quirt reported that in FY2001/02 the membership (including subscriptions) seems to have dropped back to the level observed before FY2000/2001. The decrease can be primarily attributed to non-renewal by many of those who paid membership fees as part of registration at the Sherbrooke Conference. As of 25 May, the total paid membership stood at 300, with subscriptions arriving at 5 to10 per week. About 80% of the members are located in Canada, with the remaining 20% divided between the USA and overseas.

To ease the membership renewal process, the Secretary and Treasurer have organized the process to permit membership payments by VISA. It was agreed that the webmaster should also investigate costs for online payment, but mail to the Ottawa postal box should be used as the normal path for payments.

The Secretary reported that the domain name "CAA-ACA.CA" has been re-registered, and that the process to renew web site hosting arrangements is underway.
Secretarial operating costs for the first ten months of FY01/02 totalled $1131, which include primarily the costs for postal boxes in Toronto and Ottawa, and maintaining the mailing address database including the annual membership renewal process. There was $506 dollars in the secretarial account, as of 2 June.

(M. Cheesman moved acceptance of Secretary's report, D. Giusti seconded, carried.)

Editor's Report

A number of specific issues related to content and publication process for *Canadian Acoustics* were discussed. Alternatives for a new printer are being evaluated, because of major delays in the current arrangements. There are numerous articles at various stages in the editorial process, and the decision to include conference abstracts in the June issue will add more content.

Karen Fraser and Brian Chapnik have assumed the responsibility for managing advertising in *Canadian Acoustics*. Invoices are up to date, including the March 2002 issue, and the backlog from delayed billing for advertising is being collected. The option of discounts for advertising in a sequence of 4 or 6 issues is being discussed with our current advertisers.

R. Ramakrishnan reported that he has been evaluating the possibility of publishing six issues of the journal each year. There seems to be adequate material, and a detailed business plan (anticipated cost, advertising revenues, and a target date, etc.) will be presented at the next Board meeting, and subsequently to the membership at the AGM in October 2002.

(M. Cheesman moved acceptance of Editor's report, D. Stredulinsky seconded, carried.)

Past and Future Conferences

2001 Toronto: The chair, Dalila Giusti, tabled a detailed final report; copies of the report have also been sent to organizers for the upcoming meetings. There were 98 registrants, and a surplus of approximately $14k was realized. The large exhibit and the excellent social interaction facilitated by the meals and other social periods were commended. J. Bradley moved that the conference organizers for the 2001 Toronto meeting should be congratulated as the conference was technically and financially very successful. (Seconded by D. Stredulinsky, carried).

2002 Charlottetown: A report from Annabel Cohen (conference chair) was presented and discussed. At this stage, there appear to be a good number of abstracts, and a number of special sessions have been organized. There was brief discussion of forms for student subsidies and the intended level of support - it was agreed these issues should be very clearly communicated to student applicants. The tentative fee schedule suggested by the organizers was accepted, with a suggestion that slightly higher fees would not be a problem. It was agreed that the Board meeting should be on Tuesday evening. Overall, the arrangements seem to be proceeding well.

2003 Edmonton: C. Buma provided a report on preliminary arrangements for the 2003 meeting. The organizing committee has been established: C. Buma (conference chair), Gary Faulkner (technical program chair), Megan Hodge (secretary), Eugene Bolstad (treasurer), Kelly Kruger (facilities). Hotel arrangements are being negotiated, and a two-page announcement will be ready for the December issue of Canadian Acoustics.

International Conferences: The possibility of CAA involvement in the planning and organization of a conference in Vancouver proposed by ASA and INCE-USA was discussed. No direct commitment by CAA as a corporation has been requested, other than formal endorsement, although individual members will be involved in organizing the meeting. It was unanimously agreed that it would be appropriate for CAA to be identified as a sponsor of this meeting, and the President was encouraged to investigate liaison options with the organizing societies.

CAA Website

D. Stredulinsky submitted a report on recent progress in the hosting arrangements and content for the CAA site, now hosted by Telus. Despite some problems in the transition from UWO to Cadvision to Telus, the site is functioning well with 60-100 visits per day. Content is steadily expanding, and now includes the CAA operations manual, information on CAA awards, a sustaining subscribers' page, and a job-posting page.

A number of specific details were discussed:

Links to commercial sites should be provided only for Sustaining Subscribers.

The Webmaster and Editor should develop a common policy for job advertisements, to present to the Board at the next meeting for formal approval.

Members of the Board should review the site periodically to ensure content in their respective areas of responsibility is correct and current.

Overall, there was enthusiastic support for the rapid and significant improvements. (K. Fraser moved acceptance of Webmaster's report, M. Cheesman seconded, carried).

Awards

There was discussion based on e-mail reports from members of the Awards Committee. Specific progress for various awards was reported:

There is an applicant for the Shaw Prize.

No activity was reported for the Hétu Prize

M. Cheesman agreed to be coordinator for the Hétu Prize

Details of requirements for the Signal processing Student Subsidy are on the CAA web site.

To clarify intent, and to conform with current regulatory terminology, it was decided that wording of requirements for candidates for the Shaw Prize should be changed to "Applicants must be Canadian citizens or landed immigrants. Evidence of citizenship or immigration status may be supplied, but is not required at the time of application. Those who are offered awards will be required to confirm their citizenship or immigration status as a condition of the award." (Unanimous confirmation.)

Concern was expressed about the lack of applicants for some prizes. M. Hodge agreed to prepare and distribute a notice to suitable university departments. The Secretary is to provide the mailing list used in the last such mailing.

Other Business

None was identified.

Adjournment

D. Giusti moved to adjourn the meeting, seconded by R. Ramakrishnan, carried. Meeting adjourned at 2:45 p.m.

Special Action Items Arising from the Meeting

Each Member:

Review CAA website contents within agreed areas of responsibility, at least twice during each 6 months between Board meetings, and send updates to webmaster.

J. Bradley

In collaboration with Past President, identify 3 candidates for Director

Discuss CAA liaison with organizers of Vancouver ASA/NoiseCon meeting.

D. Quirt

Collaborate with D. Giusti to handle membership payments by VISA.

Renew website hosting package to June 2003.

Provide mailing list to M. Hodge for mailing to university departments

D. Giusti

Proceed with investment in Savings Bonds, as authorized.

Acquire a corporate credit card for payment of CAA expenses.

Collaborate with D. Quirt to establish process for membership payments by VISA.

R. Ramakrishnan

Prepare and present to the Board in October 2002 a business plan for increasing the frequency of Journal publication from four to six times a year.

D. Stredulinsky

I n collaboration with Editor, establish common approach to job advertisements.

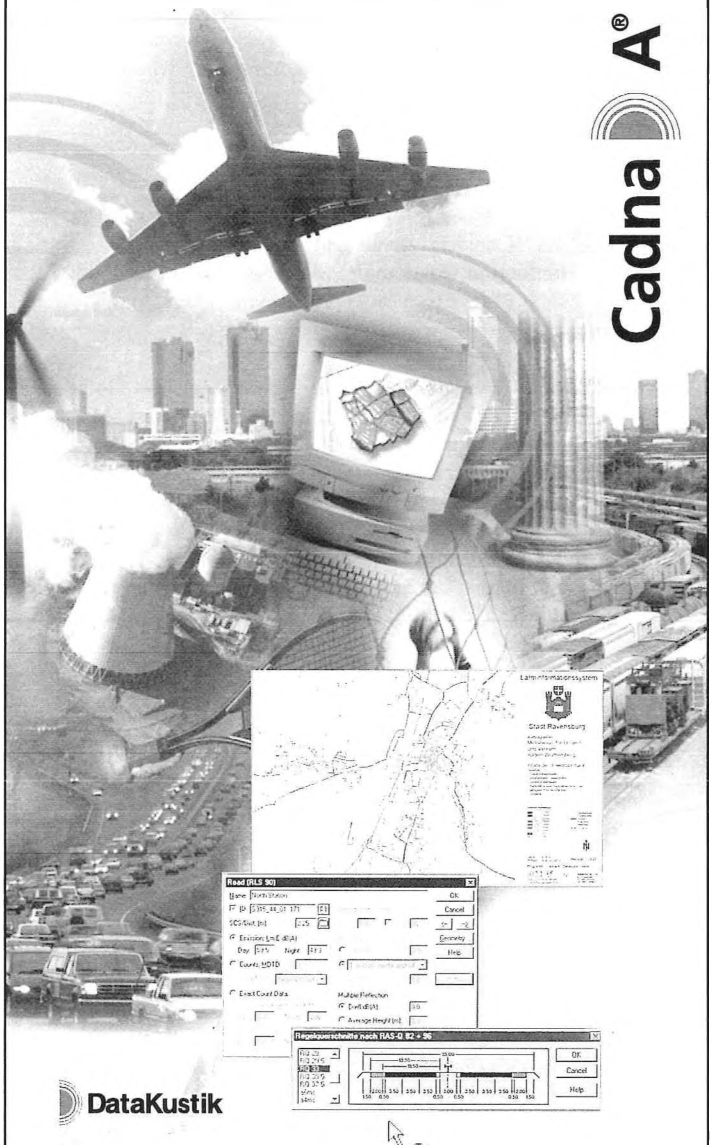
M. Hodge

Prepare and distribute notice re CAA prizes to Canadian university departments

M. Cheesman

Establish a plan for activity re Hétu prize.

State-of-the-art **software** for noise calculation



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NEWS / INFORMATIONS

CONFERENCES

The following list of conferences was mainly provided by the Acoustical Society of America. If you have any news to share with us, send them by mail or fax to the News Editor (see address on the inside cover), or via electronic mail to desharnais@drea.dnd.ca

2002

3-7 June: 143rd Meeting of the Acoustical Society of America, Pittsburg, PA. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; Web: asa.aip.org

4-6 June: 6th International Symposium on Transport Noise and Vibration, St. Petersburg, Russia. Contact: East-European Acoustical Association, Moskovskoe Shosse 44, St. Petersburg 196158, Russia; Fax: +7 812 127 9323; E-mail: noise@mail.rcom.ru

10-14 June: Acoustics in Fisheries and Aquatic Ecology, Montpellier, France. Contact: D.V. Holliday, BAE SYSTEMS, 4669 Murphy Canyon Road, Suite 102, San Diego, CA 92123-4333, USA; Web: www.ices.dk/symposia/

24-27 June: 6th European Conference on Underwater Acoustics, Gdansk, Poland. Fax: +48 58 347 1535; Web: www.ecua2002.gda.pl/

24-28 June: 11th Symposium of the International Society for Acoustic Remote Sensing, Rome, Italy. Contact: +39 06 20660291; Web: ISARS2002.ifa.rm.cnr.it/

24-28 June: 11th International Symposium on Nondestructive Characterization of Materials, Berlin, Germany. Fax: +49 30 678 07129; Web: www.cnde.com

3-6 July: International Conference on Mechatronics (MECH2K2) jointly with the 3rd International Symposium on Acoustics, Noise and Vibrations (ICANOV3), Linz, Austria. Contact: WBJ Zimmerman, University of Sheffield, W.Zimmerman@shef.ac.uk;Web: eyrie.shef.ac.uk/mech2k2

15-17 July: ACTIVE 2002 — 2002 International Symposium on Active Control of Sound and Vibration, Southampton, UK. Contact: Stephen J. Elliott, Institute of Sound and Vibration Research, Southampton University, University Road, Highfield, Southampton SO17 1BJ, United Kingdom; Tel.: +44 23 8059 2384; Fax: +44 23 8059 3190; E-mail: sje@isvr.soton.ac.uk; Web: www.isvr.soton.ac.uk/ACTIVE2002

19-21 July: Auditorium Acoustics: historical and contemporary design and performance, London, UK. Fax: +44 1225 826691; E-mail: m.barron@bath.ac.uk

CONFÉRENCES

La liste de conférences ci-jointe a été offerte en majeure partie par l'Acoustical Society of America. Si vous avez des nouvelles à nous communiquer, envoyez-les par courrier ou fax (coordonnées incluses à l'envers de la page couverture), ou par courrier électronique à desharnais@drea.dnd.ca

2002

3-7 juin: 143e rencontre de l'Acoustical Society of America, Pittsburg, PA. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél: 516-576-2360; Fax: 516-576-2377; Courriel: asa@aip.org; Web: asa.aip.org

4-6 juin: 6e Symposium international sur le bruit et vibrations des transports, Saint-Pétersbourg, Russie. Info: East-European Acoustical Association, Moskovskoe Shosse 44, St. Petersburg 196158, Russia; Fax: +7 812 127 9323; Courriel: noise@mail.rcom.ru

10-14 juin: Acoustique des pêches et écologie aquatique, Montpellier, France. Info: D.V. Holliday, BAE SYSTEMS, 4669 Murphy Canyon Road, Suite 102, San Diego, CA 92123-4333, USA; Web: www.ices.dk/symposia/

24-27 juin: 6e conférence européenne sur l'acoustique sous-marine, Gdansk, Pologne. Fax: +48 58 347 1535; Web: www.ecua2002.gda.pl/

24-28 juin: 11e symposium sur la Société internationale de la télédétection acoustique, Rome, Italie. Info: +39 06 20660291; Web: ISARS2002.ifa.rm.cnr.it/

24-28 juin: 11e symposium international sur la caractérisation non-destructive des matériaux, Berlin, Allemagne. Fax: +49 30 678 07129; Web: www.cnde.com

3-6 juillet: Conférence internationale sur la mécatronique (MECH2K2) combinée avec le 3e Symposium international sur l'acoustique, le bruit et les vibrations (ICANOV3), Linz, Autriche. Info: WBJ Zimmerman, University of Sheffield, W.Zimmerman@shef.ac.uk;Web: eyrie.shef.ac.uk/mech2k2

15-17 juillet: ACTIVE 2002 — Symposium international 2002 sur le contrôle actif du bruit et des vibrations, Southampton, Royaume-Uni. Info: Stephen J. Elliott, Institute of Sound and Vibration Research, Southampton University, University Road, Highfield, Southampton SO17 1BJ, United Kingdom; Tél.: +44 23 8059 2384; Fax: +44 23 8059 3190; Courriel: sje@isvr.soton.ac.uk; Web: www.isvr.soton.ac.uk/ACTIVE2002

19-21 juillet: Acoustique pour les auditoriums : performance et designs historiques et contemporains, Londres, Royaume-Uni. Fax: +44 1225 826691; Courriel: m.barron@bath.ac.uk

19-21 August: Inter-Noise 2002 — 31st International Congress and Exposition on Noise Control Engineering, Dearborn, MI. Contact: Inter-Noise 2002 Congress Secretariat, Dept. Mechanical Engineering, Ohio State University, 206 West 18th Avenue, Columbus, OH 43210-1107, USA. E-mail: peersen.1@osu.edu; Web: www.internoise2002.org

19-23 August: 16th International Symposium on Nonlinear Acoustics (ISNA16), Moscow, Russia. Contact: O. Rudenko, Physics Department, Moscow State University, 119899 Moscow, Russia; E-mail: isna@acs366b.phys.msu.su

26-28 August: 2nd Biot Conference on Poromechanics, Grenoble, France. Contact: J.-L. Auriault, Laboratoire 3S, Domaine Universitaire, BP53, 38041 Grenoble, France. Fax: +33 4 76 82 70 43; Web: geo.hmg.inpg.fr/biot2002

26-28 August: Joint Baltic-Nordic Acoustical Meeting 2002, Lyngby, Denmark. Fax: +45 45 88 05 77; Web: www.dat.dtu.dk

10-12 September: 32nd International Acoustical Conference – EAA Symposium, Banská Stiavnica, Slovakia. Contact: M. Culik, Physics and Applied Mechanics Department, TU Zvolen, Masarykova 24, 96001 Zvolen, Slovakia; Fax: +421 45 532 1811; Web: http://alpha.tuzvo.sk/skas/acoustics

11-13 September: 10th International Meeting on Low Frequency Noise and Vibration, York, UK. Contact: W. Tempest, Multi-Science Co. Ltd., 5 Wates Way, Brentwood, Essex CM15 9TB, UK; Fax: +44 1277 223 453; Web: www.lowfrequency2002.org.uk

16-18 September: International Conference on Noise and Vibration Engineering, Leuven, Belgium. Fax: +32 1632 2987; Web: www.isma-isaac.be

16-21 September: Forum Acusticum 2002 (Joint EAA-SEA-ASJ Meeting), Sevilla. Fax: +34 91 411 7651; Web: www.cica.es/aliens/forum2002

26-28 September: Autumn Meeting of the Acoustical Society of Japan, Akita, Japan. Contact: Acoustical Society of Japan, Nakaura 5th-Bldg., 2-18-20 Sotokanda, Chiyoda-ku, Tokyo 101-0021, Japan; Fax: +81 3 5256 1022; Web: wwwsoc.nacsis.ac.jp/asj/

9-11 October: Acoustics Week in Canada, Charlottetown, PEI, Canada. Contact: A. Cohen, Department of Psychology, University of Prince Edward Island, 550 University Avenue, Charlottetown, PE, C1A 4P3, Canada; Fax: 902-628-4359; Web: http://caa-aca.ca/PEI-2002.html

26-28 October: 6th National Congress of the Turkish Acoustical Society, Kars, Turkey. Contact: Türk Akustik Dernegi, YTÜ Mimarlik Fakültesi, 80750 Besiktas-Istanbul, Turkey; Fax: +90 212 261 0549; Web: http://www.takder.org/kongre-2002/kongre2002.html

29-31 October: Oceans 2002, Biloxi, MS. E-mail: oceans@jspargo.com; Web: www.oceans2002.com

19-21 août: Inter-Noise 2002 — 31e Congrès international et exposition sur le génie du contrôle du bruit, Dearborn, MI. Info: Inter-Noise 2002 Congress Secretariat, Dept. Mechanical Engineering, Ohio State University, 206 West 18th Avenue, Columbus, OH 43210-1107, USA. Courriel: peersen.1@osu.edu; Web: www.internoise2002.org

19-23 août: 16e Symposium international sur l'acoustique non-linéaire (ISNA16), Moscou, Russie. Info: O. Rudenko, Physics Department, Moscow State University, 119899 Moscow, Russia; Courriel: isna@acs366b.phys.msu.su

26-28 août: 2e Conférence de Biot sur la Poro-mécanique, Grenoble, France. Info: J.-L. Auriault, Laboratoire 3S, Domaine Universitaire, BP53, 38041 Grenoble, France. Fax: +33 4 76 82 70 43; Web: geo.hmg.inpg.fr/biot2002

26-28 août: Rencontre acoustique baltique-nordique combinée 2002, Lyngby, Danemark. Fax: +45 45 88 05 77; Web: www.dat.dtu.dk

10-12 septembre: 32e conférence internationale d'acoustique – Symposium EAA, Banská Stiavnica, Slovaquie. Info: M. Culik, Physics and Applied Mechanics Department, TU Zvolen, Masarykova 24, 96001 Zvolen, Slovakia; Fax: +421 45 532 1811; Web: http://alpha.tuzvo.sk/skas/acoustics

11-13 septembre: 10e rencontre internationale sur le bruit et les vibrations à basse fréquence, York, Royaume-Uni. Info: W. Tempest, Multi-Science Co. Ltd., 5 Wates Way, Brentwood, Essex CM15 9TB, UK; Fax: +44 1277 223 453; Web: www.lowfrequency2002.org.uk

16-18 septembre: Conférence internationale sur le génie du bruit et des vibrations, Leuven, Belgique. Fax: +32 1632 2987; Web: www.isma-isaac.be

16-21 septembre: Forum Acusticum 2002 (Rencontre conjointe EAA-SEA-ASJ), Séville. Fax: +34 91 411 7651; Web: www.cica.es/aliens/forum2002

26-28 septembre: Rencontre d'automne de la Société japonaise d'acoustique, Akita, Japon. Info: Acoustical Society of Japan, Nakaura 5th-Bldg., 2-18-20 Sotokanda, Chiyoda-ku, Tokyo 101-0021, Japan; Fax: +81 3 5256 1022; Web: wwwsoc.nacsis.ac.jp/asj/

9-11 octobre: Semaine canadienne d'acoustique 2002, Charlottetown, ÎPE, Canada. Info: A. Cohen, Department of Psychology, University of Prince Edward Island, 550 University Avenue, Charlottetown, PE, C1A 4P3, Canada; Fax: 902-628-4359; Web: http://caa-aca.ca/PEI-2002.html

26-28 octobre: 6e congrès national de la Société turque d'acoustique, Kars, Turquie. Info: Türk Akustik Dernegi, YTÜ Mimarlik Fakültesi, 80750 Besiktas-Istanbul, Turkey; Fax: +90 212 261 0549; Web: http://www.takder.org/kongre-2002/kongre2002.html

29-31 octobre: Oceans 2002, Biloxi, MS. Courriel: oceans@jspargo.com; Web: www.oceans2002.com

21-22 November: New Zealand Acoustical Society 16th Biennial Conference, Auckland, New Zealand. Contact: New Zealand Acoustical Society, PO Box 1181, Auckland, New Zealand; E-mail: graham@marshallday.co.nz

2-6 December: Joint Meeting: 9th Mexican Congress on Acoustics, 144th Meeting of the Acoustical Society of America, and 3rd Iberoamerican Congress on Acoustics, Cancun, Mexico. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; Web: asa.aip.org/cancun.html

9-13 December: International Symposium on Musical Acoustics (ISMA Mexico City), Mexico City. Fax: +52 55 5601 3210; Web: www.unam.mx/enmusica/ismamexico.html

2003

17-20 March: German Acoustical Society Meeting (DAGA2003), Aachen, Germany. Fax: +49 441 798 3698; E-mail: dega@akuphysik.uni-oldenburg.de

7-9 April: WESPAC8, Melbourne, Australia. Web: www.wespac8.com

28 April – 2 May: 145th Meeting of the Acoustical Society of America, Nashville, TN. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; Web: asa.aip.org

8-13 June: XVIII International Evoked Response Audiometry Study Group Symposium, Puerto de la Cruz, Tenerife, Canary Islands, Spain. Fax: +34 922 27 03 64; Web: www.ierasg-2003.org

16-18 June: ACOUSTICS – Modeling & Experimental Measurements, Cadiz, Spain. Contact: Acoustics03, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO40 7AA, UK; Fax: +44 238 029 2853; Web: www.wessex.ac.uk/conference/2003/acoustics/index.html

29 June – 3 July: 8th Conference on Noise as a Public Health Problem, Amsterdam-Rotterdam, The Netherlands. Contact: Congress Secretariat, PO Box 1558, 6501 BN Nijmegen, The Netherlands; Fax: +31 24 360 1159; E-mail: office.nw@prompt.nl

7-10 July: 10th International Congress on Sound and Vibration, Stockholm, Sweden. Contact: Congress Secretariat, Congrex Sweden AB; Tel: +46 8 459 66 00; Fax: +46 8 8 661 91 25; E-mail: icsv10@congrex.se; Web: www.congex.com/icsv10

14-16 July: 8th International Conference on Recent Advances in Structural Dynamics, Southampton, UK. Web: www.isvr.soton.ac.uk/sd2003

25-27 August: Inter-Noise 2003, Jeju Island, Korea. Contact: Dept. of Mechanical Engineering, KAIST, 373-1, Kusong-dong, Yusong-gu, Taejon 305-701, Korea; Fax: +82 42 869 8220; Web: www.icjeju.co.kr

21-22 novembre: 16e conférence bisannuelle de la Société d'acoustique de la Nouvelle-Zélande, Auckland, Nouvelle-Zélande. Info: New Zealand Acoustical Society, PO Box 1181, Auckland, New Zealand; Courriel: graham@marshallday.co.nz

2-6 décembre: Rencontres combinées: 9e Congrès mexicain d'acoustique, 144e rencontre de l'Acoustical Society of America, et 3e Congrès ibéro-américain d'acoustique, Cancun, Mexique. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél: 516-576-2360; Fax: 516-576-2377; Courriel: asa@aip.org; Web: asa.aip.org/cancun.html

9-13 décembre: Symposium international sur l'acoustique musicale (ISMA Mexico City), Mexico, Mexique. Fax: +52 55 5601 3210; Web: www.unam.mx/enmusica/ismamexico.html

2003

17-20 mars: Rencontre de la Société allemande d'acoustique (DAGA2003), Aachen, Allemagne. Fax: +49 441 798 3698; Courriel: dega@akuphysik.uni-oldenburg.de

7-9 avril: WESPAC8, Melbourne, Australie. Web: www.wespac8.com

28 avril – 2 mai: 145e rencontre de l'Acoustical Society of America, Nashville, TN. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél.: 516-576-2360; Fax: 516-576-2377; Courriel: asa@aip.org; Web: asa.aip.org

8-13 juin: XVII Symposium international du Groupe expérimental sur l'audiométrie des potentiels évoqués, Puerto de la Cruz, Tenerife, Iles Canaries, Espagne. Fax: +34 922 27 03 64; Web: www.ierasg-2003.org

16-18 juin: ACOUSTICS – Modélisation et mesures expérimentales, Cadiz, Espagne. Info: Acoustics03, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO40 7AA, UK; Fax: +44 238 029 2853; Web: www.wessex.ac.uk/conference/2003/acoustics/index.html

29 juin – 3 juillet: 8e conférence sur le bruit, un problème de santé publique, Amsterdam-Rotterdam, Pays-Bas. Info: Congress Secretariat, PO Box 1558, 6501 BN Nijmegen, The Netherlands; Fax: +31 24 360 1159; Courriel: office.nw@prompt.nl

7-10 juillet: 10e Congrès international sur le bruit et les vibrations, Stockholm, Suède. Info: Congress Secretariat, Congrex Sweden AB; Tél.: +46 8 459 66 00; Fax: +46 8 8 661 91 25; Courriel: icsv10@congrex.se; Web: www.congex.com/icsv10

14-16 juillet: 8e Conférence internationale sur les développements récents en dynamique structurelle, Southampton, Royaume-Uni. Web: www.isvr.soton.ac.uk/sd2003

25-27 août: Inter-Noise 2003, Île Jeju, Corée. Info: Dept. of Mechanical Engineering, KAIST, 373-1, Kusong-dong, Yusong-gu, Taejon 305-701, Korea; Fax: +82 42 869 8220; Web: www.icjeju.co.kr

1-4 September: Eurospeech 2003, Geneva, Switzerland. Contact: SYMPORG SA, Avenue Krieg 7, 1208 Geneva, Switzerland; Fax: +41 22 839 8485; Web: www.symporg.ch/eurospeech2003

7-10 September: World Congress on Ultrasonics, Paris, France. Web: www.sfa.asso.fr/wcu2003

10-14 November: 146th Meeting of the Acoustical Society of America, Austin, TX. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; Web: asa.aip.org

2004

5-9 April: 18th International Congress on Acoustics (ICA2004), Kyoto, Japan. Web: ica2004.or.jp

24-28 May: 75th Anniversary Meeting (147th Meeting) of the Acoustical Society of America, New York, NY. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; Web: asa.aip.org

29 November – 3 December: 148th Meeting of the Acoustical Society of America, San Diego, CA. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; Web: asa.aip.org

1-4 septembre: Eurospeech 2003, Genève, Suisse. Info: SYMPORG SA, Avenue Krieg 7, 1208 Geneva, Switzerland; Fax: +41 22 839 8485; Web: www.symporg.ch/eurospeech2003

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- Retirements
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- Distinctions
- Other news

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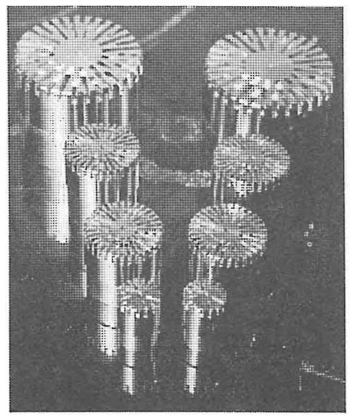

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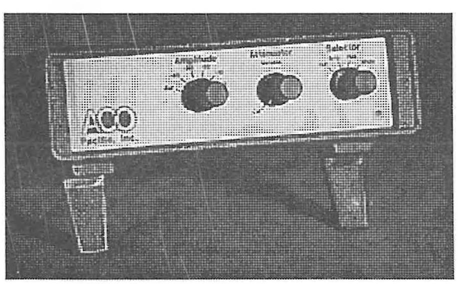

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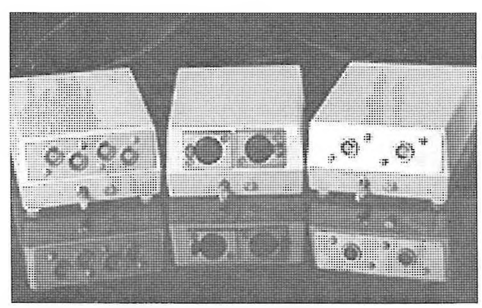

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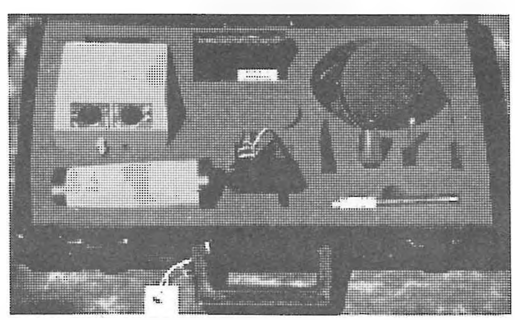

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